Water in the Gaza Strip

An Evolution of Protracted Crisis and Persistent Adaptation

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The findings, presented in this research are derived from the results of the conducted surveys and data collection, revealing the views and opinions of the participants. Statements expressed in this publication do not necessarily reflect the official position of the German Federal Ministry for Economic Cooperation and Development (BMZ), nor of Diakonie Katastrophenhilfe, nor of The Agricultural Development Association (PARC).

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ACKNOWLEDGEMENTS

The generous funds from the German Federal Ministry for Economic Cooperation and Development given to the organization were dedicated to collect the quantitative and qualitative data through the focus groups and the survey. The researchers are indebted to the leadership of Diakonie Katastrophenhilfe and the Association for Agricultural Development (PARC) for their unlimited and continuous support and interest in this research. Special thanks are devoted to Sytske Claassen, Matthew Lyle, Marius Schneider, and Sam van den Berg for their contributions to the research by reviewing and editing its content and language. We are also grateful to the field researchers of the Experts Modernity Consulting and Community Development (EMCCD) who collected most of the data and information that represent the core of this research. Also, we are hugely grateful to the 12 experts and four longstanding farmers who generously contributed to the research with their time and knowledge. Our deepest gratitude is devoted to the tens of farmers participated in the focus group discussion sessions and the ca. 500 people who participated in the survey.

The qualitative and qualitative data collection and the research underlying the publication were generously funded by the German Federal Ministry for Economic Cooperation and Development as part of a project entitled "Enhancing Drought Resilience through Innovative Water Management in the Gaza Strip." As a part of this project, Diakonie Katastrophenhilfe and PARC have constructed more than 45 communal rainwater harvesting ponds to the benefit of groups of 3-5 greenhouse farmers. As part of these constructions, the project introduced geo-membrane rainwater harvesting ponds for the first time to the Gaza Strip. In addition, more than 300 household level rainwater harvesting units have been constructed to improve water quality and availability at the household level. Moreover, trainings on water resource management for farmers and on hygiene practices for families have been conducted. Furthermore, a comprehensive media campaign targets the society at large to raise awareness on the water crisis and to promote creative solutions. Lastly, both partners adopt the Disaster Risk Reduction approach to the project and have produced the first multi-hazard map for the Gaza Strip (Safi et al. 2014).
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"How can we continue to cultivate our lands? The warning bell is ringing! Please underline this statement!"
(A farmer from Northern Gaza)

"We spend days and days cultivating the lands and continue to produce less and less to feed our families and educate our children."
(A farmer from Gaza City governorate stated)

"The cost of withdrawing water from the underground is increasing all the time. Our crops need good quality water. We are worried and don't know how we can continue to farm our lands considering these costs."
(A farmer from Gaza City governorate stated)

“Nowadays I can only plant one crop in my greenhouses. If the market price of this crop plummets, my loss will be huge. In the past, I was able to cultivate multiple crops which allowed me to adapt to the fluctuating market prices: if the price of one crop went down, the price of another would compensate and ensure my survival.”
(A farmer from Rafah Governorate)
EXECUTIVE SUMMARY

The Gaza Strip is facing many socio-economic challenges as well as man-made and natural hazards which increases the vulnerability of the population significantly. The population density, the high levels of unemployment and the lack of water management policies have categorised the Gaza Strip as an increasingly complex place to live in. In addition, the population is increasing rapidly, jobs are becoming scarcer and the current water crisis is likely to worsen. The inhabitants of Gaza have throughout history remained resilient in the face of growing socio-economic challenges. Agricultural workers, business owners and households have all developed coping strategies in order to adapt to the deteriorating water quality and issues of availability. However, given the growing severity of the situation their actions are no longer sufficient and there is a growing need for international support.

It is envisioned that this research study will be of added value to the current water crisis debate in the Gaza Strip. In order to gain a holistic understanding of people’s adaptation strategies and perception of the current water crisis in Gaza, this piece of research is aimed at the following:

1. Understanding the evolution of the water crisis in the Gaza Strip;
2. Documenting the methods used to cope with this crisis over the years;
3. Investigating the perception, knowledge, and attitude of the inhabitants of the Gaza Strip toward the water crisis;
4. Examining the topic from different perspectives making use of a mixed method approach for data collection with a particular focus on understanding local knowledge and how it can be utilised to increase resilience amongst the communities in the Gaza Strip;
5. Providing recommendations on future steps to support preventative action.
The study identifies and uses three approaches to collect data from local communities: general population surveys, focus group discussions and key informant interviews (See Table 1).

**Table 1: Research methodology summary**

<table>
<thead>
<tr>
<th>Population Survey</th>
<th>Focus Group</th>
<th>Key Informant Interviews</th>
</tr>
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<tr>
<td>469 people were surveyed from the five governorates of the Gaza Strip.</td>
<td>Discussions (FGDs) Five FGDs were conducted in each of the five governorates of the Gaza Strip</td>
<td>12 Interviews were conducted with specialists and professionals from varied government administrations in the field of water and agricultural management. Four interviews were conducted with longstanding famers who had been identified through existing relationships with agricultural based committees as having significant knowledge of water management and drought resilience practice.</td>
</tr>
</tbody>
</table>

Furthermore, the data gained from the population survey was analysed in order to learn about the general public's knowledge, views, beliefs and opinions regarding the water crisis and their proposed solutions and ways forward. The results of in-depth interviews and focus group discussions were analysed descriptively to identify the evolution of water management practices as follows:

1. Farmers' adaptation strategies and the change of agricultural practices over time to cope with the water crisis; and
2. The changes in water usage patterns and adaptation strategies at the household level.

The root causes of the current water crisis in the Gaza Strip extend to 1948, when hundreds of thousands of Palestinians were displaced to the Gaza Strip as a result of the Arab-Israeli war. Following the mass influx of refugees at the time and rapid population growth, agricultural activities intensified and the
population became increasingly dependent on the groundwater aquifer as a primary source of water. In the period that followed the six day war in 1967, the Gaza Strip lost access to the only surface water source (The Wadis) and 18% of its land area to Israeli agricultural settlements further increasing the water extraction form the groundwater aquifer. In 1994, when the Gaza Strip was placed under (partial) control of the Palestinian National Authority control a renewed mass influx of Palestinians took place, further straining the aquifer. This was followed by a period of internal Palestinian conflict, repeated Palestinian/Israeli violence and a deep economic crisis. The water crisis reached its culmination in this period and today the Gaza Strip is on the brink of losing its only water source irreversibly.

The results show that farmers have adopted a wide range of adaptation strategies, some of which have burdened them financially and decreased their profits. Farmers have resorted to different strategies in response to water shortages and heightened salinity levels as presented in the following table:

**Table 2. Farmers' adaptation strategies**

<table>
<thead>
<tr>
<th>High salinity levels</th>
<th>Water shortage</th>
</tr>
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<tbody>
<tr>
<td>- Saline tolerant crops</td>
<td>- Water saving irrigation technologies</td>
</tr>
<tr>
<td>- Purchase high quality water</td>
<td>- Digging of wells; legal and illegal</td>
</tr>
<tr>
<td>- Rainwater harvesting from rooftops of greenhouses</td>
<td>- Purchase of water from tankers, from other areas or private wells</td>
</tr>
<tr>
<td></td>
<td>- Change to less water demanding crops</td>
</tr>
<tr>
<td></td>
<td>- Abandoning agriculture</td>
</tr>
</tbody>
</table>

Today, farmers are experimenting with treated wastewater for the irrigation of crops and tensiometers to further increase their farms’ water efficiency. Clearly, interventions led by the government and the civil society are needed to support farmers in their continued struggle to ensure food security for the population of the Gaza Strip.
The farmers participated in the focus group sessions identified the root causes of the current situation and acknowledged the severity of the water crisis' consequences if the status quo continues. Many farmers demanded a constructive dialogue with the government in the hope of interventions and policies that enhance the water efficiency of the agricultural sector and build the resilience of farmers.

Households in the Gaza Strip have also built their resilience to the water crisis. In order to combat continued government water rationing many have increased their water storage capacities and started purchasing tanker water or water from private wells for their domestic uses. When the water quality became evidently unsuitable for drinking purposes, families began to purchase treated or bottled water and installed their own household-level water treatment units. These adaptation strategies often imposed further financial strains on the already burdened families in the Gaza strip.

Results show that the vast majority of respondents to the survey, agrees that Gaza suffers from a water shortage and a water quality problem. However, the majority of respondents would not intentionally engage in activities that reduce water consumption on an individual or household level. Nonetheless, about half of the respondents would practice water saving while showering or doing the dishes. In addition, the people in the Gaza Strip support policies such as enhancing the public awareness and constructing a seawater desalination plant.

The water crisis in the Gaza Strip deteriorates rapidly and there is a need for more efforts from local, national and international organisations as well as governmental bodies. The people in the Gaza Strip have been adopting negative and positive coping strategies to this crisis for decades, however they
are running out of options. More awareness raising campaigns, open discussions and public engagement are needed in order to intensify societal action in response to the looming catastrophe. While farmers and the general public are cautious of direct costs on their livelihoods, they are ready for this dialogue and seek solutions to the issue at hand. Policies and interventions that will be designed need to be sensitive to peoples' hardships and difficulties.

Photo by: Paul Jeffrey
1. INTRODUCTION

1.1. The Water Crisis in the Gaza Strip

The Gaza Strip has been suffering from a severe and exponentially deteriorating water crisis for decades and is highly dependent on the coastal aquifer as its sole source of fresh water. The Gaza Strip is a semiarid region with an average rainfall of about 317-330 mm/year ranging from 235 mm/yr in the south to 410 mm/yr in the North, with significant annual variation as can be seen in figure 1. (Ayesh 2004).

![Diagram of average annual rainfall in the Gaza Strip 73/74 to 2011/2012 Source: created PWA data]
The nearly 1.8 million people living in the Gaza Strip consume 160-190 million cubic meters (MCM) of fresh water a year which is almost double the sustainable abstraction rate of 91 MCM (Thaher 2006, Ismail 2003). Falkenmark Water Stress Index indicated that, if the sustainable water supply falls below 500 m3 per capita per year in a country (read area), then that area suffers absolute scarcity (Rijsberman 2004). Using 91 MCM as our reference, the sustainable per capita water availability in the Gaza Strip is 50 m3 per year which is about one tenth of the 500 m3 threshold suggested by Falkenmark Index. Another index which is the Water Resource Vulnerability Index states that if a country (read area) withdraws more than 40% of its annual supply, then that area will suffer severe water shortage (Rijsberman 2004). Accordingly, the Gaza Strip water scarcity is beyond severe and absolute.

According to the Coastal Municipalities Water Utility (CMWU), around 100 MCM out of the 160-190 MCM consumed yearly are used for domestic purposes noting that the network deficiency reaches almost 40%. The rest of the consumed water (60 to 90 million cubic meters) is used for agricultural purposes (PWA 2013c, Shublaq of the CMWU, pers. comm. 2014/2015). This has resulted in a major deficit in the ground water balance leading to a rapid decline of the groundwater aquifer level and eventually will lead to the depletion of this water source (PWA 2013a).

The accelerating decrease of the coastal aquifer water level has further resulted in deteriorating the quality of water due to groundwater salinization through seawater intrusion from the nearby Mediterranean Sea. The groundwater salinity in the Middle and South-Eastern parts of the Gaza Strip is natural as will be discussed later. As can be seen in Fig. 2, high salinity levels add to other types of water pollution including Nitrate contamination resulting
from sewage and the excessive use of fertilizers in for agriculture purposes (PWA 2013b). Today, 90-95% of the Coastal Aquifer's water does not comply with the World Health Organization's (WHO) standards for drinking water (PWA 2013b). The alarming United Nations study entitled "Gaza in 2020: A Livable Place?" (2012) argued that the deterioration of the coastal aquifer water quality might be irreversible by 2020, and that Gaza's water may become unusable as early as 2016.

Climate change is expected to exacerbate the already critical water situation in the Gaza Strip and also increase the populations' vulnerability to the water crisis. Climate change is predicted to decrease the average rainfall in Gaza, while increasing the intensity of the rain events. This means that climate change is expected to aggravate the water shortage crisis in Gaza, while increasing the frequency and severity of stream and flash flood events (UNDP 2010; Mason et al. 2013; Mason et al. 2012). Additionally, the climate change is expected to accelerate the seawater intrusion and increase salinity levels (Gharbia 2013). Mason et al. (2011) stated that the current economic and political conditions of the Gaza Strip do not allow proper adaptation and enhances the vulnerability.
In order to respond to these issues and the future demands of the population, the Palestinian Water Authority (PWA) drafted a National Water Strategy for Palestine (including Gaza) in 2012/2013 (PWA 2013c). The Palestinian National Authority is the governmental body responsible for managing and monitoring the Palestinian water resources in addition to preparing the water sector’s strategies and plans. The plan for Gaza is entitled “Rolling Strategy” as it entails a set of milestones that will in accumulation achieve the final objectives of the strategy. In 2032, PWA’s plan aims at achieving the following:

- Increasing the water available per person to 120 l/cap. per day.
- Decreasing the groundwater abstraction rate to 38 MCM/year.
- Making 100% of the water available for domestic purposes with chloride concentration less than 500 ppm.
- Making 90% of the water available for domestic purposes with Nitrate concentration of less than 50%.
- Increasing seawater desalination as a source of water to 129 MCM/year.
- Increasing water imports to 14 MCM/year.
- Decreasing the network deficiency to 20%.
- Increasing the water efficiency of agricultural lands to 600 m3/year per dunam.
- Increasing the treated wastewater usage in agriculture to 25 MCM/year.
- Regaining access to 10 MCM from the Wadis and the rainwater (The objective assumes reaching an agreement with Israel that reallocates the Wadis’ water)

While most of these objectives are dependent on the availability of funds (mostly from international donors) and Israeli facilitation and cooperation, the CMWU already runs a small seawater desalination plant in Dier el Balah that produces 2600 CM/day (Shaker and Shublaq of CMWU, per. Comm. 2014/2015). The CMWU is the prime water purveyor in the Gaza Strip.
providing water to the citizens of most localities in the Strip excluding Gaza City (serviced by the second purveyor) and few other small ones. CMWU is planning to enhance the capacity of this unit to 5000 CM/day by 2016. At the same time, they are in a process of establishing another unit with a production capacity of 20,000 CM/day and planning to increase the capacity of this unit to 15,000CM/day (almost 50 MCM/year) by 2020 (pers. comm. 2014/2015). Additionally, the Gaza Strip is already importing 5MCM from Israel. The cost of water production varies by source. For example, water from the aquifer costs around 0.7 NIS, while water from Israel costs around 3.0 NIS, and desalinated water costs around 3-3.5 NIS. Accordingly, the water tariff in the different localities of the Gaza Strip varies based on the mixture of water sources used. The collection rate varies by locality-in Gaza it is generally around 40% (Shaker and Shublaq of CMWU, per. Comm. 2014/2015).

1.2. The Geography, Topography and Geology of the Gaza Strip

The Gaza Strip is a small enclave with a total land area of 365 or 378 km2 (40km in length and between 5 and 12km in width), bordering the Mediterranean Sea, Egypt, and Israel (PWA 2013a). The coastal aquifer of the Gaza Strip is part of the Coastal Aquifer Basin that expands from the Northern Sinai Peninsula to Northern Israel with a total area of 18,368 km2(PWA 2013a).

The Gaza Strip is composed of 5 governorates namely Northern Gaza; Gaza, Dier el Balah, Khan Yunis, and Rafah governorates. The largest governorate in terms of area is Khan Yunis with a land area of around 108 km2, followed by Gaza (74 km2), Rafah (64 km2), North Gaza (61 km2), and last by Dier el Balah Governorate (58 km2) (GEOHIVE 2015).
At present the Gaza Strip has a significant shortage of surface water sources due to human interventions. Surface water was historically an important source of water for the people in Gaza. Five streams, three major and two minor ones, used to run through Gaza every winter. Those streams that originate from the mountains of Hebron used to carry about 20 MCM of fresh water through the Gaza Strip to the Mediterranean. The water of those streams had been utilized for irrigation and to recharge the Gaza Strip's aquifer with more than 2 MCMs of water annually (Qahaman and Larabi 2006; Ismail 2003). However, during the 1980s and 1990s, Israel built reservoirs, irrigation canals and other water structures that diverted water from feeding the Gazan Wadis. Those streams have since dried up and people gradually encroached and built houses on their flood beds. It is speculated, however not confirmed, that during periods of heavy rain and when there is a need to wash the water reservoirs, Israel releases water from the diversion structures and canals - possibly the cause of major flooding in the Gaza Strip. The biggest stream is Wadi Gaza and it suffers the severest flood risk. Around 80 families fled their homes in Al Moghraqa area in the last week of February 2015 as a result of the most recent flood event in Wadi Gaza. It is worth mentioning that Israel denies the existence of structures that can divert water towards the Gaza Strip and claims that they only have small diversion structures for irrigation (PLO 2015; Berman 2015).

The main features of the Gaza Strip's topography are the elongated ridges and depressions, dry streambeds, and sand dunes. Ridges are narrow and composed mainly of layers of sandstone (Kurkar) alternated with red brown clay layers/ these layers are sometimes covered with sand dunes (Ayesh 2014; Anan 2010). The soil of the Gaza Strip is mainly of three types, sand, clay and loess. The sandy soil covers the belt close to the shoreline. The thickness of the sand dunes reaches 50 meters forming hilly shapes in some areas around the
strip. The clay soil is prevalent in the North Eastern areas, while Loess soil is prevalent in the Wadis with a thickness that ranges 25-30 m (Ayesh 2014; Ismail 2003).

1.3. The Modern History of the Gaza Strip in a Nutshell

The Gaza Strip has always been of high strategic importance to all major powers and civilizations due to its geographical location between Africa and Asia. A long history of occupation and different powers such as the Arab Canaanites, the pharaohs of Egypt, ancient Hebrews, Greeks, Romans, Turks, and British have influenced the Gaza Strip over time (Al Aref 1943; Filiu 2014). The long situation of occupation and turbulence in Gaza continues as the Arab/Israeli conflict takes its toll on the people living in the Gaza Strip. In this study, we focus on the era that followed the 1948 War, which is considered the official start date of the water crisis.

On May 14th 1948, the Independence of the State of Israel was announced and prompted the surrounding Arab countries including Egypt, Jordan (then Transjordan), Saudi Arabia, Syria and Lebanon to join the Palestinians in the 1948 war. As a result of this war, which ended in 1949, the Israeli armies gained territory over most of Palestine. However, Egypt retained control over the Gaza Strip, and Transjordan retained control of the West Bank (Miller 2010; Pollack 2002).

The 1948 war led to the exodus of hundreds of thousands of Palestinians living in territories which is today known as the State of Israel to the Gaza Strip, West Bank, and the neighbouring Arab states. This sudden influx of displaced Palestinians tripled the population of the Gaza Strip from 70-80 thousand people to 240-245 thousand in a matter of a few months (Ennab 1994). The
vast majority of the displaced Palestinians (refugees) lived in 8 refugee camps, such as Jablya in (Northern Gaza Governorate), The Beach Camp in Gaza City, Al Bureij, Al Nuseirat and Al Maghazi in Deir el Balah Governorate, Khan Yunis Camp in Khan Yunis Governorate and, finally, Al Shaboura in Rafah Governorate (PCBS 2011).

The Egyptian control over Gaza has been exerted during two epochs: from 1948 to 1956 and from 1957 to 1967. Between November 1956 and March 1957, the Israeli Army occupied the Gaza Strip as part of the Suez Crisis in an attempt to regain Western control over the Suez Canal (Mattar 2005). In June 1967, Israel launched an all-out war against Egypt and Syria. Once again, the Israeli forces triumphed and gained control over the Gaza Strip and North Sinai. According to Ennab (1994) the size of the population in the Gaza Strip directly before 1967 ranged between 385,000 and 450,000. In 1967 and directly after the war a census survey was conducted by the Israelis and found that the number of Palestinians in the Gaza Strip was around 356,000 (Levy Economics Institute. 2015). This gap is the result of displacing thousands of Palestinians from the Gaza Strip as a consequence of the war. In addition, the Israeli census excluded all those Palestinians from the Gaza Strip who were outside of the strip at the time of the census including students, merchants, employees in other countries, and even visitors were declined them their right to get back to the strip (Ennab 1994).

Between 1967 and 1994, the Gaza Strip was under Israeli occupation. This entailed all aspects of life such as social security, education, health, agriculture and water management. This was a period of severe violence and contention between the Palestinians who were represented by the military factions united under the auspices of the Palestinian Liberation Organization (PLO) and the Israeli military and security apparatus. This instability
culminated in the outbreak of the Palestinian Intifada in December 1987. Additionally, starting in 1970, Israel established 21 settlements that occupied around 18% of the area of the Gaza Strip to accommodate less than 8,000-9,000 people (PCBR 2015; JMCC 2009).

On 13 September 1993, the Oslo Accords were signed and the Palestinian National Authority (PNA) was established in the second half of 1994 (Bregman 2002; Rod-Larson et al. 2014). The arrival of Yasser Arafat as the Chairman of the PLO signalled the beginning of a new era in the conflict (Ganim 2002). The PNA enjoyed autonomous control over the civil affairs of Palestinians in the Gaza Strip as an interim governing body until a comprehensive peace agreement between the Palestinians and the Israelis was found and the establishment of a sovereign State of Palestine. The president of the PNA and its legislative council were elected for the first time in 1996 (Ganim, 2002).

The peace process subsequently ended up in a stalemate status and let to the eruption of the second Intifada in 2000. During the second Intifada, the Israeli forces frequently invaded territories in the Gaza Strip facing and responding to fierce resistance by Palestinian militants. In August 2005, The Israeli army unilaterally emptied the Israeli settlements in the Gaza Strip and redeployed its forces to its perimeter (IMFA 2005; PLONAD 2005).

Over time, the stalemate of the peace process, the violence of the second Intifada and the resulting economic collapse led to the Palestinian National Authority becoming largely dysfunctional (Norman 2010). The strength of the Islamic groups namely Hamas and Islamic Jihad rose to unprecedented levels. The weakness of the Palestinian National Authority and the rise of the power of Hamas was compounded in 2006, when Hamas won the second
Legislative Council Election in what was considered by commentators as "a landslide victory." This victory was followed by deadly clashes between Hamas and its rival (Fatah, the main faction of PLO) that ended with Hamas gaining control over the Gaza Strip, and Fatah keeping control over the West Bank (BBC News 2014). Since then the Gaza Strip was subjected for three offensives; the last one was in July/August 2014. In these wars thousands of people lost their lives, tens of thousands were injured, and thousands of families lost their housed and became displaced.

1.4. The Population of the Gaza Strip

As explained above, the population size of the Gaza Strip was less than 100,000 people before 1948. In 1967 it reached 356,000 people. In the years that followed 1967 the population growth rate in the Gaza Strip was 2.7% in the period 1967-1980 and then 2.9% in the period 1980-1990s. The main causes that created fluctuations in the population growth rate were the high migration rates (mainly to the Gulf States) in addition to the fertility and mortality rates (Ennab 1994). According to the results of the first consensus undertaken in the Gaza Strip and West Bank by Palestinians in 1997, the population size of the Gaza Strip was 995,552 (PCBS 1999).

The number of Palestinians living in the Gaza Strip in 2014 was 1,760,037 people, 50.8% of which are males (see the following table). 65.3% of this population hold refugee status. As per the 2014 census data, the population growth rate in the Gaza Strip is 3.4, and the average family size is 5.8 people. 54.8% of the inhabitants of the Gaza Strip are under the age of 19 years old and Only 2.5% of them are over 65 years old (PCBS 2014).
Table 3. The distribution of the Gaza population over governorates in 2014. Source: Adopted from PCBS 2014

<table>
<thead>
<tr>
<th>Governorate</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaza</td>
<td>606,749</td>
</tr>
<tr>
<td>North Gaza</td>
<td>348,808</td>
</tr>
<tr>
<td>Khan Yunis</td>
<td>331,017</td>
</tr>
<tr>
<td>Dier el Balah</td>
<td>255,705</td>
</tr>
<tr>
<td>Rafah</td>
<td>217,758</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,760,037</strong></td>
</tr>
</tbody>
</table>

1.5. Research Justification

While considerable work has been done to understand the hydrological and chemical aspects of the water crisis as explained above, limited work if any has tried to understand how the water problem developed over time, how people have dealt with the challenges in the past and how people are dealing with these challenges today. The purpose of this research is to investigate and learn about the adaptation strategies and coping mechanisms that have been used and are still used by the Palestinian people in the Gaza Strip in order to survive the chronic water crisis. In this research we investigate the public support for water management policies in debates among Gaza water experts and policy makers. It also identifies potentially successful interventions for awareness raising and capacity building purposes. Finally, the public and individual willingness to engage in water conservation practices are investigated. The study results can inform awareness and advocacy efforts, both within and outside the Gaza Strip. The research study targets PARC project staff, farmers, CBOs, university students, national and international organisations and other researchers.
In order to answer the overall research question the following two main issues will be addressed:

- PART 1. Historical perspective on the human struggle for water in Gaza: Within this part, we focus on the evolution of the water crisis and on the local knowledge and practice regarding to dealing with this crisis. Within this discussion we investigate the chronology of the water shortage, quality deterioration, and how farmers and non-farmers have been dealing with the slow manifestation of those problems in addition to many other stressors characterizing the history of the Gaza Strip.

- PART 2. Public attitude towards the water crisis in Gaza: In this part, we investigate the general public's willingness to engage in certain adaptation practices to the water crisis in terms of water shortage and water contamination, and their support to a set of water crisis adaptation and mitigation policy options currently under discussion. In addition, we assess the current public understanding, perceptions and beliefs related to the water quality and availability crisis in the Gaza Strip.
2. METHODOLOGY

This research project aims at understanding how the water crisis developed historically in the Gaza Strip, and how people (especially farmers) adapted to it over time. It investigates how farmers and people currently perceive the water crisis and what kind of adaptation strategies or coping mechanisms they are using or intend to use. For this purpose a set of qualitative and quantitative tools including semi-structured interviews with key informants; focus groups discussions with farmers; and a general public survey has been utilized. In addition, literature including published papers, historical accounts, books, and governmental reports on water and agriculture were studied and used to complement the knowledge gained and to validate information collected during the project. In the following sections, the different approaches used in this study will be discussed in greater detail.
2.1 Semi-Structured Interviews

2.1.1. Data collection

In this study we interviewed 12 governmental employees as experts and key informants representing the main governmental stakeholders to the water and agricultural issues. These governmental bodies are: the Ministry of Agriculture (MoA), the Palestinian Water Authority (PWA), the Coastal Municipalities Water Utility (CMWU), the Environmental Quality Authority (EQA), and municipalities mainly Khan Yunis (KHM) and Gaza City (GM) municipalities. Additionally, a representative of PARC was interviewed. Four farmers were also interviewed in order to gain further on-ground and practical insight on issues relating to the water crisis.

The 16 interviewees are:

- Eng. Ahmed Al Yagoubi: Water Resources Technical Adviser at the PWA
- Eng. Ahmad Shaker: Design Department Manager at the CMWU
- Eng. Ali Whaidi,¹ Head of Water Department at the MoA till 1994
- Eng. Jehad Al-desht: Head of well Drilling Department at the PWA
- Eng. Kamal Abu Mouamar: Head of Wastewater Department at KYM
- Eng. Maher Salem: Director of Water Department at Gaza Municipality (GM)
- Eng. Mahmoud Shabaan: Director at PWA
- Eng. Majdy Dabour: The Head of Technical Department at PARC
- Eng. Munzer Shublaq: Director of the CMWU
- Dr. Nabeel Abu Shamala: Director at the MoA
- Dr. Thaer Abu Shbak Director of Water and Solid Lab

¹- Eng. Ali Al Whaidi is a unique interviewee as he is a retiree who worked for three administrations that controlled the Gaza Strip including the Egyptian Administration, the Israeli Civil Administration, and the Palestinian National Authority-in addition to being a farmer himself. Eng. Ali started working for the Egyptian Department of Agriculture in 1964 and continued employment with the Department of Agriculture of the Israeli Civil Administration. He retired in 1994 as the Head of Water Department of the Palestinian Ministry of Agriculture.
- Eng. Yasser Sha'ath: Head of Water Department at KYM
- Mr. Jalal Abd Sattar Al Fara, 77 years old from Khan Yunis
- Mr. Ameen Ayyad Wafi, 70 years old from Khan Yunis
- Mr. Oda Saleb Abu el Ajeen, 88 years old from Wadi el Salqa
- Mr. Ibrahim Mohammed Abu Amra, 84 years old from Diel el Balah

According to Bernard (2011) semi-structured interviews cover a clear list of topics or questions. However, the researcher may follow leads and explore certain topics in depth according to the knowledge and views expressed by the interviewees. For the interviews conducted above the following topics were covered:

- Changes of water sources, availability, quality and usage over time including before 1948; 1948-1967; 1967-1993; 1993 until today;
- Changes of agricultural practices and economy over time including before 1948; 1948-1967; 1967-1993; 1993 until today in connection to water supply and quality;
- Changes of agricultural water use over time including before 1948; 1948-1967; 1967-1993; 1993 until today
- Adaptation strategies or coping mechanisms used by farmers, and households to deal with the water crisis.

2.1.2. Data analysis
Information collected from the different key informants was compared, and collated with secondary data and information gathered from governmental and nongovernmental reports, published studies, statistical data and historical published accounts. A comparison of secondary and primary data, on the one hand aims at validating the data at hand, and on the other, achieves a holistic understanding of coping mechanisms, adaptation strategies and the water crisis on the whole in its historical evolution and current state.
2.2 Focus Group Discussion Sessions (FGDs)

2.2.1. Data collection
We conducted five focus group discussion sessions in the five governorates of The Gaza Strip in coordination with local community-based organizations (CBOs). The sessions were held between 10/25/2014 and 12/25/2014. A total number of 87 farmers participated in the sessions. The focus group discussions did not aim at statistical representativeness of participants to the total population, but rather the focus was on content, context and depth of the topic of concern (Bernard 2011). The 87 farmers were sampled according to their governorate and age group. The aim was to achieve a wide representation of geographical location and age. However, as mentioned before, those farmers may have been self-selected in terms of their interest in the topic. As noticed in the discussion sessions, the farmers participated in those focus group discussions were better informed, and higher educated than the average farmer.

The following topics were discussed in the FGDs with farmers:
- Farmers perception of the water crisis
- Farmers understanding of the causes of the water crisis
- Impact of the water crisis on farmers livelihoods
- Adaptation strategies and coping mechanism used by farmers to survive the water
- Farmers perception of the effectiveness of those strategies and mechanisms

2.2.2. Data analysis
The data collected in focus group discussions was analyzed descriptively to understand farmers' perception of the water crisis and its causes. Additionally, the narrative used by farmers in the different sessions was used to reflect the
magnitude of the water crisis impact on farmers' livelihoods and families. Framers' adaptation strategies were listed and evaluated in terms of effectiveness and cost according to farmer's narratives and views.

2.3 General Public Survey

2.3.1. Data collection
Within this research project we aimed at surveying 500 randomly selected individuals from the different governorates of the Gaza Strip as per the following figure (Fig. 3.). Considering the population size of the Gaza Strip (about 1.8 million), the sample size needed for statistical inference with a confidence interval of 95 is 450 individuals. Accordingly, we decided to target a sample size of 500 individuals to compensate for potential refusals to fill the survey by some people. 469 people participated in this survey leading to a response rate of 93.8% in November 2014. The questionnaires were completed in face-to-face contacts facilitated by trained graduate students and professionals. The vast majority of those who denied participation were females from Khan Yunis Governorate. This means that certain categories were over-represented mainly male participants, those who were married and people not living in the Khan Yunis Governate. However, as will be discussed later, the sample represents the population of the Gaza Strip within the 5% margin of error.
The questionnaire was designed to collect data about the participants' demographic characteristics, household level, water situation, beliefs regarding the water crisis in the Gaza Strip, beliefs regarding the causes of the water crisis, beliefs regarding the capacity of local organizations and communities to deal with the water crisis, beliefs regarding climate change, beliefs regarding the importance of the water crisis, water crisis risk perception, willingness to adopt measures to deal with the water crisis at the household level and adaptation policy support. The questionnaire was tested on 11 people before it was finalized and used for the purpose of this research.

The demographic data includes age, gender, education, and family income. The data on the water situation at household level entail water sources (municipality, private well, etc), number of days of water cuts per month, perceived water quality, and size of water storage tanks. Questions on participants' beliefs regarding the water situation in the Gaza Strip entail rating their agreement on a 5 level Likert scales ranging from strongly disagree to strongly agree with 4 statements as following:
- The Gaza Strip suffers a water shortage problem.
- The Gaza Strip suffers a bad water quality problem.
- The availability of water is better now in the Gaza Strip than 10 years ago.
- The quality of water in the Gaza Strip is better now than 10 years ago.
When it comes to the causes of the water crisis, participants were asked to answer two multiple choice questions. In the first question they were asked to check all the causes they believed to be the source of the water shortage problem from a list that included: 1) Israeli occupation, 2) rapid population growth, 3) climate change and 4) insufficient use of water by the people. In the second question they were asked to do the same for a list of potential causes of the water quality problem. The choices offered were: 1) using cesspits, landfills, wastewater treatment lagoons, climate change, seawater intrusion, and groundwater level decline.

Within this survey, the participants were asked to rate their agreement with statements regarding their trust in the capacities of governmental organizations and societal groups using the same 5 level scale discussed above. These statements are:
- The governmental organizations are able to deal with the water crisis.
- The municipalities are able to deal with the water crisis.
- The organizations responsible for the water resource management provide us with proper information regarding the water crisis.
- The organizations responsible for the water resource management engage the society in discussions regarding the water crisis.
- The Palestinian farmer is able to deal with the water crisis.
- The Palestinian family is able to deal with the water crisis.
- The Palestinian society in the Gaza Strip is able to deal with the water crisis.

People's beliefs in climate change were measured through rating their agreement with the following three sentences on a 5 level Likert scale. Those three statements aimed at measuring people's agreement with the reality and anthropogenic causes of climate change. For the sake of inferential analysis to be discussed before the third statement was reversed and then the average
answer of each participant was calculated and used as a measure of her/his beliefs regarding climate change (Cronbach's alpha= 0.576):
- Climate change or global warming is a real phenomenon.
- Human played a major role in causing climate change or global warming.
- Climate change is a completely natural phenomenon.

Respondents rated their risk perceptions regarding the impacts of climate change on 8 different risk targets including oneself, family, local community, farmers in their community, farmers in the Gaza Strip, Industrial sector, employment rate, and Gaza Strip. The question was "Please use the scale below to indicate how much you think the water crisis will negatively impact the following." Respondent indicated their appreciation of risk on a 4-point scale 1 no impact, 2 mild impact, 3 moderately impact, and 4 is large impact in addition to "I don't know" as a fifth option. For the sake of inferential analysis, we excluded all the "I don't know" answers keeping only those ranging from 1 (not at all) to 4 (a great deal). Then we combined all the 8 risk targets in one compound risk perception measure (Cronbach's alpha= .869) by calculating the average answer for all 8 targets for each participant.

Participants were also asked to rate the importance the government should give using a 5 level scale ranging from top, high, moderate, low and no importance at all. They were also asked to rate the importance they give to the water crisis using the same scale. Participants were asked to check the organizations or parties they think of as responsible for solving the water crisis from a list of organization that entails the presidency, the cabinets, and the legislative council, municipalities, private sector, UNRWA, NGOs and the citizens themselves.
To measure the public willingness to adapt or assist in mitigating the impacts of the water shortage problem at the individual level, the participants were asked to check whatever measure they are willing to adopt from a list of 15 measures. Those measures can be split into two sets: water conservation measures and adaptation measures. Additionally they were asked if they are willing to educate others regarding the water crisis and the necessity to deal with it. For the sake of the inferential analysis we ranked the yes answer as 1 and the no answer as 0. Then we averaged the responses for every participant to create the variable named “Willing to Adapt” (Cronbach’s alpha = .584). We also asked participants to list the top three measures in term of effectiveness. Those measures were:

- Water conservation measures:
  - Decreasing the frequency of personal showers.
  - Turning of the tap when there is no need for water while showering.
  - Washing dishes from a container rather than running tap water
  - Using a toilet with multiple levels flusher.
  - Putting a filled one liter bottle in the toilet flusher container.
  - Using a hot water cup instead of running water while shaving.
  - Decrease the frequency of car wash.
  - Using a water bucket for car wash instead of running water.
  - Using a pitcher for ablution instead of running water.

- Adaptation measures:
  - Rainwater harvesting for domestic use.
  - Reuse of gray water for irrigating the front yard garden.
  - Rainwater harvesting for recharging the aquifer.
  - Purchasing more water tanks.
  - Digging a private well.
To measure the public willingness to adapt or assist in mitigating the impacts of the quality deterioration problem at the individual levels, the participants were asked to check whatever measure they are willing to adopt from a list of 8 measures. Those measures are:
- Purchasing bottled water.
- Purchasing treated water for drinking.
- Purchasing treated water for all household uses.
- Boiling tap water before using it.
- Installing RO units at home for drinking purposes.
- Installing RO units at home for all uses.
- Chlorination of water.
- Rainwater harvesting for drinking.

Trying to understand what policies the public are supporting to adapt to the water crisis or mitigate its impacts, we asked the participants to check the policies they support from a list of 12 policies. For the sake of the inferential analysis we ranked the yes answer as 1 and the no answer as 0. Then we averaged the responses for every participant to create the variable named "Policy Support" (Cronbach's alpha= .626). Those policies can be categorized into two groups: 1) Conservation policies and 2) Adaptation measures. Conservation policies are those policies that aim at making people becomes more efficient users of water through taxes, fees, etc. Adaptation policies include policies that find alternative sources of water. The suggested policies are:
- Water conservation policies:
- Increasing efforts to enhance the public awareness regarding the necessity of water conservation.
- Increasing water tariff collection efforts.
- Increasing the water tariff.
- Making the penalties on digging illegal wells more strict.
- Shutting down illegal wells.
- Improving the water network to decrease leakage.

- Adaptation measures:
  - Increasing rainwater harvesting from houses.
  - Increasing rainwater harvesting from farms and schools.
  - Increasing the use of treated wastewater for irrigation, in compliance with the public health and religious requirements.
  - Installing a seawater desalination unit.
  - Increasing advocacy efforts to get the Palestinian water rights from Israel.

2.3.2. Data analysis

We analyzed the research data using a two-step strategy. Firstly, we analyzed all variables descriptively using averages, frequencies and percentages. Then we conducted two sets of bivariate correlation tests. The first set was for, 'the willingness to adapt to the water crisis at the individual level', and the second, 'the water crisis adaptation policy support'. These two variables were tested for correlation with the demographic variables including age, gender, education and family income. They were also tested for correlation with the beliefs regarding the water crisis, climate change, the causes of the water shortage problem, the causes of the water quality deterioration problem, in addition to risk perception. Correlation tests show linear associations between variables in one to one basis (Moore et al. 2009).
3. RESULTS AND DISCUSSION

3.1 Semi-Structured Interview Results

3.1.1. The Evolution of the Water Crisis

As could be noticed from the discussion with both experts and elder farmers, the water crisis in the Gaza Strip evolved over three epochs along the lines of the historic changes of the Palestinian Israeli conflict. The first extends from 1948 to 1967; the second from 1967 to 1993; and the last from 1993 until today. While the water crisis has developed accumulatively over this time period, this slow creeping crisis has been overshadowed by other prevailing challenges such as the ongoing conflict with Israel. Therefore, it was not until the 1990s when the water crisis began to significantly affect the inhabitants of Gaza and the problem rose to prominence.

Before 1948, the inhabitants of the Gaza Strip (ca. 70-80'000) relied mainly on rainwater and the wadis (streams) for crop irrigation and a limited number of domestic tasks such as dish washing, bathing, laundry, and others.
However, for drinking and domestic purposes people were primarily dependent on wells owned and operated by communities and municipalities (Al Yaqoubi of PWA, Abu Moammar and Sha'ath of Khan Yunis Municipality, and Qahaman of EQA, person. comm. 2014/2015).

A limited number of landlords with large tracts of cultivated lands often owned private wells and used the water from these sources for agricultural purposes (Al Wahaidi of the MoA, pers comm. 2014/2015). These views partially agree with Al Aref (1943) who mentioned that in 1943, Gaza City had 4 wells for domestic purposes managed by the Municipality of Gaza; two of those wells were operated with Diesel pumps, one with an electrical pump, and one was operated manually (some parts of Gaza City got connected to the electrical grid between 1938 and 1948). He added that in 1943, there were 48 private wells used mostly in agriculture. Qahaman and Larabi (2006) estimated the extraction rate in this period at approx. 16 MCM/year.

In this period, the Gaza Strip was cultivated mostly with rain-fed crops including cereals such as wheat and barley, pulses (e.g. lentils), vegetables (e.g. tomatoes, chili pepper, aubergine, zucchini, Jew's mallow), water melon, trees such as olives, peaches and plum, and Grapes (Sha'ban of PWA, Dabour of PARC, Qahaman of EQA, Salem of Gaza Municipality, Abu Shbak of the MoA and the elderly farmers Al Fara and Wafi, Abu el Ajeen person. comm. 2014/2015). However, large farms equipped with private wells were cultivated with citrus especially in Gaza City and the Northern Gaza governorates. Prior to 1948, close to 20% of Palestinian citrus crops was grown in the Gaza Strip (Mattar 2005). Additionally, some vegetables were irrigated by groundwater or surface water from the Gaza wadis using waterwheels (Al Whaid of the MoA, pers. comm. 2014/2015; Al Aref 1943). In this period, one of the most important crops was Barley as it was renowned for its quality and exported to countries such as the United Kingdom.
The groundwater level was quite high ranging from 2m above sea level (to the West of Der el Balah and/or el Qarara) to 10m above sea level at the Eastern corner of Gaza City and Beit Hanoun (Fig 4; Qahaman and Larabi 2006). The Chloride concentration was particularly high in the South-Eastern corner of the Gaza Strip (Al Fukhary, Khuza'a, Abasan Al Jadidia, etc) and some areas in the Central (or Mid-) area of the Strip surrounding Wadi Gaza including Al Bureij, Al Maghazi, and Al Nuseirat. The chloride concentration in those areas ranged from 800 to 1200 mg/l as can be seen in the following map (Fig. 4). In the remaining parts of the Gaza Strip the Chloride concentration ranged from 100 to 500 mg/l (Qahaman and Larabi 2006). Qahaman of the EQA (Person. comm. 2015) explained this fact by saying "this proves that the groundwater in some areas of the strip is naturally saline for hydro-geological cause."

Figure 4. Groundwater in the Gaza Strip-1935 a. Groundwater level contour map (1935). b. Chloride concentration contour map (1935); Source: Adapted from Qahaman and Larabi (2006)
In the aftermath of the 1948 War and up until 1967, there was a sudden influx of hundreds of thousands of refugees into the Gaza Strip. Hence, more water wells were dug by municipalities and the newly formed UNRWA that tried to enhance the availability of water for drinking and domestic purposes. In addition, these new water sources started to be increasingly used for irrigation of crops. This significant increase in groundwater abstraction steadily rose from 22 MCM/year during the period 1949-1955 to 78 MCM/year in the period 1960-1969 (Qahaman and Larabi 2006). This increase can be attributed to the rapid population growth in the Gaza Strip that began in 1948, in addition to the technological transformation from low efficiency manual to the higher efficiency Diesel pumps (Mattar and Sha’ath of Khan Yunis Municipality, Al Fara and Wafi, the elder farmers, pers. comm 2014/2015). The technological change might have been assisted by the Egyptian experts and the influx of expertise (refugees) in different fields as a result of the 1948 war (Abu Shamala of the MoA. pers. comm. 2014/2015).

The size of the cultivated land in this period increased to 260,000 dunam in 1967, of which around 158,000 dunam were cultivated with trees (incl. citrus) as per data collected by the Israeli Bureau of Statistics and the Israeli Water Commissions’ Aerial Photography Survey of July 1967 (Levy Economics Institute, 2015). There are no studies available to the author that documented the size of cultivated land prior to 1948.

According to Al Whaidi of the MoA, the type of crops cultivated in the strip changed rather dramatically in this period from mostly rain fed to irrigated crops. The size of citrus cultivated lands reached 72,000 dunam in 1967 (Al Whaidi and Abu Shbak of the MoA; Qahaman of the EQA, pers. comm. 2014/12015). This is supported by data published by the World Bank (1993) which stated that citrus production amounted to 50-60% of the total agricultural production value of the Gaza Strip prior to 1967. Al Whadi of the
MoA explained that this dramatic change started in 1952 when Abd el Naser, Jammal and the Free Officers overthrew King Farouq of Egypt. Abd el Naser’s regime greatly supported the growth of the agricultural sector and the production of citrus in the Gaza Strip, specifically through facilitating and supporting citrus exports to Europe and the Eastern Block and launching citrus cultivation projects such as the Amer Project (Whaid of the MoA, pers. comm. 2014/2015). Another factor that eased the occurrence of this change is the fact that the vast majority of the Palestinian people displaced to the Gaza Strip (refugees) were professional farmers eager to continue to work and earn their living in farming the lands of others in the Gaza Strip as cheap labor. Many of those farmers used to grow citrus in areas such as the city of Jaffa and its surrounding villages (Al Whaid of the MoA, pers. comm. 2014/2015).

The water situation changed significantly during this period responding to the dramatic sociopolitical and economic changes that followed the 1948 war. According to Qahaman and Larabi (2006), the water level in the Gaza Strip decreased by an average of 8 meters between 1935 and 1969 as can be seen in the following map (Fig. 5). The most significant decrease in water level had been observed in the North-Eastern part of Gaza—a decrease of up to 12m. Qahaman (pers. comm 2014/2015) stated that the population growth and the rise of groundwater abstraction in the Gaza Strip in the period from 1948 to 1969 are not sufficiently accountable for this drop in the groundwater level. Qahaman hypothesizes that the Israeli administration may have had successfully built trapping wells surrounding the North and North-Eastern parts of Gaza in order to stop water from feeding the aquifer in the Gaza Strip. However, Al Whaidi of the MoA (pers. comm. 2014/2015) stated that in Northern Gaza, giant farms of citrus that were established as discussed above might have used significant amounts of groundwater and contributed to the rapid decrease in groundwater levels as discussed earlier (pers. comm. 2014/2015).
2014/2015). Nonetheless, there was no significant change in chloride concentrations between the 1935 and 1969, because the groundwater level was still above the seawater level.

![Figure 5. Groundwater in the Gaza Strip-1969. a. Water level contour map (1969). b Chloride concentration contour map (1969); Source: Taken from Qahamn and Larabi (2006)](image)

The experts and elderly farmers agreed that, after the 1967 war and the fall of the Gaza Strip under the Israeli occupation, the Gaza Strip continued its transformation towards being more and more dependent on groundwater for all purposes, domestic and agricultural. During this era, the number of registered wells reached 2300 in 1993 (Al Whaid of the MoA; Abu el Ajeen, elderly farmer, pers. comm. 2014/2015). Such changes resulted from the rapid population growth. The abstraction rate in this period increased rapidly from 98 MCM/year between 1969 and 1975 to 107 between 1975 and 1982 to 116 between 1982 and 1990, which means that the abstraction from the aquifer started to exceed its sustainable yield of around 91 MCM/year (Qahaman and Larabi 2006). Also in this period, the Gaza Strip lost an important surface water source which are the Gaza Wadis. As discussed previously, in 1980 Israel allegedly created diversion structures (such as canals and dams) that diverted the sources of water which fed the Wadis.
(Qahaman of the EQA, Abu Amra an elderly farmer, pers. comm. 2014/2015). As has been pointed out earlier, 18% of the land area of the Gaza Strip was used as Israeli settlements. Around 30,000 to 35,000 dunams of these lands were used for agriculture (Abu Shamala and Al Whaidi of the MoA, pers. comm. 2014/2015).

The agricultural land area during the 1980s decreased gradually under the pressure of population growth and urban sprawling to a total of 195,000 cultivated dunams in 1989 (Abu Shamala 2005). The Citrus cultivated land area also decreased. In 1998, the citrus cultivated land was 62,000 dunums or 37.8% of cultivated lands in total (Abu Shamala 2005). During this era the economic value of citrus crops decreased to only 34.4% of the agricultural output value in 1984 in comparison to 40.5% in 1967, while the annual production actually increased in the same era from 91,000 to 175,000 tons in the same period (Roy 1987; Abu el Ajeen and Abu Amra elderly farmers, pers. comm. 2014/2015). Vegetable production slowly increased and dominated the agriculture lands in this period. For example, in 1967 the Gaza Strip produced only 31,800 tons of vegetables (17.4% of the agricultural output value), but by 1984, the Gaza Strip produced 104,500 tons of vegetables representing 27.8% of its overall agricultural output (Roy 1987).

At the beginning of this era, irrigation was not efficient in water consumption as techniques such as sinking or open channels were practiced. However, prompted by the technological advancement of the Israeli agriculture, Gaza farmers moved to the more efficient sprinkler technology that had evolved in efficiency over time, and later the drip irrigation technique got introduced. Today, in some areas farmers utilize the highly efficient subsurface drip irrigation technique (AL Whaid of the MoA, Al Yaqoubi of PWA, Sha’ath adn Abu Mo’amamer and Mattar of Khan Yunis Municipality, Dabour of PARC, and Qahaman of EQA, and the elder farmers Abu Amra, Al Farra and Wafi, pers.
During this same period, the Israeli Government supported a change toward cultivating cash crops such as strawberries and roses, which require higher quantities of high quality water (Al Whaidi of the MoA, pers. comm. 2014/2015).

This situation continued until 1994 when the Palestinian National Authority was established as a result of the peace negotiation between the Palestinian Liberation Organization (PLO), the Israeli Government and the signing of the Oslo Accords. With the establishment of the PNA, the majority of water used in the Gaza Strip (apart from the Israeli settlements) fell under the governance of the PNA. The first few years of this epoch witnessed massive developments in infrastructure, construction, industry, and tourism. Furthermore, there was a mass influx of Palestinians due to establishing the PNA in the Gaza Strip. The result was a significant increase in the demand for water and led to the dramatic increase in the construction of wells in the Gaza Strip. The total number of wells in the Gaza Strip during this period exceeded 4000 (Qahaman of the EQA, pers. Comm. 2014/2015). The water extraction rate increased rapidly to 135 MCM/year between 1990 and 1998 and to 150 MCM/year between 1998 and 2003 (Qahaman and Larabi 2006). Later on, the stalemate of the peace process and the eruption of the Second Intifada highly weakened the capacity of the PNA to enforce law in the Gaza Strip resulting in the construction of thousands of illegal wells and a general lack of water management. The number of wells during this period was around 10,000-15,000 (Shublaq of the CMWU; Qahaman of the EQA, pers. Comm. 2014/2015). The abstraction rate increased further to more than 180 MCM per year (Abu Shbak of MoA, Matar and Shaath of the Municipality of Khan Yunis, Qahaman of the PWA, pers. Comm. 2014/2015).
During the period from 1993 to 2005, the agricultural land decreased by almost 10,000 dunams from 174,210 crop dunams (around 130,000 actual dunams) in the 1993/1994 season to 161,502 crop dunams (around 120 actual dunams) during the 2003/2004. The shrinking size of the cultivated land was caused by the rapid population growth accompanied by significant increases in the built environment (PCBS 1997; 2005). Yet in 2005, the Israeli Army relocated its forces to the perimeter of the Gaza Strip and emptied all settlements. This allowed for cultivating thousands of additional dunams. The cultivated areas in the Gaza Strip reached 181,281 crop dunams (around 135,000 actual dunams) in the agricultural season 2006/2007 (PCBS 2009). After the 2012 war, the Israeli army released more land to the Palestinians from what used to be the Access restricted area further increased the cultivated land to around 201,154 dunams (around 150,000 actual dunams) in the agricultural season of 2012/2013 (Sha'ath of the Municipality of Khan Yunis, Majdy of PARC, pers. comm. 2014/2015; MoA 2014).

Starting in 1997, many Israeli intrusions took place into the border areas of the Gaza Strip during which the Israeli army conducted extensive and frequent uprooting of citrus trees (Abu Shamala and Al Whaidi of the MoA, pers. Comm. 2014/2015; PCBS 1997; 2005). During the 2008/2009 war on the Gaza Strip, more trees were uprooted which caused the citrus cultivated lands to reduce further to around 13,000 dunams (MoA 2012). Recently, the MoA in the Gaza Strip has supported the revitalization of citrus agricultural production, which has led to an increase in the size of citrus cultivated land to approximately 16,500 dunams in the 2012/2013 agricultural season (Abu Shamala of the MoA, pers. Comm. 2014/2015; MoA 2014). Further, compensating for the diminished citrus cultivated lands, farmers have increased the size of agricultural land cultivated with other crops. Olive trees increased from about 13,000 dunams in the 1993/1994 season to 26,600 dunams in the 2007/2008 season, and size of land cultivated with field crops

Rapid population growth and developments in the built environment and economy, and lack of adequate control and water management practices lead to an exponential deterioration of the water quantity and quality (Qahaman of the EQA pers. comm. 2014/2015). In the period between 1969 and 2000, the groundwater level decreased by 3 meters in average throughout the Gaza Strip (Fig. 6). However, most of the drop took place in the Southern areas of the Gaza Strip as can be seen in the following map (Fig. 6). More importantly, this period witnessed the drop of the groundwater level below the seawater level for the first time. This has been the starting point of sea water intrusion in fresh water sources that today poses many challenges to Gaza’s population. Nowadays, the Chloride pollution is more apparent throughout the entire Gaza Strip as most of the water shows a chloride concentration surpassing the acceptable WHO levels (Qahaman and Larabi 2006).
While there is no historical record for the Nitrate pollution of Gaza’s groundwater sources comparable to the chloride pollution data, the Nitrate pollution has also increased rapidly in the period that followed 1993. For example, El-Naeem et al. (2009) investigated the changes in the Nitrate concentration levels during the period between 1994 and 2004 in the Northern area of the Gaza Strip (Between Wadi Gaza and the Northern borders of the Gaza Strip with Israel). The authors found that in 1994 the Nitrate concentration in wells of the researched areas ranged between 20 and 290 mg/l, noting that 72% of the wells had Nitrate concentration levels above the WHO standards (50 mg/l) for drinking water. In 1999/2000, the Nitrate concentration levels ranged between 14 and 318 mg/l and 78.5% of the wells in the area under investigation exceeded the WHO standard on nitrate concentration for safe drinking water as well. In 2004, only 14.5% of the wells were found to show Nitrate concentration levels below WHO standard. The Nitrate concentration during this period ranged from 15 to 432 mg/l.
3.1.2. Agricultural Impacts and Farmers' Adaptation

The fast decline of the groundwater level and deterioration of the groundwater quality affected farmers in many ways as shown by interviews conducted with experts and farmers. Many farmers had to abandon their farms and sell them for construction purposes partially because of the heightened costs for irrigation and the decreased accessibility to good quality water. Farmers adapted to the changes in water quality and salinity levels by changing to less water intensive and more saline tolerant crops. However, these crops were less profitable, for example, farmers started to shift production on a massive scale and grow olive trees, vegetables and field crops instead of the highly profitable citrus fruits.

In order to cope with the rapid population growth people of the Gaza Strip have transformed their water management towards a large-scale use of groundwater as a source of water instead of depending on rain fed irrigation. Arguably, this adaptation strategy was successful and effective as it supported the people of Gaza during the rapid population growth from around 70,000-80,000 before the 1948 War to approximately 1.8 million people in 2014 (PCBS 2014). This strategy has also proven being negative in the long run considering the currently catastrophic water situation in the Gaza Strip. This strategy was facilitated by technological improvements that decreased the cost of water wells and increased the effectiveness and efficiency of water pumps.

Under pressure of the rapid population growth and urban sprawling the land area began to decrease significantly. At the same time the productivity of lands and dependence on intensive agriculture increased to compensate for the decreased agricultural land area. This is noticeable due to the relatively large number of greenhouses active in the Gaza Strip. Also, to increase the economic feasibility of the cultivated lands many farmers changed their crops
to more lucrative cash crops. For example, following the 1948 war farmers began to grow citrus fruits due to the price that could be gained in the market, following the subsequent drop in citrus fruit prices, farmers have moved onto other more profitable but less sustainable crops. Ultimately this coping strategy has proven to be unsustainable as the crops are high quality water demanding. In the last decades, many farmers in the Gaza Strip again changed to less water demanding crops such as olive and palm trees and chili peppers.

Another important adaptation strategy that was utilized by Gaza's farmers was using more efficient irrigation networks. In the years that followed 1967, the Palestinian farmers in Gaza moved toward using more effective irrigation technologies such as sprinkler and drip irrigation as a mechanism to decrease their water consumption-inspired by the long Israeli expertise in the Agricultural sector. This strategy is effective in decreasing the water consumption for farming practices while at the same time saving unnecessary costs. Some farmers now use subsurface drip irrigation in the newly rehabilitated lands of the Access restricted area (Al Ya'oby and Sha'ban and Al Dasht of the PWA; Sha'ath, and Abu Moamar of the Municipality of Khan Yunis, pers. Comm. 2014/2015).

Adapting to the increase in water salinity, farmers in the Gaza Strip started changing crops towards more saline tolerant ones with variations within the Gaza Strip based on the levels of salinity in each area. Semi-structured interviews conducted with experts from PARC showed that within the vegetable and crops category many farmers moved from growing highly profitable, but high quality water demanding crops (e.g. cucumber, strawberry, roses, zucchini, peens, melons and water melons, and etc.), to moderately saline tolerant ones (e.g. peppers, eggplant, potatoes, corn flower, cabbage, end
etc.) and highly saline tolerant crops such as tomatoes. In the fruits category, many farmers refrained from planting fruits such as apples and peaches because of their high sensitivity to water quality levels. These changes have affected the economic wellbeing of many farmers especially in the areas where water is highly saline (Majdy of PARC, Qahaman of the EQA, and Al Yaqoubi of the PWA. Pers. Comm. 2014/2015).

Rainwater harvesting is a relatively new adaptation strategy which was first introduced to Gaza by local NGOs at the end of the 1990s and the start of the 2000s and is still being implemented and developed. At the beginning, the ponds were mostly made from plastic lining compounded with a small well in the farm. Consequently, this was then modified and adapted to a concrete and metallic sheeting structure of different sizes and forms. Rainwater harvesting especially from greenhouses helps farmers by providing them with higher quality water that allows for the production of more profitable plants. At the end of the 1990s, farmers were suspicious regarding this new technology as there was an apparent lack of awareness of the water crisis—today rainwater harvesting is widespread in the Gaza Strip, especially in Southern areas (Sha'ban of the PWA, Abu Shbak of the MoA, Qahaman of the EQA, Majdy of PARC, pers. Comm. 2014/2015).

In 2004, the PWA, the EQA, and some water focused NGOs started experimenting with the use of treated wastewater for irrigation purposes (Sha'ban from the PWA, Al Whaidi of MoA, and Qahaman from the EQA, pers. comm. 2014/2015). According to Qahaman from the EQA, the first experiment was in Ishtewi area (in Al Zaitoun neighborhood in the Gaza Strip) in which treated wastewater was used for irrigating citrus and olive trees. Another experiment was in Beit Lahya area, where treated wastewater is used for irrigating grass to grow fodder for livestock. These novel practices are only developing at a slow pace and receive religious and social opposition due to
farmers' beliefs and the public's doubts regarding the validity of the use of treated wastewater. Another concern is the quality of treated wastewaters in terms of salinity levels (Al Whaidi of MoA, pers. comm. 2014).

3.1.3. Adaptation to the Water Crisis at the Household Level

The population in the Gaza Strip has had to learn to adapt to water challenges as the situation with water has become more critical. The water consumption of the people in the Gaza Strip is below 100 l/capita per day: less than the WHO daily recommendation. This is a clear indicator of the low living standards prevalent in the Gaza Strip. The municipalities' water availability depends on their access to water and will be available to communities in one of the 3 listed scenarios: 1) 4-7 hours a day; 2) 4-7 hours every two days; and 3) 4-7 hours per three days (Shaker of the CMWU pers. comm. 2014/2015). This unreliable access to water has changed consumption patterns amongst the population limiting water used for hygiene and increased the percentage used for agriculture and drinking purposes (Shaker of the CMWU pers. comm. 2014/2015). Further, access to technological advances has further increased the stress on water supply. For example, until the 1970s when the Gaza Strip was connected to the electrical grid, the Palestinians' life style in the Gaza Strip was much less demanding in terms of water as families did not use washers, and electrical water heaters (albeit they had solar heater) that increased significantly their water consumption (Gordon 2008; Al Whaidi of MoA, the elderly farmers Abu Amra and Abu el Ajeen, pers. comm. 2014/2015).

Shaker from CMWU (pers. Comm. 2014/2015), argued that the Palestinians in the Gaza Strip never enjoyed a situation of abundance that allowed them to be wasteful in terms of water. He explained that soon after the Palestinians in the Gaza Strip became almost fully connected to the water network, and equipped with electrical equipment, they were faced by the water shortage
problem that forced them to push their water consumption pattern toward conservation and stewardship. Water conservation strategies utilized by the population in the Gaza Strip included decreasing the number of showers, using water pockets while washing cars (when available) instead of tap water, decreasing the waste of water while cooking, dish washing, etc. These are effective and positive strategies as long as they do not impact on the hygiene levels of the population, particularly of children and the elderly (Sha'ban of the PWA, Abu Moamer, Matar and Sha'ath of the Municipality of Khan Yunis, pers. Comm. 2014/2015).

Another adaptation strategy is an increase in the water storage capacity at the household level in order to deal with repeated water shortages of tap water. Generally, it is common to see multiple water tanks on the roof of houses in the Gaza Strip (Shaker of the CMWU, pers. Comm. 2014/2015). However, the people in the Gaza Strip have also devised negative adaptation strategy to face the water shortage issue including the illegal drilling of water wells especially in the period that followed the eruption of the second Intifada. This has greatly weakened the PNA and prohibited it from enforcing the law. The drilling of thousands of illegal wells has further contributed to the exploitation of the groundwater aquifer (Sha'ban of the PWA; Shaker of the CMWU; pers. comm. 2014/2015). In some areas which suffer severe groundwater scarcity (particularly in Southern Gaza), it is very common for people to purchase untreated water from local sellers for domestic purposes (25 NIS/ cubic meter) during the long and frequent water cuts they suffer (Sha'ban of the PWA, Abu Moamer, Matar and Sha'ath of the Municipality of Khan Yunis; Shaker of the CMWU pers. comm. 2014/2015).

The fast deterioration of the water quality in the Gaza Strip, especially the noticeable saline intrusion, drove the Palestinian people in the Gaza Strip to
adopt a number of adaptation measures. The vast majority of Gaza's households are purchasing their drinking water from a little more than 300 water treatment plants in the Gaza Strip among which only a hundred are properly registered and monitored (Shublaq and Shaker of the CMWU, pers. comm. 2014/2015). The water from those plants is relatively costly (ca. 35 NIS per cubic meter). The plants use Reverse Osmosis Technology, which has been suggested by some experts as being wasteful: Reverse Osmosis Systems purify 50% of the inflow and transforms the other 50% to brackish water outflow. Alternatives are required especially in the areas that are suffering severe water shortage. Additionally, families usually purchase this water from truckers and then store it in metallic or plastic containers. The quality of water from many of those plants is questionable especially considering the weak governmental monitoring and licensing schemes (Sha’ban of the PWA; Abu Shbak of the MoA). Ayesh (2013) found that the water in 20% of the water tanks, in more than 26% of tankers, and 74% of drinking water distribution points of these plants is biologically contaminated. Other measures adopted by the better off strata of the community are purchasing bottled water for drinking or installing household level Reverse Osmosis Units. In one case known to the principal investigator of this research, one household installed a seawater treatment plant for drinking and domestic uses. The unit of this building is not treating seawater, but rather highly saline water from its illegal well.
3.2 Focus Group Discussions' Findings

The farmers participated in the focus group discussion sessions demonstrated an impressive understanding of the water crisis of the Gaza Strip. They have been coping with this crisis for decades and adapted positive as well as negative adaptation strategies. Generally, they are worried regarding the agricultural sector in the Gaza Strip and the future of their livelihoods. Hence, they are becoming more open towards new ideas such as the use of treated wastewater and the adoption of more efficient water irrigation strategies. In the following sections farmers' perspectives of the water crisis, their adaptation strategies and what they think about the future will be discussed.

3.2.1. Causes of the Current Water Crisis in the Gaza Strip

The farmers participated in the focus group sessions identified two causes of the water crisis in the Gaza Strip: 1) water shortage; and 2) severe water pollution. The farmers in the five focus groups articulated five causes of the current water crisis in the Gaza Strip: 1) The Israeli occupation; 2) population growth; 3) wasteful behaviour of farmers and the general public; 4) lack of governmental control and policies; and 5) climate change.

1- Israeli occupation:

Many farmers blamed the Israeli occupation for causing the water shortage in the Gaza Strip, mentioning three different approaches: 1) diverting the Wadis or streams water which used to run into the Gaza strip during the winters; 2) digging groundwater trapping wells around the groundwater aquifer of the Gaza strip, and 3) wasteful water use in the Israeli settlements before they were closed down in 2005. In terms of water quality, some farmers claimed that the Israeli occupation would purposefully establish wastewater treatment
plants and lagoons in the areas that supply the best groundwater quality in order to pollute the water. Some farmers added that before the establishment of the PNA, most people relied on cesspits as they were not connected to wastewater networks which contributed to the nitrate pollution problem in the Gaza Strip. Farmers also mentioned the wars on Gaza as major cause of their water problem. During the wars the Israeli army destroyed many agricultural wells causing a lack of access to farmers' water sources.

2- Population growth and urban Sprawling

Farmers participated in all focus group sessions agreed that the rapid population growth in the Gaza Strip sets huge pressure on the water situation increasing the water demand beyond the capacity of the aquifer. For example, one of the farmers from Rafah partaking in the FGDs stated that “The population growth and urban sprawling is taking place on the expense of agriculture in the Gaza Strip. Such growth made abstraction from the groundwater aquifer to exceed recharge.”

3- Wasteful water use by farmers and the general public in the Gaza Strip

The farmers stated that excessive use of fertilizers and pesticides contributes significantly to the water pollution problem in the Gaza Strip. Furthermore, they listed many ways in which some farmers waste water including the following:
- Illegal digging of agricultural wells. One farmer from Khan Yunis Governorate stated that “Now, a farmer who owns less than one dunam would dig a well and start wasting water as much as he can”
- Framing sandy soil that allows water to rapidly infiltrate the aquifer and thus
require much more water than clayey soil. A farmer from Khan Yunis Governorate stated that “In the past farmers used to be more conservative with water; they only provided enough water to the plant to flourish. Today, farmers cultivate the sand dunes in which a tomato seedling that needs only 2 litres would consume 20 litres, or a tree that only needs 20 litres will consume 30.”

- Using old and dysfunctional irrigation networks that leak. One farmer from Gaza Governorate stated that “some farmers' irrigation networks are dysfunctional; hence they irrigate their plants using the old technique of sinking which is very wasteful.”

- Farming of water-demanding plants for export, such as strawberry.

- When it comes to the general public, the farmers were very skeptical regarding people's awareness of the water problem and the way they use water. They mentioned the following as wasteful domestic behaviours:

- Using and digging illegal private wells.

- Adopting wasteful lifestyle such as using bathtubs for showering or cleaning cars too often using tap water. One farmer from Deri el Balah Governorate stated: "Some people have weak faith [in God]; they would consume 10 litres of water when they ablute."

- Using reverse osmosis water treatment units at the household level causes the loss of significant amounts of water. A farmer from Northern Gaza Governorate mentioned that "many people installed filters in their houses. The filter purifies one glass of water and makes two unusable. This is very wasteful and very costly."

4- Governmental Policies and Law Enforcement

The farmers explained that the lack of sufficient law enforcement of the Palestinian National Authority after the eruption of the second Intifada led to the waste of huge amounts of water. The fact that thousands of illegal domestic and agricultural wells were dug during this time is a clear example of
this. One farmer stated: "In the past [before 1993] we used to provide ownership documents for at least 24-50 dunams to be able to get a permit to dig one well; now anybody can dig a well even if he owns only one or two dunams." Additionally, some farmers explained that before the second intifada every well had a meter to measure water extraction. However, this is not the case anymore and farmers and families are unaware of the amount of the water they withdraw from the aquifer and thus tend to be water wasteful. Furthermore, many farmers criticised a lack of effective and sufficient water awareness campaigns to help the less educated farmers understand the water problem and use effective strategies to conserve water.

One prominent complaint regarding governmental policies was directed at farming practices in the former Israeli settlements (now called Al Muhararat). The farmers stated that many NGOs have leased and farmed the governmental lands in Al Muhararat. They explained that most of these Muhararat consist of sandy soils which do not store water and thus require huge amounts of water for cultivation. Furthermore, they added: the NGOs are not paying for this water from their own money which makes them less attentive regarding their water usage. They argued that these farms should either be shut down or privatized. One farmer from Khan Yunis stated "privatization means success; NGOs do not pay from their own pocket for water; which makes them able to consume a lot of water planting things that do not help anybody."

Farmers called for an enforced and efficient governmental strategy to deal with the current water crisis. This reflects either a lack of awareness regarding the PWA strategy previously discussed or a lack of trust in the capacity of the government to enforce such a strategy. As shown above, the farmers' awareness of the water crisis suggests the possibility of a productive dialogue
between farmers and officials in the governments. Many farmers partaking in
the focus group discussions asked for specific governmental interventions
such as the following:
- Enforcing the law in regards to illegal wells and putting better monitoring
schemes in place
- Establishing communal rainwater harvesting ponds in areas where many
farmers are practicing agriculture. One farmer from Dier el Balah
Governorate mentioned "in Al Maghazi there are 1000 agricultural dunams
that share the same valley. If the government provided them with a rainwater
harvesting pond, they will benefit from the better quality water and spare huge
amounts of groundwater."
- Establishing more rainwater collection ponds to recharge the aquifer and
decrease the amounts of rainwater wasted to the sea.
- Enhance the extension services provided to farmers and use such services to
promote better water management practices.
- Stop or privatize farming in the former Israeli settlements to decrease the
waste of water in these areas
Providing farmers cultivating sandy lands with clay in order to enhance the
soil's capacity to hold water and thus decrease excessive water consumption.

5- Climate and climate change

In multiple sessions, many farmers mentioned the climate conditions and
climate change related causes of the current crisis in the Gaza Strip. Many
farmers emphasized that the volume of rainfall has decreased in Gaza further
impacting the groundwater aquifer recharge. A farmer from Northern Gaza
Governorates (2014) stated that "rain rates fluctuate from year to year, but
rain now is less than before." Another farmer from Khan Yunis Governorate
(2014) stated: "it used to rain for 20 days before, now the number of rainy
days are much less." A farmer from Dier el Balah Governorate (2014) stated that "Global warming lead to increased temperatures, which in turn increase evaporation and cause the losses of significant amounts of water."

3.2.2. Impact of the Water Crisis on Farmers

The aggravating water crisis takes a devastating toll on farmers. Some farmers think that the agricultural sector in the strip is on the verge of complete collapse. One farmer from Northern Gaza stated: "how can we cultivate our lands anymore; the warning bell is ringing; please put many lines under this statement." Farmers in all focus groups highlighted a decrease in profitability of farming. One farmer from the Gaza City governorate stated: "We spend days and days cultivating the lands to get less than sufficient income to feed our families and educate our children." Another farmer from Gaza Governorate said: "I and five of my sons work in the land to make very little profit at the end; I keep spending my savings on the land in vain." One farmer from Khan Yunis Governorate stated: "I used to have two greenhouses: one cultivated with tomatoes; and the other with melon. The melon production was very little, that I gained only 300 NIS out of it because of the high water salinity." Even though the common theme of farmers' water crises induced suffering is decreased profitability but it takes many forms such as the following:

- Continuously decreasing water levels requires further deepening of the agricultural wells which means additional costs and efforts.
- Continuously decreasing pumping capacity of wells elongates the period of time needed for sufficient irrigation, which in turn means longer working hours and an increase in costs especially noting the high fuel price in the Gaza Strip. Costs for pumping water increased even further in the past year when the tunnels to Egypt, which used to bring cheap fuel into Gaza, were closed down. One farmer from Gaza governorate stated that "the cost of
withdrawing water from the underground is increasing all the time; our crops need good quality water. We started being worried regarding our capacity to keep farming our land because of this cost."

- The water in some areas, in particular in the South-Eastern governorates of Rafah and Khan Yunis, is completely unsuitable for irrigation purposes, which forces farmers to purchase tanker water at high costs that amount to 25 NIS per cubic meter of water as mentioned by farmers from Rafah Governorates.

- For those farmers who purchase their water from private wells owned by others, the continuously weakening pumping capacity increases the time waiting for their turn to irrigate. They mostly receive insufficient amounts of water; insufficient and untimely irrigation causes diseases to widespread and damage crops.

- For those communities in the South-Eastern side of the Gaza Strip, who depend on water piped to them from wells in the western side of the Gaza Strip, the decreasing water levels in those wells has decreased their pumping capacity (by 60% as mentioned by some farmers from Rafah Governorates) which in turn has increased the cost of water and complicated their irrigation schemes. The high fuel price has doubled the cost of one hour of pumping from 50 NIS to 100 NIS as has been mentioned by a farmer from Rafah Governorate.

- The deteriorating water quality has decreased the productivity of many farms.

- The deteriorating water quality has forced many farmers to shift to less profitable but more saline tolerant crops. This has rendered farmers more vulnerable to price fluctuations on the markets. One farmer from Rafah Governorate stated: "now I can only plant one crop in my greenhouses. If the price of this crop plummeted in the market, my losses will be huge. In the past, I was able to cultivate multiple crops which made me able to adapt to the fluctuating market prices; if the price of one crop went down, the good price of the other crops will compensate and help me survive."
- The deteriorating water quality has forced some farmers to dig more and more wells searching for good quality water, however without success. One farmer from Gaza Governorate stated: "I have four wells now; whenever I dig a new well it provides good quality water for one or two years, and then the quality of water deteriorates so I start digging a new one."

### 3.2.3. Farmers' Adaptation Strategies

As has been shown above, farmers have been exposed to the water crisis for decades adopting various adaptation strategies. Adopted strategies by farmers show different levels of effectiveness and a high variation in terms of additional costs. Farmers have dug wells to adapt to the water shortage problems, when salinity levels of the water of these wells rose, they dug even more wells in other areas searching for water of higher quality. In other areas, where farmers lost hope in finding good quality water, they started to purchase piped higher quality water from other areas costing them 50-100 NIS/hour. If they could not purchase piped water they purchased trucked water at an even higher cost (25 NIS/cubic meter). Other farmers have shifted their production to less profitable crops which are less water demanding or more saline tolerant.

Dependence on groundwater for irrigation purposes has shown to be a negative strategy in the long term as it leads to a rapid waste of fossil water that has accumulated for thousands of years. Digging thousands of wells without any type of governmental control and monitoring has even more negative effects. The situation has aggravated in recent years and has left farmers with only few choices. This desperate situation is shown in one of the statements by the farmers (2014) which reads: "the warning bell is ringing." The government and the civil society are called upon by the farmers themselves to prepare and implement plans that help Gaza's farmers
Water in the Gaza Strip
decrease their dependence on groundwater gradually, but rather fast. Changing crops into more saline tolerant or/and less water demanding ones is positive and effective; however, in many cases this adaptation strategy comes at the expense of the economic wellbeing of the families. One farmer from Gaza Governorate (2014) stated that "Instead of growing aubergine, and tomatoes, we planted chilli pepper that needs less water, now everybody grows chilli pepper and so chilli pepper became overly available in the market which made its price to plummet greatly and cause huge losses for us." Governmental intervention may be needed to organize and coordinate the crop production in the Gaza Strip to make similar adaptation strategies less risky on farmers. Further adaptation strategies of farmers to the aggravating water crisis are as follows:
- Changing from irrigated farming to rain fed farming. While this strategy is surely positive in the sense that it provides safe good water, the economic profitability of this is questionable. Even more questionable is the capacity of this strategy to sustain sufficient food security for the already insecure people living in the Gaza Strip due to unreliable irrigation intervals of plants.
- Undertaking maintenance of the irrigation networks to decrease leakages. This strategy is positive and effective and should be undertaken regularly
- Purchasing generators in order to adapt to regular power shortages and to irrigate their lands at specific times of the day. However, this has added extra costs their businesses.
- Establishing rainwater harvesting ponds to collect and store water for irrigation. Sometimes framers mix the high quality rainwater with water of less quality to prolong the period during which farmers have a reliable supply of good quality water for irrigation. This provides an opportunity to farmers to cultivate more profitable crops that require higher quality water and is thus
positive in terms of its impact on water quality and availability and on farmers' livelihoods.

- Using tensiometers to decrease water consumption for irrigation. This strategy was not so common among farmers. Few farmers spoke about using this strategy. However, according to those farmers, this strategy is quite effective in saving water and decreasing the costs on farmers. One farmer from Northern Gaza governorates stated: "I am using a tensiometer, it does not only save water, but also saves fertilizers, which saves a lot of money."

- Decreasing the cultivated lands to reduce economic losses, one farmer said: "now I cultivate two dunams instead of 10. This decreases the risk of losing, but also decreases my profit. This affected my livelihood and standard of living. I had to decrease the allowances of my children, my expenses on my family's recreational activities, and my expenditures in general."

One adaptation that was rated as effective by farmers in almost all the sessions is rainwater harvesting. Rainwater harvesting from greenhouses, farms, and houses was mentioned in all sessions as an effective adaptation strategy. However some farmers stated that plastic rainwater harvesting ponds are usually ineffective as they get damaged rather rapidly. Many farmers think that more rainwater harvesting ponds should be established at the individual and communal levels.

Many farmers mentioned water conservation as an effective adaptation strategy. In this context, some spoke about the use of tensiometers, fixing the irrigation networks, or decreasing irrigation intervals. Some farmers suggested the need for governmental control on the extraction of water from private wells as a mechanism to decrease wasteful water usage.

Farmers were less sure regarding the effectiveness of using of treated wastewater for irrigation. None of the farmers in the sessions spoke about
their experience in this regard, but some farmers in some sessions believed that this can be an effective strategy. However, other farmers were skeptical regarding the quality of the treated wastewater. This suggests a need for trusted monitoring systems for wastewater usage for irrigation.

3.3 General Public Survey Results

The survey data revealed that 56% of the participants are male (N=469). About 76% of participants are married and about 22% are single (N=469). The family size of 49% of the participants is between 5-10, while 43% of the participants have families of less than 5 members, and only 8% have families of more than 10 members. The average age of the participants is 36.6 years, ranging from 18 to 72. The study shows that only 16% of the participants have an education level less than secondary school, 40% of them have a secondary degree, 8% hold diplomas, while 35% hold at least the first university degree (N=469). Regarding the monthly net income of the families of the participants, the study shows that 53% of them have a net monthly income of 1500 NIS or less, while 28% have an income that ranges from 1500 NIS to 3000 NIS, 12% of the families make an income of 3000-4500 NIS, 4% make more than 4500 NIS, and only about 3% of the families make no income at all (N=469). About 36% of the participants are from Gaza Governorate, followed by 21% that are from Northern Gaza Governorate, 16% from Rafah Governorate, 15% from Middle Gaza Governorate and the other 12% are from Khan Yunis Governorate (N=469).

According to the Central Bureau of Statistics the Palestinian people above 18 years old in 2007 were split almost equally gender-wise as 50.2% of the populations were males. The share of married persons of this population was at 68.3% and non-married ones at 26.5% (Radwan pers. comm. 26/2/2015).
This means that our sample is rather biased toward males and married people but within the 5% margin of error. This may be due to the fact that the sample was derived from the civil administration record which includes all people registered instead of all people actually living in the Gaza Strip. Another reason may be the fact that there was some self-selection bias toward males and married participants. Accordingly the data and findings from this survey should be inferred to the Gaza’s population with caution. As mentioned earlier, most of those who denied participation were females from Khan Yunis.

3.3.1. Descriptive Analysis

The survey data revealed that the vast majority (83.0%, N=469) of participants' households are mainly dependent on the municipality network as a source of water, followed by private wells (10%). 6% of the participants' households purchase their water from private wells, tankers, etc. (N=469, Fig. 3-4.). Only 4% of the participants stated that they never suffer of water cuts; whereas, 58% stated that they are affected at least 1-4 days per month by water cuts. 16% believe that they have water cuts for 5-9 days a month, and as much as 21% stated that they suffer more than 10 days a month of water cuts (N=469). The results confirmed the excessive omnipresence of illegal wells among Gaza households as explained earlier. Also, the extent of the water shortage problem is reflected in the number of days of water cuts. According to Shaker from the CMWU (pers. Comm. 2014/2015), water cuts range from less than a day per week to two out of three days. The average size of water storage tanks at the participants' households is 1928 liters (almost 2 CM) ranging from 300 to 8000 liters. This shows how the people of the Gaza Strip are adapting to water cuts through increasing their water storage capacities. For a family of five, a water tank of about 2000 liters will be sufficient for 4-5 days of water cuts, while it is sufficient for only two to three days of continuous water cut for a family of 10.
As much as 26% of the participants think that the quality of the water available in their houses is very low, while 19% think that their water quality is moderate. Furthermore, only 22% think that their water is of good quality, and as few as 2% believe that their water quality is very good (N=469, Fig. 7). These results show the magnitude of the water problem as the vast majority suffers serious water accessibility and quality problems. Even though, there is a high level of negative perception of the water quality in the Gaza Strip, the actual situation is not reflected as 95% of the water in the Gaza Strip does not fit the WHO standards for drinking water (PWA 2013). However, it seem that people’s perception of the water quality is only in reference to the water salinity problem and other issues, such as Nitrate pollution, have not been taken into consideration so far.

![Figure 7. Water at participants homes](image)

As can be seen in the following figure, the people of the Gaza Strip are aware of the water quantity and quality problem they are facing (Fig.8). The vast majority (92%) of the participants either strongly agrees or agrees that Gaza suffers a water shortage problem, while only 4% disagree or strongly disagree and 4% are not sure. When it comes to the water quality problem, 89% of the participants either agree or strongly agree that the Gaza strip suffers a water quality problem, while 5% either strongly disagree or disagree, and 6% are unsure.

However, the people in the Gaza Strip are less sure regarding the direction the
water crisis problem is taking. Only 52% of the people either strongly disagree or disagree with the following statement: "The water quantities in the Gaza Strip now are more than 10 years ago", while 20.5% either agree or strongly agree with this statement and 28% stated that they do not know. In reference to the water quality problem, only 57% either strongly disagree or disagree with a statement that reads: "Water quality is better now in the Gaza Strip than 10 years ago", while 21.5% either agree or strongly agree, and 22% stated that they do not know. This shows an apparent need for more work to be done in informing the people of the Gaza Strip in regards to the water crisis and its developments. The findings below further support this.

![Figure 8. Beliefs regarding the water crisis in the Gaza Strip](image)

When it comes to the causes of the water shortage problem, people seem to be rather aware of the problem generally. Respondents seem to be quite sure regarding some root causes such as the occupation, wasteful behavior, seawater intrusion, but rather unclear regarding others such as climate change, cesspits, dumpsite, and population growth. The people's perception of the causes of water shortages are listed below:
- 82% of the participants blame the Israeli occupation for the water shortage problem;
- 73% view the wasteful water use of the people in the Gaza Strip as a root cause;
- 55% blame population growth;
- Only 31% see a relation to climate change.

In terms of the water quality problem, the large majority views the decreasing groundwater level and its imposed seawater intrusion as the primary root cause. However, they also believe that some minor issues such as pollution from the sewage treatment plants and dumpsites are major causes of the water quality deterioration problem in the Gaza Strip opposite to the facts on the ground. The respondents perceived causes of the current water quality deterioration problem are listed below.
- 76% of respondents blame the decreasing groundwater level for the water quality deterioration;
- 74% of respondents identify seawater intrusion;
- 73% blame the sewage treatment plants;
- 72% blame the use of cesspits;
- 69% blame the dumpsites;
- 67% blame climate change.

While an impressive proportion of participants view climate change as a prime cause of the water quality problem and to a lesser extent of the water shortage issue, most citizens of the Gaza Strip seem rather confused or unaware of the climate change phenomenon generally. Only 52% of the people in the Gaza Strip believe that climate change is real, while 14% believe it is not, and 34% state that they do not know. In numbers: 51% believe that humans play a significant role in causing climate change, while 16% do not see a correlation, and 33% stated that they do not know. 44% of participants do not believe that climate change is an entirely natural phenomenon, while 27% view climate change as an entirely natural phenomenon, and 30% stated that they do not know. These statistics show that almost half of the people are
unaware of the climate change phenomenon, and some of those who are aware are rather confused. This suggests the need for more intense interventions to improve the public awareness of climate change and its local impacts in the Gaza Strip.

Respondents are rather split regarding the capacity of the governmental institutions and municipalities to deal with the water crisis in the Gaza Strip. Only 35% of the participants either strongly agree, or agree that the governmental institutions are able to deal with the water crisis, whereas, 38% either disagree or agree, and 26% are not sure. When it comes to municipalities, only 36% either strongly agree or agree that municipalities are able to deal with the water crisis; while 34% either disagree or agree, and 25% are unsure (Fig. 9). Only 29% either strongly agree or agree with the following statement: "The organizations responsible for water resource management provide us with appropriate information on the water crisis." Whereas, 49% either strongly disagree or disagree with the statement, and 22% state that they do not know. Similarly, only 30% of participants either strongly agree or agree that "the organizations responsible for the water resources in the Gaza Strip engage the society in discussing the water crisis." However, 48% either disagree or disagree with that the above statement, and 23% stated that they do not know.

Figure 9. Trust in organization's capacities
Respondents seem to be highly concerned viewing the impacts of the water crisis on their lives, families and the society at large. However respondents have shown more concern on farmers, their families, and communities than the industrial sector, and employment rate. About 62% of the participants believe that the water crisis will impact them personally to a larger or moderate extent (Fig. 10). However, 73% believe that the water crisis will impact their families to a large extent or moderately. When it comes to the impact on their local communities, 81% believe that the impact will be large or moderate. Speaking of farmers in their communities, 85% of the participants believe that the impact of the water crisis will be large or moderate. When it comes to farmers in Gaza, similar results were obtained as 84% believe the impact will be large to moderate. People are only a little less worried regarding the impact of the water crisis on the industrial sector; 62% believe the impact will be large to moderate. 55% believe that the water crisis will impact the employment rate in the Gaza Strip to a large or moderate extent. Speaking of the Gaza Strip at large, as much as 84% believe that the impact of the water crisis will be large to moderate.

Figure 10. Risk perception of the water crisis
At the same time, the inhabitants of Gaza Strip seem skeptical regarding their capacities to meet the challenges of the water crisis (Fig. 11). Only 27.5% of the participants strongly agree or agree that the Palestinian farmers in the Gaza strip are able to face the water crisis, while 43% either strongly disagree or disagree, and 30% stated that they do not know. When it comes to the Palestinian family in the Gaza Strip, only 35% either agree or strongly agree that they are able to cope with the water crisis, while 45% either strongly disagree or disagree, and 20% do not know. Speaking of the society in the Gaza Strip at large, 30% of the participants either strongly agree or agree that the society is able to cope with the water crisis, while 43% either disagree or strongly disagree, and 27.5% do not know. This clearly suggests a need to involve the general public in discussing the water crisis and its solutions to enhance their confidence in themselves and the governmental institutions. Only by involving people in discussions with municipalities and civil society, can the citizens of Gaza realize their individual capacities and gain in trust to governmental institutions.

![Figure 11. Trust is societal capacities to face the water crisis](Image)

People in the Gaza Strip believe that the water crisis should be a high priority at both the governmental and personal levels. 46% of the participants believe that the water crisis should be an ultimate priority for the government, while
46% think it should be a high one. At the personal level, 43% believe the water crisis is an ultimate priority for them, while 36% believe it is a high priority.

Even with this extensive concern and lack of trust in the organizational and societal capacities to face the water crisis challenge, people seem to think of the water crisis in a rather technically limited scope not recognizing the political and economic complexity of the water crisis. People also may be skeptical regarding the interest and especially the capacity of the higher level of governments being capable of handling such a crisis. People seem to think of the municipalities and themselves as the prime parties dealing with the water crisis. As much as 78.5% of the people think that municipalities are responsible for finding solutions for the water crisis, while 61% think that citizens themselves are responsible for finding solutions for the water crisis. Only 38% of respondents view the presidency as responsible, 27% think that the cabinet is responsible, and 23% think that the legislative council is responsible for finding solutions (Fig. 12). 29% of the participants think that the UNRWA should be responsible for finding solutions, for the water crisis, while 12% think that the NGOs should be responsible, and 11% think that the private sector should be responsible.

![Figure 12. Public perception of the organizational responsibility for facing the water crisis](image-url)
According to results obtained, the majority of the inhabitants of Gaza would not intentionally engage in activities that reduce their water consumption on an individual or household level. The most supported practice among the participants (N=469) is turning off the shower taps when there is no need for water while showering: 47.5% of the participants stated that they do so (Table 4). 43% said they would wash dishes using water from containers rather than using tap water. The third most supported practice is decreasing the number of personal showers with 40% support. 39% said they would decrease the number of times they wash their cars. 35% of the participants would utilize multiple grade toilet flushers. 34% stated that they would use a cup of hot water instead of tap water when shaving, while 33% stated that they would use water buckets when washing cars instead of tap water. 32% of the participants would put a one liter bucket in the flusher container of their toilets' so they use less water when flushing. 30% would use pitchers instead of tap water for ablution. The least preferred practice is using household gray water to irrigate the backyard plants with only 13% support.

The majority of people are also unwilling to adapt to the water shortage crisis. For example only 36.5% stated that they would buy more tanks to increase the storage capacity at their households to enhance their storage capacity. 35% of the participants stated that they would collect and use rainwater at the household level, while 26% would dig private wells at households. 21% would collect rainwater and inject it into the aquifer. Additionally only 29% said they would educate others regarding the water crisis and the necessity of adaptation (Table 4).
Table 4: Willingness to adapt the water shortage problem

<table>
<thead>
<tr>
<th>Adaptation and Coping Measure</th>
<th>% Willingness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreasing showering frequency to decrease water consumption</td>
<td>39%</td>
</tr>
<tr>
<td>Turning off tap during shower when there is no need for water</td>
<td>47.5%</td>
</tr>
<tr>
<td>Washing dishes from water in containers not from running water</td>
<td>43%</td>
</tr>
<tr>
<td>Using toilet flushers with multiple grades</td>
<td>35%</td>
</tr>
<tr>
<td>Putting a full one liter plastic bottle in the toilet flusher container to decrease the amount of wasted water</td>
<td>32%</td>
</tr>
<tr>
<td>Using cups of hot water when instead of using running water</td>
<td>34%</td>
</tr>
<tr>
<td>Reducing car wash frequency</td>
<td>39%</td>
</tr>
<tr>
<td>Using water buckets for car wash instead of tap water</td>
<td>33%</td>
</tr>
<tr>
<td>Using a pitcher instead of tap water on ablution</td>
<td>30%</td>
</tr>
<tr>
<td>Collecting and using rainwater</td>
<td>35%</td>
</tr>
<tr>
<td>Reusing gray water for planting of the home garden</td>
<td>13%</td>
</tr>
<tr>
<td>Collecting rainwater and injecting it in aquifer</td>
<td>21%</td>
</tr>
<tr>
<td>Educating others about water problem and the need to deal with it</td>
<td>29%</td>
</tr>
<tr>
<td>Buying additional water tanks for storing largest amounts of water</td>
<td>36.5%</td>
</tr>
<tr>
<td>Digging a private water well for your home</td>
<td>26%</td>
</tr>
</tbody>
</table>

Regarding to adapting to the deteriorated water quality, the most preferred option for the Palestinian population in Gaza is the purchase of treated water for drinking purposes with 59.5% (N=469) of participants willing to do so (Fig 13). This option was seconded by purchasing treated water for all household uses (42%). 40% stated that they are willing to purchase bottled water for drinking purposes. 37% of the participants are willing to install RO units at home for drinking purposes, while 25% are willing to install such units for all purposes. 27% are willing to boil tap water, while 27% would chlorinate their tap water. Rainwater harvesting for drinking purposes was the least preferred option of people to adopt as adaptation measure (24%).
Figure 13. Willingness to adapt to the deteriorated water quality at the household level

In reference to the public support for governmental policies to mitigate or adapt to the water crisis, the most preferred policy is increasing efforts to enhance the public awareness of the water crisis and the necessity of conservation water with 60% (N=469) participants support rate. Public support to establishing a seawater desalination plant came second with 56%. About 46.5% of the participants support intensifying advocacy efforts on Israel to ensure Palestinians’ right to water (Table 5). About 44% support improving the water network to decrease leakage. About 41% of the participants support increasing efforts to collect rainwater from homes, while 33% support increasing efforts to collect rainwater from farms and schools. About 40% of respondents are in support of shutting down illegal wells, while 35% support making the financial penalties on digging illegal wells stricter. Almost 36% support increasing the water tariff, while only 27% (least preferred) are in support of efforts to increase the water tariff collection. Only 28% of the participants support purchasing water from Israel.
### Table 5: Water Mitigation and Adaptation Policy Support

<table>
<thead>
<tr>
<th>Policy</th>
<th>% Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase public awareness efforts regarding water conservation</td>
<td>60%</td>
</tr>
<tr>
<td>Increase rain water harvesting from households</td>
<td>41%</td>
</tr>
<tr>
<td>Increase rain water harvesting from greenhouses and schools</td>
<td>33%</td>
</tr>
<tr>
<td>Increase water tariff collection efforts from citizens</td>
<td>27%</td>
</tr>
<tr>
<td>Increase water tariff on citizens</td>
<td>36%</td>
</tr>
<tr>
<td>Making the financial penalties on digging illegal wells stricter</td>
<td>35%</td>
</tr>
<tr>
<td>Shutting down illegal wells</td>
<td>40%</td>
</tr>
<tr>
<td>Improving the efficiency of the water network</td>
<td>44%</td>
</tr>
<tr>
<td>Increasing the use of treated wastewater in agriculture: observing the public health and religious standards</td>
<td>34%</td>
</tr>
<tr>
<td>Purchasing water from Israel</td>
<td>28%</td>
</tr>
<tr>
<td>Establishing a seawater desalination unit</td>
<td>56%</td>
</tr>
<tr>
<td><strong>Increasing advocacy efforts to make Israel give the Palestinians their water rights</strong></td>
<td><strong>46%</strong></td>
</tr>
</tbody>
</table>

### 3.3.2. Inferential Analysis

In order to comprehend potential associations between the willingness to adopt water crisis adaptation measures at the household level and supporting the adaptation policies, we performed a set of correlation tests between those two indicators and a set of demographic, knowledge, and belief variables investigated in this survey. These analyses show potential parameters that can be used to enhance the public acceptance or support to certain preferred behaviors or policies. The two sets of analyses suggest the need to focus on enhancing public awareness regarding the course of the water crisis, its causes, and climate change in order to enhance public willingness to engage in individual measures or support policies to adapting to the water crisis in the Gaza Strip. Also, it suggests the need for increasing the public risk perception in regard to the water crisis to prompt adaptive behavior individually or at the public level.
3.3.2.1 Willingness to adapt at the individual level

Age correlates strongly and negatively with the willingness to adopt individual adaptation measures to the water crisis \((P=-0.115)\), whereas the years of education correlate positively \((P=0.092)\) as can be seen in the following table (Table 6). Other demographic factors such as gender, family size, and family income have no association with individual’s willingness to adapt to the water crisis. This suggests the need to focus on younger people for being more receptive to new ideas in relation to the water crisis.

Speaking of the beliefs regarding the water crisis in the Gaza Strip, the tests show that beliefs regarding the existence of the water quantity and quality problem do not associate with the willingness to adapt, but beliefs regarding the change in the water situation over time do. For example, believing that water is now more abundant than 10 years ago correlates significantly and negatively \((P= -0.154)\) with the willingness to adopt adaptation measures to the water shortage problem at the individual level. Believing that the water quality now is better than 10 years ago also correlates negatively \((P = -0.111)\) with this variable. Beliefs regarding the reality and anthropogenic causes of climate change do not correlate with this willingness. This means that enhancing public awareness regarding the increasingly deteriorating water situation in the Gaza Strip may increase the public willingness to adapt to the water crisis.

Beliefs regarding the causes of the water quantity and quality problem in the Gaza Strip associate with the willingness to adapt to the water shortage problem in many ways. The beliefs that the Israeli occupation is causing the water shortage correlate negatively with the willingness to adapt individually to the water shortage \((P = -0.154)\), whereas believing that rapid population growth, climate change, and inefficient use of water cause the water crisis
correlates positively ($Ps = 0.186, 1. 89, and 1.166$ respectively). Believing that the use of cesspits, landfills, or climate change is causing the water quality problem in the Gaza Strip does not correlate significantly with the willingness to adapt to the water shortage at the individual level. However, believing that sewage treatment plants, seawater intrusion, or declining water table are causing the water quality problem to correlate significantly with the willingness to adapt individually to the water shortage problem ($Ps = 0.108, 0.147, and 0.153$). The correlation between risk perception and the willingness to adapt individually to the water shortage problem is strong and positive ($P = 0.175$). This suggests the need to enhance public awareness regarding the causes of the current water shortage problem focusing on climate change, population growth, wasteful behavior, seawater intrusion and declining groundwater table may enhance public willingness to adapt to the water crisis.
Table 6: Correlation tests results for the willingness to adapt to the water crisis individually and other variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pearson Coefficient</th>
<th>Significance</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>-0.115*</td>
<td>.013</td>
<td>469</td>
</tr>
<tr>
<td>Gender</td>
<td>0.056</td>
<td>0.228</td>
<td>469</td>
</tr>
<tr>
<td>Family size</td>
<td>-0.019</td>
<td>0.683</td>
<td>469</td>
</tr>
<tr>
<td>Education</td>
<td>0.092*</td>
<td>0.047</td>
<td>469</td>
</tr>
<tr>
<td>Family income</td>
<td>-0.054</td>
<td>.331</td>
<td>469</td>
</tr>
<tr>
<td>Gaza suffers water shortage</td>
<td>0.051</td>
<td>0.268</td>
<td>469</td>
</tr>
<tr>
<td>Gaza suffers water quality problem</td>
<td>-0.002</td>
<td>0.963</td>
<td>469</td>
</tr>
<tr>
<td>The water is more available now than 10 years ago</td>
<td>-0.154*</td>
<td>0.001</td>
<td>469</td>
</tr>
<tr>
<td>The water quality is better now than 10 years ago</td>
<td>-0.111*</td>
<td>0.016</td>
<td>469</td>
</tr>
<tr>
<td>Climate Change</td>
<td>-0.16</td>
<td>0.737</td>
<td>469</td>
</tr>
<tr>
<td>Israeli occupation causing water shortage</td>
<td>-0.093*</td>
<td>0.044</td>
<td>469</td>
</tr>
<tr>
<td>Population growth causing water shortage</td>
<td>0.186*</td>
<td>0.000</td>
<td>469</td>
</tr>
<tr>
<td>Climate change causing water shortage</td>
<td>0.189*</td>
<td>0.000</td>
<td>469</td>
</tr>
<tr>
<td>Inefficient use of water causing water shortage</td>
<td>0.166*</td>
<td>0.000</td>
<td>469</td>
</tr>
<tr>
<td>Use of cesspits causing water pollution</td>
<td>0.088</td>
<td>0.058</td>
<td>469</td>
</tr>
<tr>
<td>Landfills are causing water pollution</td>
<td>-0.028</td>
<td>0.542</td>
<td>469</td>
</tr>
<tr>
<td>Sewage treatment plants causing water pollution</td>
<td>0.108*</td>
<td>0.019</td>
<td>469</td>
</tr>
<tr>
<td>Climate change causing water pollution</td>
<td>0.048</td>
<td>.300</td>
<td>469</td>
</tr>
<tr>
<td>Seawater intrusion causing water pollution</td>
<td>0.147*</td>
<td>0.001</td>
<td>469</td>
</tr>
<tr>
<td>Decline in the water table causing water pollution</td>
<td>0.153*</td>
<td>0.001</td>
<td>464</td>
</tr>
<tr>
<td>Risk perception</td>
<td>0.175*</td>
<td>0.001</td>
<td>345</td>
</tr>
</tbody>
</table>

* Significant at the 5% confidence level
3.3.2.2 Support of adaptation policies to the water shortage problem

The correlation tests for the adaptation policy support and the demographic and beliefs variable show a slight deviation from the results for the willingness to adapt individually to the water shortage problem. Age associates negatively (P = -0.154), whereas education level and family income associate positively with policy support (Ps = 0.186 and 0.113) as can be seen in the following table (Table 7). Both gender and family size have no significant correlations with policy support. Among the beliefs regarding the current water crisis in the Gaza Strip only believing that the water quality now is better does significantly and negatively associate with policy support (P = -0.092), whereas believing that the Gaza Strip suffers water shortage, and water pollution and believing that the water is more abundant now than 10 years ago do not associate with policy support. Believing in climate change and believing in the anthropogenic causes of climate change associate positively with policy support (P = 0.091). Again enhancing the public awareness regarding the increasingly intensifying water crisis and climate change may enhance public support to public policies aiming at mitigating or adapting the water crisis.

Believing that the rapid population growth causes the water shortage in the Gaza Strip very strongly (P = 0.310) associates with policy support. Also, believing that climate change and inefficient use of water are causes of the current water shortage does strongly and positively associate with policy support (Ps = 0.218 and 0.197). Believing that the Israeli occupation is a cause of the current water crisis does not associate with policy support. Among the causes of the current water quality problem, believing that the sewage treatment plants, seawater intrusion, and decline of the groundwater table are causes for the current water quality problem associates positively with policy support (Ps = 0.159, 0.172, 0.231); whereas believing that using
cesspits, landfill and climate change are causes of the current water quality problems does not associate with policy support. Risk perception correlate positively with policy support (P = 0.160). This assures the need to increase public awareness regarding the causes of the current water crisis focusing on population growth, wasteful behavior, climate change, declining groundwater table, and seawater intrusion.

Table 7: Correlation tests results for the support of adaptation policies and other variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pearson Coefficient</th>
<th>Significance</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>-0.154*</td>
<td>.001</td>
<td>469</td>
</tr>
<tr>
<td>Gender</td>
<td>0.038</td>
<td>0.416</td>
<td>469</td>
</tr>
<tr>
<td>Family size</td>
<td>0.007</td>
<td>0.877</td>
<td>469</td>
</tr>
<tr>
<td>Education</td>
<td>0.186*</td>
<td>0.000</td>
<td>469</td>
</tr>
<tr>
<td>Family income</td>
<td>0.113*</td>
<td>.014</td>
<td>469</td>
</tr>
<tr>
<td>Gaza suffers water shortage</td>
<td>0.054</td>
<td>0.240</td>
<td>469</td>
</tr>
<tr>
<td>Gaza suffers water quality problem</td>
<td>-0.014</td>
<td>0.761</td>
<td>469</td>
</tr>
<tr>
<td>The water is more available now than 10 years ago</td>
<td>-0.057</td>
<td>0.218</td>
<td>469</td>
</tr>
<tr>
<td>The water quality is better now than 10 years ago</td>
<td>-0.092*</td>
<td>0.047</td>
<td>469</td>
</tr>
<tr>
<td>Climate Change</td>
<td>0.091*</td>
<td>0.049</td>
<td>469</td>
</tr>
<tr>
<td>Israeli occupation causing water shortage</td>
<td>-0.024</td>
<td>0.597</td>
<td>469</td>
</tr>
<tr>
<td>Population growth causing water shortage</td>
<td>0.310*</td>
<td>0.000</td>
<td>469</td>
</tr>
<tr>
<td>Climate change causing water shortage</td>
<td>0.218*</td>
<td>0.000</td>
<td>469</td>
</tr>
<tr>
<td>Inefficient use of water causing water shortage</td>
<td>0.197*</td>
<td>0.000</td>
<td>469</td>
</tr>
<tr>
<td>Use of cesspits causing water pollution</td>
<td>-0.006</td>
<td>0.896</td>
<td>469</td>
</tr>
<tr>
<td>Landfills are causing water pollution</td>
<td>0.007</td>
<td>0.884</td>
<td>469</td>
</tr>
<tr>
<td>Sewage treatment plants causing water pollution</td>
<td>0.159*</td>
<td>0.001</td>
<td>469</td>
</tr>
<tr>
<td>Climate change causing water pollution</td>
<td>0.051</td>
<td>.269</td>
<td>469</td>
</tr>
<tr>
<td>Seawater intrusion causing water pollution</td>
<td>0.172*</td>
<td>0.001</td>
<td>469</td>
</tr>
<tr>
<td>Decline in the water table causing water pollution</td>
<td>0.231*</td>
<td>0.001</td>
<td>464</td>
</tr>
<tr>
<td>Risk perception</td>
<td>0.160*</td>
<td>0.001</td>
<td>345</td>
</tr>
</tbody>
</table>
3.4 Research Limitations

This research is exploratory. We wish that it will spark further research efforts and discussions regarding the different topics touched upon. In this research experts, farmers and the general public who use different sets of tools and methodologies were interviewed and their beliefs analyzed and evaluated. However, the research was limited in terms of time, scope and available resources. Accordingly, the research is limited and shows weaknesses; however it is hoped that more researchers will be inspired to work on gaps identified in this piece of research to further inform adaptation strategies adopted by Gaza's population to the water crisis.

The research was written based on the knowledge of many experts, and elderly farmers in order to understand the chronology of the water crisis, agricultural practices and behaviors related to the use of water. The gathered information from key informants has been cross-checked with previously published data and research to ensure validity. All available resources have been used to inform the research, however, the databases, books, publications accessible within in the Gaza Strip are limited. Accordingly, further research to investigate the validity of the findings is highly appreciated and to be hoped for. A rather comprehensive understanding of the water crisis and peoples' adaptation has been established, however we are in support of research further analyzing any of the phases discussed in this research to reveal new realities, present more trends and suggest additional questions.

For the period that preceded the establishment of the PNA, statistics on population, agricultural lands and products, and water extraction were scattered and mostly inaccessible. We tried to use as much reliable statistics as possible considering our limited capacity to access data and information
gathered by non-Palestinian organizations. Additionally, collecting numbers from different organizations usually suggest the issue of consistency in terms of assumptions, measurements, etc. For example, the Israeli census data on population only counts those who are in the country on the day of census, whereas, the Palestinian census also includes those who are abroad for short periods of time such as students, merchants, etc. This is especially true for the cultivated land area, the MoA uses crop land area units for reporting on cultivated land area, while other organization use regular land area units. We attempted to calculate the regular land area when utilizing the MoA values, but these calculations are limited in their accuracy as we used factors provided by the MoA experts. However, it is worth mentioning that statistical accuracy is not the main concern as this research is primarily interested in extracting the major patterns of behavioral change related to water, water use, agricultural practice and public water use.

As for the focus group discussion sessions with farmers, only five sessions were conducted. While the sessions revealed a wealth of knowledge regarding farmers' knowledge, perceptions, suffering, adaptations, and views regarding the water crisis and its solutions, we believe that more focus group discussions would enhance the representativeness of those findings and bring more confidence regarding the outcomes of this research.

In the survey research with the general public, we achieved a relatively high response rate. Most of those who abstained from responding were females from Khan Yunis. This makes our sample rather biased to males, and those who do not live in Khan Yunis. However, similar deviations are quite omnipresent in the survey research literature without jeopardizing the validity of those studies. Moreover, the reliability of some of the variables used for the inferential analysis are reasonable, but not high as could be noticed with
Cronbach's alphas of climate change beliefs, willingness to adapt and the policy support which ranged around 6 for all three. This weak reliability may stem from the general public's uncertainty of the issue which, in turn, leads to inconsistency in answers. Additionally, the choices listed, in particular the adaptation measures and policy support, do not necessarily resemble in terms of their cost, perceived difficulty and requirements which decrease their internal consistency and thus their reliability as variables.
4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The water crisis in the Gaza Strip is not new. It has been evolving over more than 65 years. Rapid population growth after the 1948 War and uncontrolled urban sprawling confused agricultural development policies and approaches as can be seen in table 7. In addition, respondents talked about Israeli policies such as diverting the Gaza Wadis’ water. All these elements have contributed to the current water shortage problem. All combined has resulted in a gradual decrease in the groundwater table, which allowed for the seawater intrusion phenomenon to take place and turn the groundwater in many areas in the Gaza Strip into brackish water. Nitrate pollution that has resulted from a poorly managed wastewater network, the use of cesspits, and excessive use of fertilizers has added to the problem of salinity to make 95% of the groundwater in the Gaza Strip undrinkable.
Agricultural production in Gaza has contributed partially to the water crisis while also reinforcing other stressors. Trying to accommodate the rapidly growing population, farmers moved from rain-fed to irrigated crops and have thus quickly become dependent on the groundwater aquifer for most part of their businesses. Responding to governmental policies (under the Egyptian mandate and the Israeli occupation), farmers cultivated high quality water demanding crops such as citrus, and then strawberry and roses. These crops were seen as lucrative by farmers and were identified as ways to enhance the economic efficiency of the limited Gaza lands. To ensure access to enough water for these crops farmers dug hundreds if not thousands of wells that have contributed to the worsening water crisis.

The water crisis affected farmers in many ways. Some farmers stopped being able to access sufficient amounts of water; they had to purchase water from other people, tankers or even from neighboring communities. The cost of water has increased steadily over the last 40 years and this rise has become more substantial in recent years with the increase to the cost of fuel needed for pumping. The pumping capacity of private or communal wells has been weakened over time and led to farmers changing their work schedules to accommodate the water pumping. Farmers suffered decreased crop production as a result of deteriorated water quality and thus sustained significant economic losses.

In order to manage some of the ever-increasing challenges, farmers have adopted many positive measures trying to adapt to the water shortage and quality deterioration problems. More water efficient irrigation technologies have been designed and implemented (such as drip irrigation). Many farmers have moved towards less profitable but also less water demanding crops. Others have shifted to more saline tolerant crops. Some have established (on
their own or assisted by local NGOs) rainwater harvesting ponds. Farmers are increasingly open to adopt measures such as the utilization of treated wastewater to irrigate crops. Furthermore, farmers are willing to make their irrigation practices more efficient using technologies such as tensiometers.

However, some of those adaptation measures are quite costly compared to the impacts on farmers' lives. Many farmers complained that less water demanding, and saline tolerant crops are not profitable enough, which has affected their quality of life. Other farmers complained that their choices became too limited in terms of the crops they can grow and that they became increasingly vulnerable to price fluctuation and a potential market overload. Some farmers have again moved toward rain-fed crops; however, here the production is limited and their market value is further decreasing the already meager profit for farmers. Rainwater harvesting can be of very beneficial as it provide farmers with high quality water that can help them diversify their crops and enhance their lands' productivity. This was one of the reasons why the project in which this research is an activity to promote new technologies of rainwater harvesting.

The better educated and more engaged groups of farmers (such as those who participated in the focus group sessions) are quite aware of the water crisis and its root causes. Those farmers were also critical to their fellow farmers' wasteful behaviors, such as:
- Digging illegal wells,
- Using dysfunctional irrigation networks,
- Farming sandy soils without proper preparation

Farmers who participated in the focus group discussions have welcomed more governmental engagement in managing and monitoring the agricultural water management issue. Such engagement can take the shape
of managing and monitoring the agricultural wells, establishing communal rainwater harvesting ponds, and support in improving the sandy soil in some areas to become more water efficient.

Generally, the population residing within the Gaza Strip is also aware of the water crisis. However, some people are a little confused regarding the direction of the crisis. They are also adapting to the water crisis by digging illegal wells and by enhancing their water storage capacity to cope with long periods of water shortage. They are less informed about some root causes such as climate change and to a lesser extent about population growth. They also show confused or distorted attitudes regarding challenges such as dumpsites being a cause of the water pollution.

The people of the Gaza Strip are generally concerned in regards to the impacts of the water crisis on themselves, their families and their communities. At the same time, they lack confidence in themselves and place limited trust in water related governmental organizations to deal with challenges related to water throughout their communities. Communities generally feel that the water crisis is a technical concern and that municipalities, rather than higher level governmental organizations such as the presidency and the parliament, should be responsible for improving the situation. Only a relatively slim minority believes that the governmental institutions responsible for water resource management provide appropriate information to them or engage in discussions regarding causes of the water crisis, ways to reduce water consumption and increase efficiency.

The majority of citizens of the Gaza Strip are not willing to adopt new measures at the household level to cope with the increasing water shortages such as increasing their storage capacity. However, slightly less than 50% of
the respondents are willing to engage in water conservation practices such as turning the shower tap off when water is not needed or decreasing the frequency of showers. A smaller percentage is still willing to increase household storage capacity, harvest rainwater at the household level, and dig new wells. When it comes to adapting to the water quality problem, the majority of people is willing to purchase treated water for drinking. Almost 50% of respondents are willing to purchase bottled water and treated water for domestic purposes as well.

At the policy level, the only two policies supported by a majority of people were enhancing the public awareness in regards to the water crisis and its solution and installing a seawater desalination plant. Advocating for water rights and rainwater harvesting are supported by a large minority of the people. The least supported policy is increasing water tariff collection.

Older people seem to be less willing to adapt to the water crisis or support public adaptation policies. Education and family income associate with policy support. Awareness of the alarming direction of the water crisis associates with both, more willingness to adapt and adaptation policy support. Better knowledge regarding some of the causes of the water shortage and quality problems such as population growth, climate change, seawater intrusion and declining groundwater level associate with better adaptive behaviors towards the water crisis.
## Table 8. The Evolution of the water Crisis and corresponding adaptations in the Gaza Strip since 1948

<table>
<thead>
<tr>
<th>Period</th>
<th>Water Status</th>
<th>Context</th>
<th>Main Stressors</th>
<th>Adaptation strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>before 1948</td>
<td>• Rainwater was the main source of water.</td>
<td>• British Mandate</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>• Groundwater was used mainly for domestic purposes.</td>
<td>• Limited population size (70-80,000 people)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Low groundwater extraction rate (16 MCM/year)</td>
<td>• Cultivated land size is unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• High groundwater level (2-10 m) above sea-level (1935)</td>
<td>• Mostly rain-fed crops agriculture</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Low Chloride levels except in the South-Eastern parts of the Strip, and some parts of the middle area where it ranged from 800-1200 mg/l.</td>
<td>• Some irrigated citrus farms owned by big land lords existed</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• No electricity except in few areas in Gaza City</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Simple not-water wasteful lifestyle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1948-1967</td>
<td>• More reliance on groundwater for domestic and agricultural purposes.</td>
<td>• Egyptian Administration</td>
<td>• Sudden population growth</td>
<td>• Moving towards irrigated crops to increase productivity and economic wellbeing.</td>
</tr>
<tr>
<td></td>
<td>• Groundwater extraction rate reached more 78 MCM/year</td>
<td>• The population reached more than 356,000 people by 1967.</td>
<td></td>
<td>• More reliance on groundwater for domestic purposes and agricultural purposes</td>
</tr>
<tr>
<td></td>
<td>• The water level dropped by 8 meters but stayed mostly above sea-level</td>
<td>• The cultivated land reached 260,000 dunams (in 1967)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Chloride levels stayed the same as above</td>
<td>• Change towards irrigated crops mostly focusing on citrus (72,000 dunams)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• No electricity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1967-1994</td>
<td>• sole dependence on groundwater</td>
<td>• Israeli Occupation</td>
<td>• Population Growth</td>
<td>• Decreasing cultivated land to accommodate population growth</td>
</tr>
<tr>
<td></td>
<td>• The Gaza Strip lost the streams’ water almost completely</td>
<td>• 18% of Gaza lands were confiscated to establish Israeli settlements</td>
<td>• Urban Sprawl</td>
<td>• Increasing land productivity by cultivating more profitable mostly irrigated crops</td>
</tr>
<tr>
<td></td>
<td>• The number of wells reached 2300 by 1993</td>
<td>• The population size continued increasing to reach more than 600,000 people.</td>
<td>• Israeli Settlements</td>
<td>• Using more efficient irrigation technologies including sprinklers and drip irrigation to decrease water consumption.</td>
</tr>
<tr>
<td></td>
<td>• Extraction rate reached more than 116 MCM/year (1990), exceeding the sustainable yield</td>
<td>• The cultivated land decreased to 195,000 dunams (1989)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### An Evolution of Protracted Crisis and Persistent Adaptation

#### 4. CONCLUSIONS AND RECOMMENDATIONS

**1994 till now**
- The number of wells reached 10,000 wells.
- Extraction rate reached more than 160-190 MCM/year.
- The Groundwater level continued dropping and most of the aquifer became below sea-level.
- The Chloride pollution increased considerably to cover the majority of the strip. In some areas it exceeded 2000 mg/l.
- 95% of Gaza Strip became unsuitable for drinking.

### Gradually decreasing citrus cultivation
- Moving towards vegetables cultivation
- Cultivating cash crops such as strawberry and roses
- The Gaza Strip got connected to the Israeli power grid in the 70s.
- Life style gradually became more water intensive.

### Palestinian National Authority Control
- Excessive development took place between 1994-1997/8
- Thousands of Palestinians returned to Gaza in 1994 and after.
- Second Intifada erupted in 2000.
- Israeli settlements were emptied in 2005 and land returned to Palestinians.
- Three wars were launched on Gaza between 2007 and 2015.
- Strict Israeli Siege was imposed on Gaza since 2007.
- The population size continued increasing to reach more than 1.7 million in 2014.
- The cultivated land decreased to 150,000 dunams even using the land left by Israel.
- Land cultivated with citrus decreased dramatically to about 15,000 dunams only.
- The cultivation of vegetables increased using greenhouses.
- The production of strawberry and roses decreased.
- The cultivation of olive trees increased.

### Population growth
- Urban Sprawl
- Water shortage
- Water salinity and pollution
- Violence and wars
- Israeli Siege

### Using efficient irrigation technologies
- Digging illegal wells for agricultural and domestic uses
- Changing crops towards less water demanding and more saline tolerant ones.
- Purchasing piped or trucked water for irrigation.
- Collecting rainwater for irrigation purposes (growing field).
- Reuse of treated wastewater for irrigation (experimentation phase).
- Use of new technologies (Tensiometers) to make irrigation more efficient (growing practice).
- Households increase water storage capacity to withstand long water cuts periods.
- Households purchase treated and untreated water for household use.
- Households purchase treated or/bottled water for drinking purposes.
- Households use household water treatment units (growing practice).
- Households conserve water (growing practice).
- Households collect rainwater (experimental phases).
4.2. Recommendations

4.2.1. Policy Level

- The governmental organizations and NGOs may better engage the public, especially farmers, in discussions regarding the water crisis and its possible solutions. Better public engagement would enhance the governmental planning towards adopting effective objectives with more public willingness to endure the costs of such options. Public acceptance is an important condition for the sustainability of these options.

- The governmental organizations and the NGOs may make more efforts increasing the public awareness regarding the water crisis, its course and direction and the causes focusing on population growth, climate change, declining water level, and seawater intrusion.

- The governmental organizations and the NGOs may exert more efforts enhancing the public awareness in regards to climate change and its local impacts.

- The governmental organizations and the NGOs may assist the farmers adopting adaptation measures such as rainwater harvesting, using conservative irrigation schemes, using technologies such as tensiometers, and using treated wastewater for irrigation. Governments and NGOs may provide farmers with tensiometers and even more importantly with simple approaches to use them. Farmers need to be assured regarding the quality of the treated wastewater to be used by them, which may suggest the need for active and trusted monitoring schemes.

- The governmental organization and the NGOs should help farmers move toward crops that are less demanding on water in general and on high quality water specifically without jeopardizing their wellbeing and enhancing their vulnerability. This can be attained through coordinating the process of crop production among farmers so they do not exceed the market capacity and
suffer major losses.
- The governmental organization may engage farmers in discussing schemes that allow better management monitoring of the illegal agricultural wells.
- The governmental organizations may find ways to regulate and monitor the illegal private wells.
- The governmental organizations may need to promote rainwater harvesting at the houses level through including related regulations in the buildings licensing procedures in the Gaza Strip.
- NGOs may need to implement more projects focusing on rainwater harvesting from houses, farms, and schools.
- The governmental organizations may need to foster more public acceptance through advocacy and training on the viability of gray water usage to irrigate some trees, crops, and back yard gardens, etc.

4.2.2. Farmers’ level
- Farmers may better organize themselves so they can discuss their issues including the water crisis impacts and coordinate crop production more effectively to decrease losses. Also, they can advocate more actively for better governmental engagement in relation to water crisis as they suffer the most.
- Farmers may seek opportunities to harvest and use rainwater.
- Farmers may maintain their irrigation networks to decrease leakages.
- Farmers may seek assistance in regards to using technologies that facilitate more water efficient irrigation at their farms.
- Farmers may be open to use treated wastewater for irrigation, noting the need to know the characteristics of this water so they do not suffer crop damage or harm consumers’ health.

4.2.3. Individual and Household level
- Individuals may need to proactively seek knowledge regarding the current water crisis and its causes including climate change.
- Individuals and families may need to be ready to adopt more water efficient life style.
- Families may need to establish rainwater harvesting units that help them benefit from the rainwater in winter and enjoy greater storage capacity in the dry seasons.
- Individuals may need to engage proactively in the discussions on water adaptation policies and get ready to pay the cost of the adopted policies.
- Individuals may need to be willing to accept agricultural products irrigated with treated wastewater. This acceptance should be facilitated with proper monitoring on both the treated wastewater and crops.
- Families may need to stop looking for fast fixes such as digging illegal wells.
- Families should be more cautious regarding the actual quality of the drinking water they purchase as many water sources are not trusted.

4.2.4. Research
This research is an exploratory research that is limited in its scope and methodology. More research is needed to establish the evolution of the water crisis and adaptation measures utilizing historic documents, official statistics, etc. More research is needed to understand the farmers' perspectives on the water crisis utilizing methodologies that allow for the participation for the largest possible number of farmers. More research is needed on the determinants of public behavior in relation to the water crisis as this study focused only on a limited number of factors. Understanding the mindset of farmers and the general public allows for better engagement and behavioral change awareness campaigns. In addition, more research is needed on the following issues:
- The comparative effectiveness and cost of different policy options;
- The comparative effectiveness and cost of different individual and household level water conservation options;
- The comparative effectiveness and cost of different adaptation measures to the water crisis such as rainwater harvesting, more storage capacity, etc;
- Finding more effective and less costly policies or measures at the different levels of adaptation to the water crisis
- Climate change impact on the Gaza Strip in general and agriculture specifically.
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