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Prospect of Water Desalination on the Light of Current and Future Water Consumption Behavior: Khan Younis Governorate as a Case Study

By

Yousef Shaheen

BSc. In Civil Engineering

Infrastructure M.Sc program

Supervisor

Dr. Husam Al-Najar

Assistant Professor

Depatrment Of Environmental Engineering

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أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Prospect of Water Desalination on the Light of Current and Future Water Consumption Behavior: Khan Younis Governorate as a Case Study

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Signature: **Yousef Shaheen** التوقيع:

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بسم الله الرحمن الرحيم

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تحلية المياه في ضوء سلوك الاستهلاك الحالي والمتوقع مستقبلاً لمدينة خان يونس

Water desalination in the light of current and future water consumption behavior in Khan Younis City

وبعد المناقشة العلنية التي تمت اليوم السبت 02 شعبان 1435هـ، الموافق 2014/05/31م الساعة الواحدة والنصف ظهراً بمبنى القدس، اجتمعت لجنة الحكم على الأطروحة والمكونة من:

د. حسام محمد النجار	مشرفاً ورئيساً	H. Najjar
د. جهاد توفيق حمد	مناقشاً داخلياً	....
أ.د. خليل محمود طبيل	مناقشاً خارجيًا	....

وبعد المداولة أوصت اللجنة بمنح الباحث درجة الماجستير في **كلية *الهندسة*/** قسم **الهندسة المدنية- البنى التحتية**.

واللجنة إذ تمنحه هذه الدرجة فإنها توصيه بتقوى الله ولزوم طاعته وأن يسخر علمه في خدمة دينه ووطنه.

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أ.د. فؤاد علي العاجز

ABSTRACT

Groundwater is the only source of domestic water in Khan Younis Governorate, as well as, the Gaza Strip. Due to urban expansion, population growth and illegal use of groundwater for irrigation purposes, ground water in the Gaza Strip is over abstracted leading to seawater intrusion. Thus the sea water desalination plants are proposed to provide potable water.

The main objective of the current research is to study the feasibility of seawater desalination as a resource of potable water on the light of the current water consumption practices in sub-urban areas.

Several interviews were conducted with technicians, engineers and decision makers from Khan Younis Governorate and the relevant institutions. A questionnaire was distributed to farmers who owned different categories of agricultural lands to investigate the source of irrigation water. After collection of 430 questionnaire data were analyzed by using Statistica 10, SPSS and excel software. Additionally, reviewing of most water desalination projects; quantity, quality of water, costs of treatment and supply and socioeconomic aspects were conducted.

Khan younis Governorate constitutes of seven municipalities where the percentage of unaccounted for water of the municipal water distribution systems ranges from 15.8 % to 43.6%. Relatively high proportional correlation between the unaccounted for water and the urban agriculture was found (with accuracy 79%) especially for fruit trees cultivated in areas less than 5 dounms per each owner. Due to the sensitivity of vegetables to the salinity of municipal water, farmers who cultivated vegetables have their own agricultural wells which also used for domestic purposes leading to negative correlation with the percentage of unaccounted for water (with accuracy – 67%) for the same category of landownership less than 5 dounms. Moreover the summation of fruits and vegetables cultivations area in relation with un accounted for water cultivated illustrate that there are a proportional relation (with accuracy 73%).

After projected these relations supported with questionnaire results of the future urban agriculture, it obvious that there would be increasing by 10.1% of the original unaccounted for water due to the improved water supply quality (desalination) in urban agricultural regions. Furthermore, there will be increase in groundwater abstraction by 1,387,869 MCM/year in the traditional agricultural areas.

After analyzing the soci-economic factors, The farmers capable to pay 0.47 $ per cubic meter. Therefore new policy and regulation concerning water resources management should be implemented for semi urban area in Gaza Strip t minimize the unaccounted for water. Moreover a new resources for agricultural purposes should be studied such as the reuse of treated water affluently.

ملخص البحث

المياه الجوفية هي المصدر المائي الوحيد للسكان في محافظة خان يونس ، فضلا عن قطاع غزة. بسبب التوسع العمراني والنمو السكاني و الاستخدام غير المشروع للمياه الجوفية لأغراض الري والسحب الإضافي للمياه الجوفية أدى إلى تسرب مياه البحر إلى الحوض الجوفي. وبالتالي فإن تحلية مياه البحر الحل الوحيد لتوفير المياه الصالحة للشرب.

الهدف الرئيسي من البحث الحالي هو دراسة جدوى تحلية مياه البحر كمصدر لمياه الشرب على ضوء ممارسات استهلاك المياه الحالي والمستقبلي في المناطق شبه الحضرية.

العديد من المقابلات أجريت مع الفنيين والمهندسين و صناع القرار من محافظة خان يونس و المؤسسات ذات الصلة. وقد تم توزيع استبيان المزارعين الذين يملكون فئات مختلفة من الأراضي الزراعية في المناطق شبه الحضرية للتحقيق من مصادر مياه الري. وبعد جمع 440 استبيان تم تحليل البيانات باستخدام عدة برامج منها STATISTICA 10 وSPSS و Excel. بالإضافة إلى مراجعة معظم مشاريع تحلية المياه؛ كماً ونوعية ومن حيث تكاليف معالجة المياه وتوريدها للسكان والجوانب الاجتماعية والاقتصادية.

محافظة خان يونس تتشكل من سبع بلديات حيث بلغت نسبة الكميات المفقودة من المياه من شبكات توزيع مياه البلدية تتراوح من 15.8% إلى 43.6%. حيث تم العثور على علاقة طردية كبير نسبيا بين كميات المياه المفقودة في شبكات التوزيع و الزراعة الحضرية حيث بلغ (مستوى الدقة حوالي 79%) وخاصة بالنسبة للأشجار المثمرة في المناطق أقل من 5 دونمات لكل مالك. ونظرا لحساسية زراعة الخضراوات لملوحة المياه المقدمة من البلدية، فالمزارعين الذين يزرعون الخضروات يعتمدون على الآبار الزراعية الخاصة والذي بدوره أدى إلى علاقة عكسية مع نسبة كميات المياه المفقودة من شبكات التوزيع مع المساحات الزراعة حيث بلغ (مستوى الدقة حوالي -67%) لنفس مجموعة المالكين ذوي ملكيات أقل من خمس دونمات. علاوة على ذلك فإن محصلة الأشجار المثمرة و الخضروات من حيث المساحات الزراعية في العلاقة مع نسبة كميات المياه المفقودة من شبكات التوزيع توضيح أن هناك علاقة طردية حيث بلغ (مستوى الدقة حوالي 73%).

بعد إسقاط هذه العلاقات مدعمة بنتائج الاستبيان من الزراعة الحضرية في المستقبل، من الواضح أنه سيكون زيادة بنسبة 10.1 ٪ من كميات المياه المفقودة في شبكات التوزيع الأصلية للمياه نظرا لتحسين نوعية المياه (تحلية المياه) في المناطق الحضرية الزراعية. علاوة على ذلك، سوف يكون هناك زيادة في استخراج المياه الجوفية بحوالي 1387869 مليون متر مكعب / سنة في المناطق الزراعية التقليدية.

بعد تحليل العوامل الاجتماعية و الاقتصادية، فان المزارعين قادرين على دفع سعر تكلفة المتر المكعب من المياه حوالي 0.47 دولار .ولذلك فإن القطاع بحاجة إلى وضع سياسات و قوانين جديدة لتنظيم و إدارة مصادر المياه في المناطق شبه حضرية لتقليل كميات المياه المهدورة. إضافة لذلك دراسة مصادر جديدة للاستخدام الزراعي كإعادة استخدام المياه المعالجة بكفاءة.

Dedication

This research is dedicated to:

The spirit of my father and my uncle…

My mother for her prays, love and continuous sacrifices …

My brothers and sisters…

My family for their encouragements …

All of my friends and colleagues…

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List of Abbreviations and Acronyms

AKM	Abassan Kabera Municipality
ASM	Abassan Saghera Municipality
BSM	Bani Sohaella Municipality
CMWU	Coastal Municipalities Water Utility
FAO	Food & Agricultural Organization
FM	Al-Foukhariy municipality
GSWDP	Gaza Sea Water Desalination Plant
KM	Khozaa Municipality
KYG	Khan Younis Governorate
KYM	Khan Younis Municipality
(L/c.d)	Liter Per Capita Per Day
MCM	Million Cubic Meters
MOA	Ministry of Agriculture
MOLG	Ministry of Local Governance
PCBS	Palestinian Central Bureau Of Statistics
PWA	Palestinian Water Authority
QM	Al-Qarara Municipality
SWDP	Sea Water Desalination Plant
UNDP/PAPP	United Nations Development Program
WHO	World Health Organization

Chapter 1: Introduction

Chapter 1: Introduction

Gaza Strip is a very small area of land with a total area of only 360 square kilometers (PCBS, 2013). It is underlined by a shallow aquifer, which is contiguous with the Israeli Coastal Aquifer to the north. Gaza is the “downstream user” of the Coastal Aquifer system. The Gaza Aquifer has a natural recharge rate of approximately 95 million cubic meters (MCM) of water per year from rainfall, infiltrated irrigations, and lateral inflow of water (CAMP, 2000; Nasser, 2003).

Fresh water has become a scarce commodity due to over exploitation and pollution of water. Increasing population and its necessities have lead to the deterioration of surface and sub-surface water. The importance of groundwater for the existence of human society cannot be overemphasized. Besides, it is an important source of water for the agricultural and industrial sector.

Population growth and urban horizontal expansion after 2005 (Israeli withdrawal) have persistently raised the demand for water supply and consequently increased the exploitation of groundwater in the Gaza strip. Approximately 90% of the domestic water in the Gaza Strip comes from the shallow coastal aquifer via 10% licensed municipal wells. Most of the farmers in agricultural areas use private unlicensed wells (Sharma, 2008; Al-Najar, 2010).

Underlying Gaza’s geographical, political, social, and economical positions, there are different local, national and international factors that make it difficult for the nation to break its long and ongoing poverty cycle. Therefore, Gaza's residents have been using possible means of saving their food needs. Urban agriculture is one of the most persistent approaches for supplying food in the Gaza Strip. The quantity and quality of drinking water have deteriorated over the past two decades due to the excessive use of irrigation water especially in the semi urban areas (Mushtaha, 2006; Al-Najar, 2010).

The importance of this research is to study the future of sea water desalination on the light of the current water consumption behavior. By studying the current water distribution situation and expectation for the future consumption of water after desalination process. The work will focus on current and future losses of water, where municipal water services system is used for agricultural purposes illegally.

1.1 Problem Statement

Gaza Strip is characterized of population and expansion of cities and refugee camps are increased. Currently, the water quality is deteriorated due to the negative balance of ground water as a result of sea intrusion. The PWA and all relevant institutions propose the desalination of sea water as a source of water supply to Gaza strip residents (PWA, 2012).

Khan Younis governorate constitutes of 7 administrative municipalities districts including 54 different distribution zones. It has an approximate rectangular shape of

116 km^2. The population recorded about 369,048 inhabitants in year 2013 (PCBS, 2013). It have a total of 295 wells. But only 38 wells serve the domestic water supply in the area providing about 15,001,990 m^3 while the meter readings accounted for 9,989,310 m^3 in year 2013. It is obvious that unaccounted water equals 33.4% for all municipalities. (Khan Younis Governorate municipalities, 2013). From Khan Younis's water engineers points of view; this low efficiency might be due to:

1) The efficiency of the water pipe network system itself within the domestic area.

2) Unaccounted For Water (UFW) which is seen in the illegal connections from the municipal networks towards the urban agricultural area of Khan Younis governorate for agriculture purposes.

Khan Younis Governorate characterized by urban agriculture. The agricultural land area in Khan Younis urban areas is about 37,806 dounms representing more than 32.8% of the Khan Younis Governorate total area. The absence of clear desegregation between domestic and urban agriculture water consumption lead to uncertainty about the system efficiency and the actual domestic consumption (Ministry of Agriculture, 2013). The urban agriculture influences the efficiency of water network because of its needs of huge amount of water.

Additionally the agricultural production has reached to high limits of water availability. At the same time, it confronted with the socio-economic demands related to food insecurity and the needs for the coming generation (Sourani, 2005). Increasing competition among urban needs makes water very limited resources (Shomar,2010).

This research focused on the unaccounted for water on light of the quality improvements (desalination) and examining the main factor impacts on water losses changes from the domestic municipal water. Either discussion the urban agriculture crops water requirements and reflections after the sea water desalination plant would exist. Furthermore, discussion the future socio-economical factor after quality improvements.

1.2 Goal and Objectives

The goal of the current research is to identify the relation between unaccounted for water and the urban agriculture among Khan Younis seven municipalities. Moreover, identifying the urban agricultural changes on the light of improving water quality (desalination). Defining its reflections on the unaccounted for water and the socio-economic aspects such as the willing to pay. Leading to describe the main objectives of the research which are;

1. Study the current situation of water distribution system.
2. Identify the main factors that lead to increase in the unaccounted for water
3. Study the current and expect future water consumption behavior on the light of improved water supply quality (desalination).
4. Determine the future urban agriculture changes and the socio-economic aspect to minimize the unaccounted for water.

1.3 Structure of the Thesis

The basic structure of the thesis is organized in six chapters, as follows:

Chapter One: Introduction

It provides a background on Khan Younis water crisis, summary on the problem statement, research objectives, and structure of the research.

Chapter Two: Literature Reviews

It summarizes the literature reviews along with background information related to water consumption, losses, observations from the past. And its potential impacts on domestic water demand in the future, and if the desalination plant is existing.

Chapter Three: Study Area and Research Methodology

The study area describes the geographically with briefing about its water resources and crisis, water system operation and maintenance, and historical metrological data analysis. For the research methodology it deals with the methodology used to achieve the objectives of the study, starting from assessing the potential impact of water consumption, calculating UFW. Conducting the comparison between current situation and expectation of water consumption and expectation of water consumption if the desalination plant is existed and its impacts.

Chapter Four: Results and Discussions

It explains the findings, results and discussion on domestic water demand and the expectation of water meter readings after the desalination plant is existed and its impacts. These findings are to be compared with the current consumption and the urban agriculture influence on domestic water demand. All of these findings will be discussed and compared with local, regional, and international studies, moreover there will be a looking over socio economic issue.

Chapter Five: Conclusion and Recommendations

It provides a brief summary of the research findings as a conclusion followed by future recommendations for the best practices.

References contains the basic references, which have been reviewed by the researcher.

Appendix contains the basic tables.

Chapter 2: Literature Review

Chapter 2: Literature Review

2.1 Introduction

The present situation in the water sector in Palestine and the challenges to be faced are related to several factors. Including the extreme scarcity of water resources, continuous growth of water demand due to population growth, economic development and rising standards of living. Insufficient water supply and sanitation, inadequate tariffs, insufficient control on water consumption, and excessive water losses. (PWA, 2004).

This chapter will illustrate the global and local literature reviews along with background information related to groundwater and desalination in the light of current situation. It will discuss the unaccounted for water, in addition to the potential impacts on water demand for both domestic and agricultural sectors.

2.2 Ground Water Beneath the Gaza Strip

Gaza Strip is one of the semi-arid areas where rainfall is falling from October to April. The rate of rainfall is varying in the Gaza Strip and ranges between 200 mm/year in the south to about 400 mm/year in the north. While the long term average rainfall rate in all over the Gaza Strip is about 317 mm/year (Al-Najar, 2007, 2010). Groundwater aquifer is considered the main source of water supply for all kinds of human usage in Gaza Strip (domestic, commercial, agricultural and industrial). This source has been faced a deterioration in both quality and quantity for many reasons, e.g. low rainfall, increased in the urban areas which led to a decrease in the recharge quantity of the aquifer, and increasing in the population. All of these factors deplete the groundwater aquifer and led to seawater intrusion in some areas. As a result in pressure differences between the groundwater elevation and sea water level (Sharma,2009). Gaza Strip is one of the highest population intensity in the world where the population has reached more than 1.85 Million inhabitants living within 365 Km^2, and it is expected to reach more than 3.7 Million inhabitants by year 2035 (PCBS, 2013).

The groundwater underneath the Gaza Strip is limited to the Gaza Strip area, while the coastal aquifer is extended from Haifa in the north to Sinai desert in the south, Hebron Mountain in the east and the Mediterranean Sea in the west. Where the aquifer is being recharged by different components such as rainfall, water networks leakage, wastewater collection system leakage, agricultural return flow and from recharge storm water ponds. The quantities of all those different components estimated to be on average of about 170 to 185MCM yearly (IWA, 2012).

The major documented water quality problems in the Gaza strip are elevated salinity and nitrate concentrations in the aquifer. Almost all municipal wells within the Gaza strip contain a high level of chloride that exceeds a value of 250 mg/L and Nitrate value more than 50 mg/L. As shown in Figure (2.1), the Khan Younis governorate has a large number of wells; most of them are private agricultural wells.

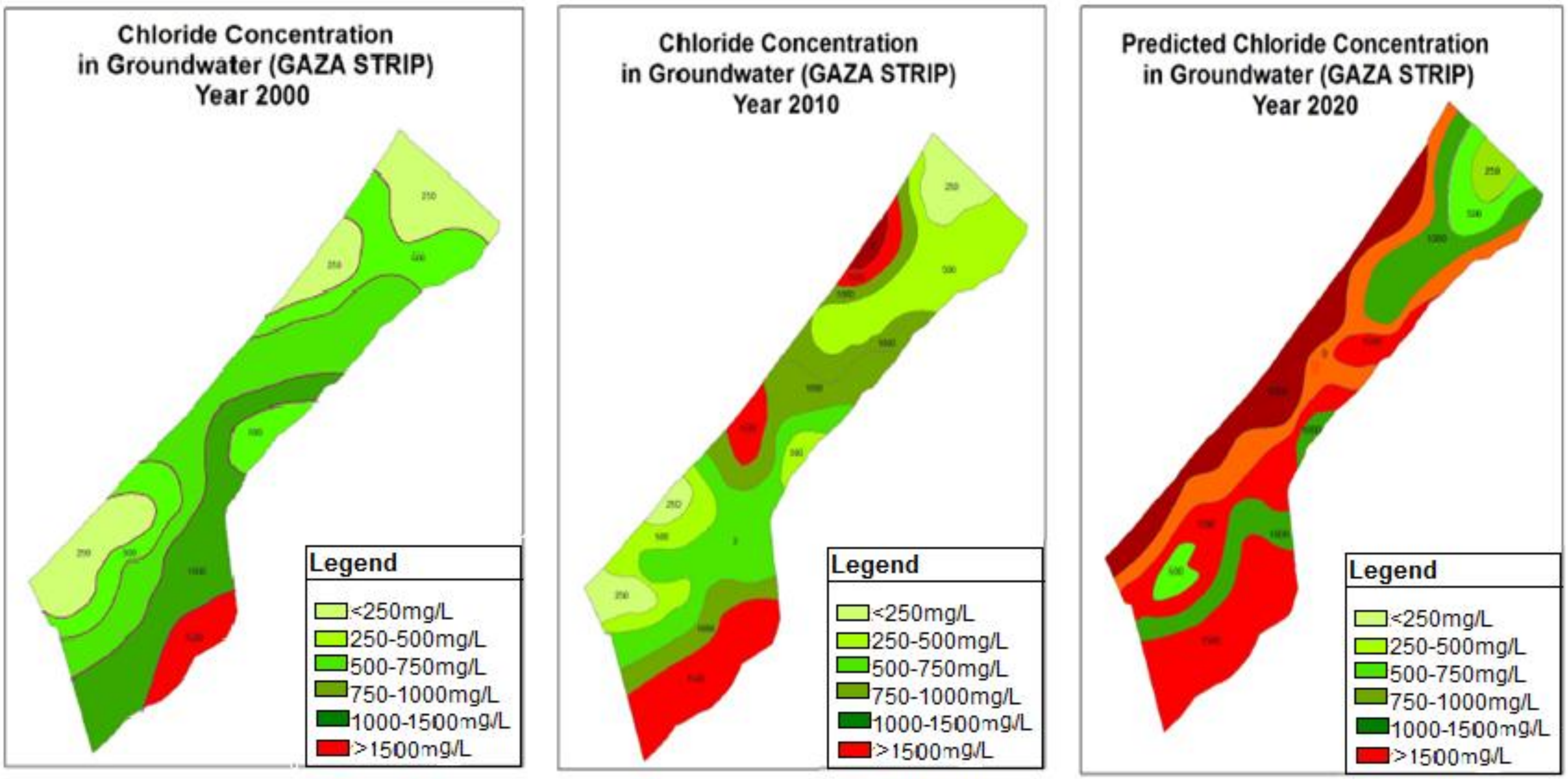


Figure (2.1): Levels of chloride (denoting salinity) in the groundwater within the borders of Gaza, for the years 2000, 2010, plus predicted data for 2020.(Source: PWA, 2012)

In general, the quality of water extracted from Gaza Strip coastal aquifer varies by area and time and does not meet the World Health Organization (WHO) guidelines values for drinking water quality (CMWU report ,2006, 2008, 2009,2010,2012).

Stalinization of groundwater may be caused by a number or combination of different processes. Including seawater intrusion, migration of brines from the deeper parts of the aquifer, dissolution of soluble salts in the aquifer (water-rock interaction). And contribution from discharges from older formations surrounding the coastal aquifer. In addition, potential man-induced (anthropogenic) sources include agricultural return flows, wastewater seepage, and disposal of industrial wastes (Bartram, *et. al*.,1996). The thickness of the saturated groundwater aquifer underneath the Gaza Strip ranges from few meters in the eastern and south east of the Gaza Strip to about 120-150 m in the west and along the Mediterranean Sea.

The aquifer is mainly composed of unconsolidated sand stone known as Kurkar formation which overlaying the main source of water in Gaza Strip in the shallow aquifer which is part of the coastal aquifer. Impermissible layer called Saqiya formation which is considered as the bottom of the Gaza Coastal Aquifer with thickness varies from 800-1000 m. (Isamil, 2003).The thickness of the unsaturated aquifer which is the overlaying part of the saturated groundwater aquifer ranges from 70–80m in the eastern and south-eastern part of the Gaza Strip to about few meters in the western and along the coast. (Metcalf and Eddy, 2000).

The available groundwater quantity could be identified if the saturated aquifer reservoir thickness is known in addition to the hydrological parameters of the aquifer such as effective porosity. The area of the groundwater reservoir is limited to the area of the political border of the Gaza Strip. The area where the groundwater quantity with chloride less than 250 mg/L is about 33.4 Km^2 while it has been recorded in year 2009 to be about 44.8Km^2. So it has been shrinking of about 10 Km^2(Al-Yaqubi, *et. al*, 2011). In 2011, the recorded water abstracted from groundwater was around 86.7 MCM "Including UN wells", while agricultural water abstraction is assumed to be around 80 MCM. The following Table (2.1) illustrates the overall groundwater abstraction for each governorate in the year 2011. (CMWU ,2011).

Table (2.1): Amount of water uses over Gaza Strip (CMWU, 2011)

North Governorate (m^3)	22,030,009
Gaza Governorate (m^3)	33,226,214
Middle Governorate (m^3)	12,524,944
Khan younis Governorate (m^3)	13,677,696
Rafah Governorate (m^3)	7,866,840
Total (m^3)	89,325,703
Mekorot Water (m^3)	4,864,880
Water abstracted from the ground water (m^3)	84,460,823
UNRWA wells abstractions (m^3)	2,269,361
Agricultural wells abstractions (m^3)	80,000,000
Total water requirement from all sources (MCM)	~166.7

2.3 Agriculture in the Gaza Strip

Agriculture is the prevalent sector in Gaza's economy, which contributes to 32% of its economic production. Over the last five years it's contribution to the national Gross Domestic Production (GDP) has reduced from 9.1% in 2000 to about 7.0% in 2005. while it increase during 2013 to reach 12.2% of gross domestic production which means that the period of the study is located in economic growth due to the farmer have been import seeds, fertilizers and pesticides from Egypt illegally (MOA, 2014). Most of the agricultural areas are located within and surrounding of the denser residential areas. Therefore, this type of agriculture could be classified as urban agriculture due to its location. Moreover, some of the green houses are irrigated from the municipal water network within the residential areas. Fruit trees are cultivated within and close to the built up areas. On the other hand, rain fed crops occupying the eastern area of the Gaza Strip. The agricultural area in Gaza Strip is estimated to be about 176,000 dounms, and the total supply is estimated to be about 80.5 MCM (PWA, 2013).

Gaza Strip is characterized of population and expansion of cities and refugee camps are increased. The export-oriented agricultural production has reached to high limits of water availability. Food insecurity is caused by the socio-economic factors leading to expected huge demands for generations in the future. Increasing competition among urban agricultural needs, soil and water in limited resources.

"Agriculture in Gaza is already more urban than rural" was one of the conclusions of the Gaza Urban Agriculture Committee (GUAC) workshop in 2000, referring to the high degree of urbanization of the area.

An official resource, the Ministry of Planning went further by stating that: "All agriculture in Gaza can be considered to be urban agriculture.". The main conclusion of the workshop was that we cannot neglect the prevailing potentials problems in the agricultural sector in Gaza Strip. The Palestinian Agricultural Relief Committees (PARC) aims to wide-reaching strategy to carry out potentials problems by the active participations of stakeholders at all levels of society. (Sourani, 2005)

Urban agriculture is not a new invention. However, recently urban agriculture has become a systematic focus of research and development attention as its scale and importance in the urbanizing world become increasingly recognized (Veenhuizen, *et al*, 2010). A recent study by the United Nations Development Programme (UNDP) indicated that about 800 million urban residents worldwide are involved in urban agricultural activities as a survival strategy (CDM, 2011). Between 1993 and 2005, urban agriculture could increase its share of world food production from 15% to 33% (Smit, 2006). Accordingly, the urban agriculture will influence the efficiency of water network because it needs a huge amount of water.

Because vegetables consume the highest water quota; water consumption for each type is evaluated to investigate the feasibility of using the groundwater for irrigation. In spite of the crops, which are cultivated in green houses, they consume the highest quota of irrigated water especially carnation which consumes more than 1500 m^3/dounm/year (one dounm =1000 m^2). The current water tariff which is considered by the Ministry of Agriculture in the total cost of crop production is (0.16 \$/m^3). This value represents only the cost of pumps operation and fuel. Water, as an asset, is never been evaluated on the light of Gaza water crisis. For instance; carnation and strawberry are the two main agricultural export products from Gaza Strip (cash crops cultivations). As shown in Table (2.2) the factor of water requirements in (percentage), it can be separated into two items by using mass criteria method. One for fruit and olive trees which required 738 m^3/dounm/year and the second for vegetables which required 685 m^3/dounm/year (PWA; MoA, 2013).

Table (2.2): Cultivated area and water requirement of each crop in the Gaza Strip (PWA; MoA, 2013).

Crop Type	Area cultivated (dounms)	Water requirement		
		m^3/dounm	10^6 m^3/year	% of total
Citrus	12,600	900	11.34	14
Olives	22,897	700	16	20
Date Palm	Only small area remaining			
Almonds	3,163	400	1.35	1.7
Fruits	10,333	400	4.13	5
Vegetables (Protected)	21,382	650	13.89	17.3
Vegetables (open fields)	47,044	700	32.93	41
Flowers	514	1500	0.77	1
Ornamental	132	500	0.07	0.1
Field crops	36,562	Rain fed	0	0
Total	154,627	-	80.48	100

2.4 Desalination the Proposed New Source of Water

Desalination of sea water is considered as one of the man kind's earliest form of water treatment, and it has become one of the most sustainable alternative solution to provide fresh water for many communities and industrial sector. It plays a critical role in socio-economic development in a number of developing countries, especially in water stress regions such as Africa, Asia and countries in the Middle East. (Adger and Kelly,1999)

Hence, industry, agriculture developing and population increasing in developing countries will accelerate the deterioration and depletion of available fresh water resource. Furthermore people in many countries of the world neither have financial nor oil resources to allow them to develop technologies of water. So, one of the most water technologies is sea water desalination of sea water to solve the problem of scarcity in resource. (Arndt and Simler, 2007)

Recently, the utilization of renewable sources of energy (e.g. solar, biomass, wind and geothermal) to drive desalination plants has emerged as a promising sustainable solution for fresh water supply in regions lacking energy supply.

Currently, over 14,451 industrial scale desalination units, with an average production rate of 60 million m^3/d, are operating worldwide. Continuous progress in desalination technology makes it a primary, if not the only, candidate for alleviating severe water shortages across the globe (Henthorne, 2009).

Moreover, desalination costs are competitive if compared with the operation and maintenance costs of long-distance water transport systems. Desalination costs have been continuously decreasing over the years as a result of advances in system design and operating experience, the associated reductions in specific unit size, and specific power consumption (Fritzmann, *et. al.*, 2007).

2.4.1 Existing Desalination Plants in the Gaza Strip

In the beginning of the nineties, three pilot Reverse Osmosis (RO) desalination plants were constructed as brackish water desalination; one plant in Deir El-Balah and two plants in Khan Younis.

The average production per plant is about 30 to 40 m^3/hour. Those plants aimed to improve the public health of people and to secure partially accepted water for drinkable usage in their areas.

By time the efficiency of the plants have decreased due to the increase of salinity of the brackish water well and the lack of experience for the local staff in operation and maintenance. However, using desalination water as an alternative source for drinkable usage has developed and increased as a type of investment projects for the private sector. Also, we will focus on the public sector in Gaza strip.

2.4.2 Proposed Gaza Sea Water Desalination Plant

The Feasibility Study (PWA and CDM, 2003) reported that the United States (US) Government is working to fulfill future needs that have been established in accordance with the provisions of Article 40, Interim Agreement between Palestine and Israel. The agreement aims to strengthening cooperation which was established by the Israeli- Palestinian-American Water Committee. So the US addressed the issue of brackish or seawater desalination in the Gaza Strip. For this sake, the United State Agency for International Development (USAID) has been committed to the Palestinian National Authority to give grants for designing, constructing, and supervising the reverse osmosis Gaza Sea Water Desalination Plant (GSWDP). The production capacity of phase (I) is estimated at 60,000 m^3/day (~ 20 MCM/year) and the plant is assumed to be in operation by the year 2005. But now, and because of the political conditions, this date may be postponed. The production phases are estimated according to the PWA and CAMP report 2001 as follows:

1. Phase 1: 60,000 m^3/day in operation by 2005.
2. Phase 2: 60,000 m^3/day in operation by 2008.
3. Phase 3: 20,000 m^3/day in operation by 2014.
4. Phase 4: 10,000 m^3/day in operation by 2018.

The final target capacity shall be 150,000m^3/day (~55MCM/year) by the year 2020. But if it exists it won't serve as planned 100% of the usage.

Seawater intake shall be employed to feed water to the plant. Samples were collected from the Mediterranean Sea close to the proposed site intake one Km far from the shore.

By the end of the construction phase of the GSWDP, the turnkey American contractor will carry out the responsibility for Operation for three years in a contract with USAID, and then the operation contract will be shifted to the Coastal Municipal Water Utility (CMWU) instead of USAID for a possible period of seven years. Since the operation cost of the plant will be a load on the CMWU during this extended operation contract, the World Bank is expected to financially support the CMWU as part of its obligations Gaza project. This large-scale plant will serve all people in Gaza Strip through the Gaza Regional Carrier. The site of the plant lies in the middle area of the strip, with total land area at 27,000 m^2.

According to (PWA and CDM, 2003), the operation and maintenance costs will be 0.54 US$/$m^3$ in the first phase and is estimated to drop to 0.42 US$/$m^3$ when the final phase is completed based on energy costs of 0.055 US$/KWh. The master plan study argues that the tariff structure is designed not only to encourage the water conservation but also to allow an appropriate rate to support the expansion of desalination facilities.

2.4.3 Cost of Cubic Meter of Desalinated Water

By the beginning of 1960s, water desalination technology has been started to be as an alternative conventional water resource. The main challenge at that time was the high cost of produced water. The limiting factor that is still affecting the price of cubic meter is the power cost and the water quality of the produced water.

In the last decay, a rapid progress and high competition have occurred in the Reverse Osmosis (RO) desalination technique and technology. The main aim of that is to decrease the consumption power. New researches and Figures argue that in order to produce one cubic meter of desalinated water, 3.5 KWh is needed.

In the feasibility study report (PWA and CDM, 2003) which was submitted by USAID to PWA, the sections related to capital cost, operation and maintenance cost, and financial analysis of GSWDP were intentionally left blank.

Regarding to water desalination market, Israel signed a Build, Operate, and Transfer (BOT) contract with the international French water company VIVENDI in 2002 was finished. This contract were aim to construct the RO seawater desalination plant at Ashkelon / Israel, with a capacity of 100 MCM/year at production cost at 0.527 US$/$m^3$ (IWA, 2012)

Thus, energy consumption is the main limited factor in the economic feasibility in the determination of the cost of cubic meter of desalinated water. Energy devices are critical to the cost effectiveness of today's seawater desalination plants. Those devices aim to lower the net high- pressure power consumption.

Since GSWDP will not be a co-generation power plant, power costs are significant. The facility (GSWDP) will be empowered by the new Gaza thermal power plant 140

MW at that time assuming the electricity is working well. The bulk of operation costs of the facility are in the energy costs, assessed to as high as 72% of total Operation and Maintenance (O&M) costs.

The master plan indicates that those costs are based on fixed units of cost of power at 0.055 US$/$m^3$ of consumption. The type of Operation and Maintenance (O&M) of a desalination plant in general is a decisive factor in identifying cost per cubic meter. By the year 2020, the total production in the final phase of the GSWDP is 150,000 m^3/day which equals 55 MCM/year. At the same time, the total domestic water consumption is estimated at 89 MCM/year by year 2020. The estimated cost of cubic meter that is produced from GSWDP in phase (I) is at 0.54 US$/$m^3$ and can drop to 0.42 US$/$m^3$ at the final phase (PWA, 2009). Consequently, the consumer shall charge for the production and pumping of the cubic meter around 0.75 US$/ m^3 in phase I (Ismail, 2003). So, families can afford for the water produced from GSWDP. Al-Ghuraiz (2002) report argued that people in the Gaza Strip could afford to pay up to US$ 0.7 per cubic meter with accepted water quality.

The PWA aimed to protect poor people by adopting a smart tariff setting and cross-subsidies through lowering the first slid in the water tariff system.

2.5 Un-accounted for Water

Unaccounted-for water (UFW) represents the difference between "net production" and "consumption" (the volume of water that can be accounted for by legitimate consumption, whether metered or not) (Sharma, 2008). Water loss levels of Unaccounted For Water (UFW) widely vary per country and per city and it's ranging from 15% to 42% as shown in Figure (2.2). which mean every community have their own properties in unaccounted for water leading to water losses management.

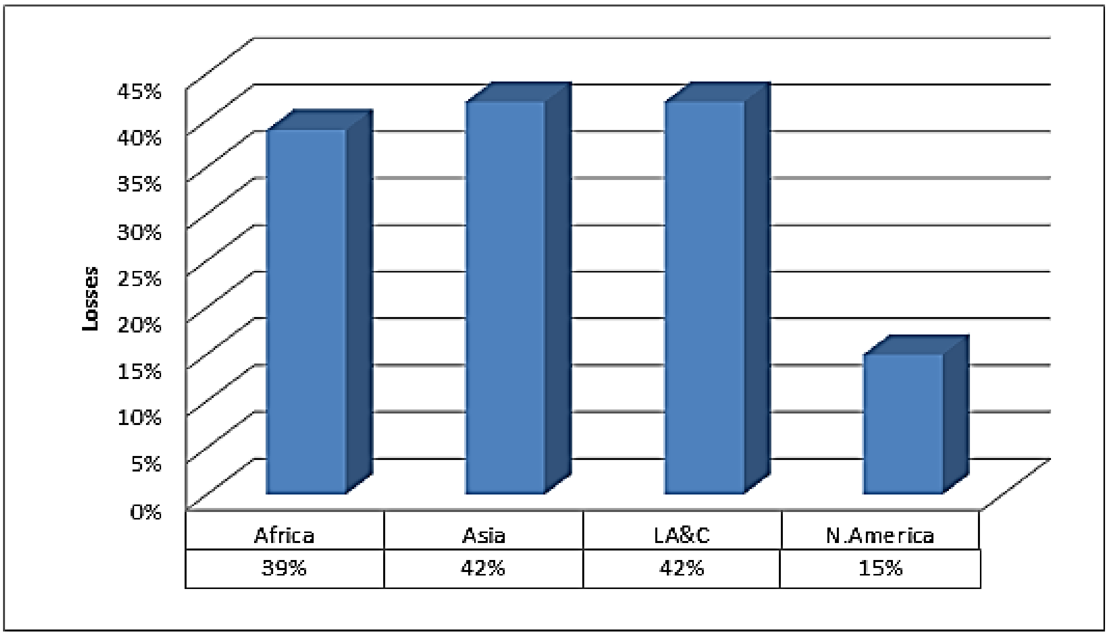


Figure (2.2): Water loss levels variation in the world (UNICEF, 2000).

Water loss of Unaccounted For Water (UFW) from a water distribution system is a significant factor affecting water delivery to customers.

Water loss can be either:

1. The apparent losses due to meter inaccuracies or unauthorized consumption.
2. Real losses due to leakage at water service lines, breaks or leakage on mains and hydrants at storage facilities (EPD, 2007)

2.5.1 Acceptable levels of Water Loss

Around the world there are many committees limited the unaccounted for water with specific percentile. American Water Works Association (AWWA) leak detection and Accountability Committee (1996) recommended 10% as a benchmark for Unaccounted For Water (UFW). UFW levels and action needed are as follows (Sharma, 2008).

< 10%	Acceptable, monitoring and control
10-25%	Intermediate, could be reduced
> 25%	Matter of concern, reduction needed

Chapter 3: Study Area and Research Methodology

Chapter 3: Study Area and Research Methodology

Khan Younis is a geographical part of the Gaza Strip. Gaza Strip is a part of the Palestinian coastal plain in the south west of Palestine, where it forms long and narrow rectangle on the Mediterranean Sea. It is located between longitudes (34^{o} 20′) and (34° 25′) east and latitudes (31° 16′) and (31° 45′) north. It is bordered by Egypt from the south, Negev desert from east, and the green line from the north. The Gaza Strip occupies an area of about 365 Km^2; about 41 Km long and (6 to 12 Km) wide. (Khalaf, 2007)

Gaza Strip is considered as one of the densest place in the world where 1.85 million residents are living in this narrow strip (PCBS, 2013). This population is concentrated in four cities, many villages, and eight refugee camps (Khalaf et. al, 2007; Metcalf and Eddy,2000). Geographically, the Strip is divided into five main governorates; The North, Gaza, Middle, Khan younis and Rafah governorates.

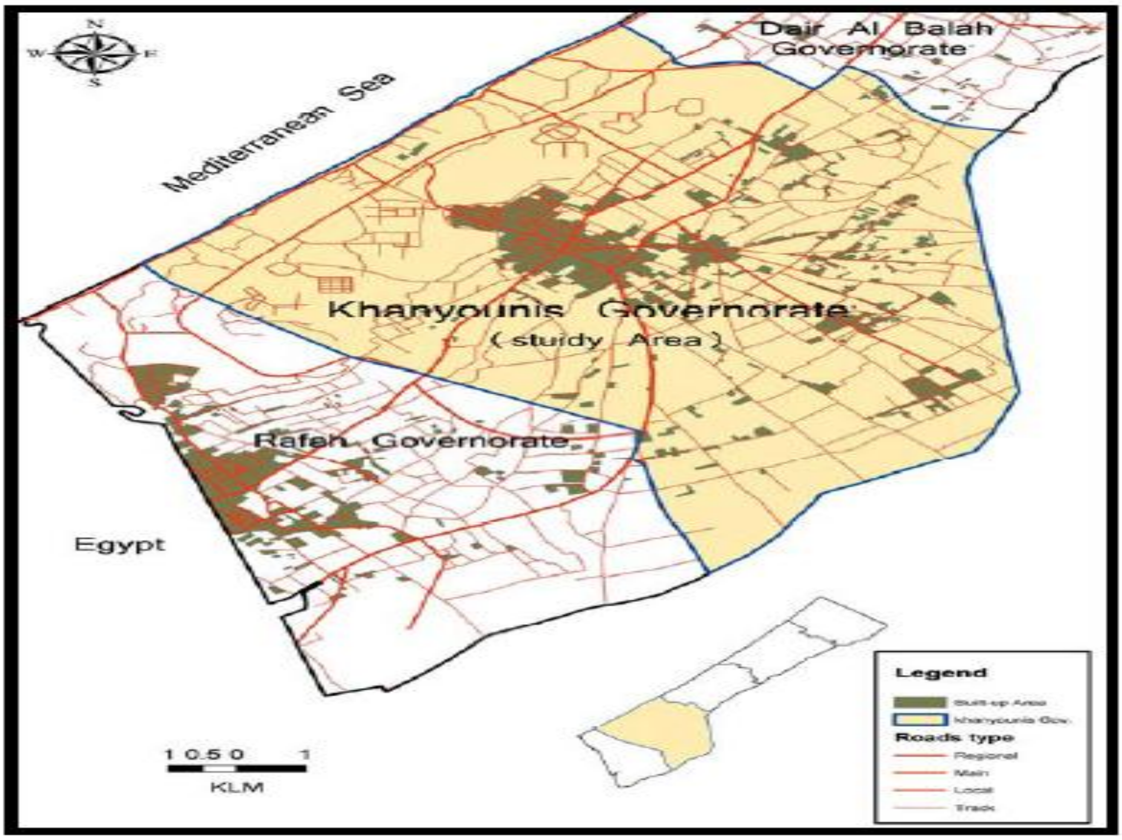


Figure (3.1): Location map of Khan younis Governorate (MoLG).

3.1.1. Location of Khan Younis Governorate

Khan Younis governorate is Located between latitude 31^{0} 15‘ 30’’ and 31^{0} 24‘ 20’’ north upper hemisphere and longitude 34^{0} 19‘ 11’’ and 34^{0} 22‘ 22’’ east. It is boarded from the north by Deir al-Balah, from the south by Rafah, from the east by the green line lands which was occupied in 1948, and the Mediterranean Sea to the west. (Farra,1997)

Khan Younis governorate area is about 116 square kilometers, which represents 30.59% of Gaza Strip area and over 0.41% of the area of historical Palestine. Khan Younis governorate includes a number of towns; Bani Sohaella, Abassan Saghera, Abassan Kabera, Khozaa, AL-Qarara and AL-Foukhariy. Khan Younis governorate constitutes of 7 municipalities, one for each town. In addition to 3 camps for refugees like north, south and west camp as the following:

1. Khan younis city municipality which includes (Downtown, Camp, AL-Amal, AL-Baten AL-Samen, AL-Mahta, AL-Kateba, AL-Sattar, Quezan AL-Najar, Quezan Abu-Rashwn, Sheikh Nasser, Maan, AL-Jalaa, AL-Tahreer, AL-Mawassi, AL-Nasser, AL-Salam, AL-Manara, Goret AL-Lout andAL-Qureen).
2. Abassan Kabera town municipality.
3. Abassan Saghera town municipality.
4. AL- Foukhariy town municipality.
5. Bani Sohaella town municipality.
6. AL-Qarara town municipality.
7. Khozaa town municipality.

3.1.2. Land Use

As noticed from satellite image in Figure (3.2) and referring to (appendix 3), the total area of the governorate is (116 km^2), but municipal authorities reach (97.8 km^2). The cultivated area in Khan Younis is (37.3 km^2). where (10.7 km^2) were cultivated via green houses, in addition to (13.7 km^2) were dedicated to seasonal crops in grain open fields and (12.9 km^2) were dedicated to fructification cultivation. This means that (38.12%) of Khan Younis municipals authorities areas are cultivated land area and (32.16%) of total governorate areas are cultivated land. Besides, about (18.1 Km^2)are arable lands. This means that 18.1 Km^2 out of 37.3 Km^2 are considered agricultural and arable lands occupying about (15.6 %) of Khan Younis governorate lands. (interviews with MoLG & MoA)

Khan Younis governorate master plan for 2013 identified build up area of (23,000) dounms, which represents (23%) of the total master plan area, compared to (950) dounms which are dedicated for industrial and commercial and representing about (1%) of the total master plan area. So, we can classify it as agricultural governorate. (see appendix 3 for more information)

Figure(3.2): Khan Younis governorate satellite image. (MOLG, 2012).

Demographic and social characteristics

In the census of 1997, Khan Younis Governorate population reached around (175,000) inhabitants, where as in 2007, Khan Younis Governorate population reached (270,979) inhabitants with a growth rate of (4.23%). It represents 19% of the Gaza Strip total population (PCBS, 2013).

PCBS population estimation (2013) illustrated that Khan Younis Governorate's population reached 369,048 inhabitants and for more information about the residential distributions over the municipalities see appendix 2.

3.1.3. Rainfall of Khan Younis Governorate

The governorate of Khan Younis is suffering from a sharp decrease in rainfall quantities of around 290 mm/year with 30 rainy days per year. This is because that Khan Younis is located in the transitional zone between the arid desert climate of the

Sinai Peninsula in Egypt and the temperate and semi-humid Mediterranean climate along the coast (Ajjur, 2012).

Reference evapotranspiration value in Gaza Strip varies from 2 to 3.03 mm/d in winter, and reaches its maximum value in summer at about 5.11 mm/d (Ajjur, 2012).

3.1.4. Khan Younis Governorate Water Distribution System Situation

The percentage of efficiency of Khan Younis governorate is (66%).This high efficiency is reflecting two things in this area. The first thing is referring to the efficiency of the water pipe network system within the domestic area which is obvious in old city and old zones. The other thing is referring to the Unaccounted For Water (UFW) which is seen in the illegal connections from the municipal wells towards the agricultural area of Khan Younis governorate.

Water distribution system in Khan Younis comprises of main transmission pipes, distribution pipelines, ground water storage tanks, wells, booster pump stations and control valves. The supply scheme in Khan Younis is an intermittent water distribution system which is prevalent in Gaza Strip, where the water distribution cycle is completed every 48 hour to 72 hour in other areas; this is due to the insufficient water infrastructure besides the scarce water sources. This system is controlled by manual operated valves located at the main feeders in the water network which may participate in worsening the network efficiency.

Quantity and quality are the main problems of drinking water in Khan Younis governorate. The shortage of water in Khan Younis municipalities are mainly caused by the distribution system losses which are estimated by (33 %) of the abstracted water quantities by municipalities. Over (99.7%) of Khan Younis governorate residents currently have access to water services, but unfortunately do not receive appropriate water quantities or qualities (Interview with CMWU, 2013).

The water distribution system in new towns are in good conditions. It was installed (15-23) years and most of the pipes in the network are made of steel, UPVC, and polyethylene. Unfortunately, the municipal water network services in Khan Younis city is poor condition. It was installed (25-45) years and the pipes in the network are made of spastoes, steel, UPVC, and polyethylene. So, the efficiency is not sufficient due to high rate of losses which are caused by leakage, illegal connections, and misreading of counters flow meters (Interview with CMWU, 2013).

3.2. Research Methodology

3.2.1. Data Collection

Data was collected from different sources and using different tools as follows:

3.2.2. Metrological Data

Metrological data is one of the most critical and essential required information for the research, where lots of literatures were reviewed including: scientific papers and research, relevant MSc dissertations in addition to scientific websites. Unfortunately;

Khan Younis have been suffered from data scarcity in addition to inappropriate documentation. So, metrological data was collected from scattered resources including Ministry of Agriculture (MOA), Coastal Municipalities Water Utility (CMWU), Khan Younis Governorate and Khan Younis municipalities' engineers and previous relevant researches.

3.2.3. Field Survey

During the study, the researcher used two deferent methodologies. The First was used for municipality through interviews with relevant institutes engineers and managers, to study the current water situation. The second was a questionnaire for farmers which discussed the effect of changes in their crops in case after the sea water desalination plant is existed. And to expect the future water consumption leading to understand the future situation of water desalination.

3.2.3.1. Data Collection by Inspection

Primary data are those data which were directly collected by the researcher. It included the direct observation during the field visits to: Khan Younis main water pumping station, existing desalination plant, several agricultural lands, tracking water distribution network operation, beside several interviews with farmers and operators.

3.2.3.2. Interview Data Collection

The essential data were the main stake for this research according to the unique nature of its field and the obligation of utilizing whatever available sources. So, the secondary data was collected from the relevant institutions such as: Palestinian Central Bauru of Statistics (PCBS), Palestinian water authority (PWA), Ministry of Local Government (MoLG), Ministry of Agriculture (MoA), Khan Younis Governorate, Coastal Municipal Water Utility (CMWU) and Khan Younis governorate municipalities.

3.2.3.3. Khan Younis Water Resource, Water Distribution Network and Meter Reading

Khan Younis water supply and demand quantities were mainly collected from the main responsible institutions for distributing water in the whole of the Gaza Strip including Khan Younis, which are PWA, CMWU, MoLG (for maps and water situation) and Khan Younis municipalities (for all data relevant to losses).

Water treatment and distribution in Khan Younis Governorate is being managed directly by Khan Younis municipalities and operated by cooperation of municipalities with CMWU. So, these two organizations had the main stake in providing all the sufficient data about water distribution network. As one of the research objectives is to assess the current water distribution systems on the per capita water consumption from meter readings and comparing it to the expected future demand in existing of desalination impacts, so, Khan Younis governorate water distribution system was comprehensively studied in order to assess the gaps that influence the per capita consumption.

To find out the amounts of water that reaching Khan Younis households, chronological data of water meter readings were obtained for the same period (2011-2013). The water losses data assess the differences between the pumped quantities and the meter readings reached to the households. So, comprehensive meetings were held with several employees at collective departments in Khan Younis municipalities.

3.2.4. Questionnaire Design

After exposure to the unaccounted for water (UFW) with relevant engineers and managers institutes, all of them reported that a huge part of water losses were used for agriculture purposes. Noticed that Khan Younis governorate municipalities do not grant any license for agricultural usage. So, farmers connected to the water municipal networks illegally. In addition, high staff of relevant institutes proved these assumption which is the detection of the agricultural illegal connections.

So the research oriented about relation between water losses percentage with agricultural ownerships areas located in urban areas. As a result there was need to make a questionnaire to find the relation connected between them.

To identify the agricultural water consumption of Khan Younis municipalities, the researcher must study land use of the areas to define the urban areas that located within municipal water networks borders. So; the researcher must study the water distribution networks system maps, to identify the agricultural urban holdings. But in the lack of actual maps, the researcher considered additional survey were taken from local residents to located municipal water networks borders.

A 6 members helped to identify the areas that may be close to municipal water service borders. They helped in identifying water municipals networks maps, and helped to identify the samples places as the questionnaire was done in semi urban areas only.

Questionnaire studied the affect of freshness of desalinated water on ownerships cultivated areas. The questionnaire for farmers related to the future situation after existing of desalination plant.

As the Questionnaire studied the affect of freshness after the sea water desalination plant existed, which is difficult for farmers to understand. The researcher made a workshop for his volunteers in order to understand the questionnaire, saving time and effort. Moreover, the researcher also conducted a structural interviews survey with farmers using his volunteers, to make sure farmers are understand the questionnaire well.

3.2.4.1. Water Distribution Zones in Khan Younis

As mentioned before, water distribution system of Khan Younis is an intermitted supply. So, Khan Younis was divided into water distribution zones in order to cope with the water scarcity. Due to the random spreading of the urban areas, in addition to the nature of urban agriculture in Khan Younis; the existing water distribution map was unclear. So, several interviews were held with Water Department and relevant staff in order to prepare a map for water distribution zones. These maps have a major impact on easing the determination of the water losses in the water network in order to determine the sample of questionnaire and location.

The water distribution networks maps of five municipalities, out of seven municipalities are in old documentation system, where municipalities were used papers not a new computerized programs for drawing their water networks.

Through the full cooperation from Khan Younis Municipalities with the researcher, water distribution network maps for Khan Younis governorate in most zones were developed utilizing hard copy. The network layout and characteristics were reviewed including all water pipes, water wells, …etc. Khan Younis and Abassan Kabera were the only two municipalities that have a moderate AutoCAD map that includes these data which ease the task.

Several interviews survey were held with farmers as questionnaire and the MOA relevant staff; in addition, to interviews with Khan Younis municipalities, to know how the urban agriculture behavior for the current situation. Then to understand how these regions are distributed in their agricultural activities, leading to identify future agricultural consumptions on the light of current losses. Developing an equations to expect the future situations depend on the cultivated areas.

3.2.4.2. Sample Size and Distribution Along Khan Younis Governorate

To determine and estimate the sample size referring to the sample would be In terms of the numbers you selected above, the sample size n and margin of error E are given by (Rasot, 2012)

$$x = Z_{(c/100)}^{2} * p(1-p)$$

$$n = {}^{N x}/_{((N-1)E^{2} + x)}$$

$$E = \text{Sqrt}[{}^{(N - n)x}/_{n(N-1)}]$$

Where

n sample sized needed.

N Population size which are the farmer are going to choose your random sample from whom 5659 farmer (source MOA, 2014).

P Fraction of responses that you are interested in taking 50% due to there is no old studies for Khan Younis governorate.

$Z_{(c/100)}$ Critical value for the confidence level c where the confidence level is the amount of uncertainty you can tolerate taking 95%.

E Margin of error is the amount of error that you can tolerate taking 5% as most common use for this equation.

By applying the equations to get the smallest sample required, the researcher finds out that the sample size is 360 samples. But it distribute along the ownerships (for less than 5 dounms, 5-20 dounms, 20-50 dounms, 50-100 dounms and more than 100 dounms) as seen in Table (3.1).

Table (3.1) Sample size distribution based on the size of land ownership. (MoA, 2014)

Land ownership categories	Area (dounms)	No. of farms	Sample size
0—05	2181	1072	69
05—20	6457	2191	141
20-50	9355	2009	129
50-100	9355	210	14
100+	6474	116	8
TOTAL	39462	5898	360

And due to the lake information of ownerships distributions for each municipality. the MoA survey the summation of areas for each holding category per municipality (MoA, 2014). To ease the work, the researcher distribute the related questionnaire samples due to their percentage of holdings areas, where the summation of each category areas per municipality is known from MoA. So, the researcher distributed the samples per municipality and each municipality divided into 5 ownership categories. Each category in specific municipality represent a percentage of total holdings areas in all municipalities for the same category. As seen in Table (3.2) it illustrate per municipality.

Table (3.2): Sample size distribution due to municipality

Municipality	Sample size					Total
	0-5	05--20	20-50	50-100	>100	
Al-Foukhariy	8	15	9	2	1	35
Al-Qarara	9	17	22	1	1	50
Abassan K	9	15	13	4	1	42
Abassan S	5	19	6	0	0	30
Khozaa	6	9	15	1	1	32
Bani Sohaella	8	18	16	1	1	44
Khan Younis	24	48	48	5	3	128
Total	69	141	129	14	8	360

But, because there are some holding which does not represent the actually, the researcher raised each holding in each municipality to 10 samples at least to be more accurate. There are some municipalities that do not have specific holdings which confused the questionnaire survey, moreover; the small number of samples does not represent the sample in the municipalities. All of the above is according to the research opinion, and the Table summations became 440 sample in order to be more accurate and representative like the Table(3.3).

Table (3.3): Sample size distribution for each municipality of Khan Younis Governorate

Municipality	Sample size					Total
	0-5	05--20	20-50	50-100	>100	
Al-Foukhariy	10	15	10	5	5	45
Al-Qarara	10	20	25	5	5	65
Abassan K	10	15	15	10	5	55
Abassan S	5	20	10	0	0	35
Khozaa	10	10	15	5	5	45
Bani Sohaella	10	20	20	5	5	60
Khan Younis	25	50	50	5	5	135
Total	80	150	145	35	30	440

3.2.4.3. Questionnaire Analysis with Software Program

The researcher used simple linear regression statistical model by Excel to analyze the questionnaire data. And using where this soft program within the Features Excel are Scheduled table data display, draw charts, multi- species and attractive. As a means of expression and representation of the data in an easy, store, organize and retrieve data easily (database).The Book of work can collect inside a large number of chips Securities diverse worksheets, charts and papers and papers charts. The possibility of adding all the shapes in the drawing toolbar in the worksheet. The researcher use Excel in Analysis of the survey, and to draw graphs presentations in process of data and drawing tools ease to the researcher developing and understand the relations.

(STATISTICA 10), the relationship between water losses percentile and cultivation types areas per holdings can be theoretically defined. So, with the hypothesized UFW scenarios, the different impacts on water losses indicated by the cubic meter where agricultural areas by dounms.

STATISTICA is statistical software used around the world in more than 20 countries. Stat Soft's STATISTIC line of software has gained unprecedented recognition by users and reviewers. In addition to both basic and advanced statistics, STATISTICA products offers specialized tools. where the researcher used the program to define the relationship between water losses UFW and cultivation types areas per holdings finding out the a linear regression relation. Also it enables statisticians and researchers to conduct data mining in order to check their models’ accuracy. One of the perfect abilities of this statistical software is the high quality graphs.

3.2.4.4. Expected Water Losses After the Sea Water Desalination plant

The researcher planned to make sure how the effect of farmer cultivations after the sea water desalination plant constructed would affect the water balance which seemed that the desalination is a solution for water problem. Moreover, the researcher needed to know the behavior of user after the proposed desalination plant would construct affecting by urban agriculture even the future impact of the yearly residential and agricultural consumption regime can be obtained.

Evaluating the system without losses is the challenge for the researcher in which some farmer thought that, if the residential usage from the ground water table is reduced to reach low proportions, the ground water table will increased and the water will become fresh of salts and pollutant. So, the water will become more fresh and appropriate for new agricultural type.

3.2.4.5. Cost Analysis on The Light of UFW

Finally, Willingness to pay is a type of valuation technique for non-market goods. Different survey methods are available for generating willingness to pay data. However, cost evaluation per desalinated cubic meter is more difficult, where there were two techniques of evaluation costs.

The first technique of cost analysis discuss two methods one of them mention that the user pay 3 – 4 % of the individual yearly income. And the other related to the old cost adding another limited cost for supporting by drinkable water referring to related institutes, which will discuss the two methods later in chapter four. The second technique of cost analysis also discuss two methods. One of them mention that the old cost of undrinkable water which pumped to the municipal water distribution system per cubic meter adding 25% of old cost to get the desalination cost per cubic meter. And the second method of evaluation the cost of desalinated cubic meter related to operation and maintaining costs, which discussed the two methods later in chapter four.

Chapter 4: Results & Discussion

Chapter 4: Results & Discussion

4.1. Introduction

To achieve the objectives which mentioned in the first chapter; firstly it is important to discuss and analyzing the municipal water meter readings and water supply. So, several meetings, interviews and field visits were conducted with CMWU in both HQ in Gaza City and its branch in Khan Younis city. Supplied water quantities were calculated from the CMWU and Municipalities records. Meter reading quantities were calculated by reviewing the recording meter quantities on special software managed by the collection department in CMWU- Khan Younis, in addition to meetings with Khan Younis Governorate Municipalities (Khan younis, Bani Sohaella, Abassan Kabera, AL-Qarara, Khozaa, Abassan Saghera and AL-Foukhariy Municipalities).

The current meter readings behavior was identified by assessing the current water losses situation. Water supply and meter readings behaviors were identified and compared. The comparison included the water distribution network efficiency and UFW for each municipality.

As agricultural activities form one of the basic income sources for Khan Younis's population, in addition to being the largest water consumer. So current Agricultural water consumption will be discussed, leading to develop general relation in between urban agriculture areas and UFW to expect the future losses of municipal water after the sea water desalination plant exist.

Water desalination process lay down as a solution for shortage of water which would be discussed as expectation on the light of municipal water losses of the networks.

Expecting the future desalinated water losses behavior in most Khan Younis governorate municipalities, connecting with expected future urban agriculture areas as the result of the questionnaire which done on farmers in Khan Younis governorate municipalities, specifying the future losses forecasting using the developed equation from the current agricultural activities.

Finally, discussing the soci-economical factor as a studying the current bills situation and expecting future costs after sea water desalination plant in terms of cubic meter unit cost.

4.2. Khan Younis Water Distribution System

The production of Khan Younis wells was around 15 MCM in 2013 and the meter readings was around 10 MCM, which means that the percentage of efficiency is 66% (Municipalities, 2013). This bad efficiency is reflecting two things in this area; the first thing refers to the efficiency of the water piped networks systems itself within the domestic area which is obvious in the old city and old zones. The second reason refers to the Unaccounted For Water (UFW) which is seen in the illegal connections from the municipal networks for agricultural purposes.

Quantity and quality are the problems of drinking water in Khan Younis, also The water shortage of the networks are mainly caused by the distributions systems losses which are estimated by 33% of the abstracted water by Khan Younis Municipalities. Over 99.7% of Khan Younis residents currently have access to water networks services, but unfortunately they are not receiving appropriate water quantities or qualities.

As well as, the daily average per capita water production is 111 L/c.d but actually the meter readings usage is 74L/c.d far below the World Health Organization recommendations for urban populations (Municipalities and CMWU, 2013). Khan Younis governorate water abstraction during 2013 reached 15 MCM, where the monthly production of the governorate in the same year varied from 970,592 m^3 to 1,472,354 m^3. The general monthly average of Khan Younis's ground water abstraction reaches 1,250,166 m^3, which means that the average annual abstraction will exceed 15 MCM.

Khan Younis governorates have 38 Municipal wells. Water is normally abstracted from 27 wells and discharged directly into the networks in the west area which covered 242,753 inhabitants (around 66% of total governorate populations). Including AL-Foukhariy municipality for a unique well, AL-Qarara municipality for 3 wells and Khan Younis municipality for 27 wells known have the most population concentration in the whole governorate as seen in Tables 4.1.

Table (4.1): Khan younis, AL-Foukhariy and AL-Qarara Municipalities (wells direct pumping to network).

Municipality	Numbers of wells support the system	Well No.	Well name	Year of construction	Production m^3/hr
Al-Foukhariy	1	P/159	Al-Foukhariy	2006	120
Al-Qarara	1	K-19		1999	60
	2	L-179		1988	80
	3		Al-Matahen	2012	50
Khan Younis	1		Al-Saada	2012	110
	2	L/41	Eastern	1960	90
	3	L/43	Aea	1961	80
	4	L/127	Al-Ahrash	1980	105
	5	L/176	Old South	1980	90
	6	L/159a	New Amal	1998	110
	7	L/182	New South	1998	115
	8	L/184	Rashwan a	2000	115
	9	Li/286	Rashwan b	2000	100
	10	Ls 4391	Rashwan c	2001	70
	11		Ryada city	2002	75
	12	L/190	North sattar	2002	40
	13	L/189a	New challenge	2003	90
	14		Maan	2003	110
	15		Al-Estad ryady	2005	70

	16		Al-Mawassi	2007	85
	17	L/198	Culture center	2007	55
	18		New sea	2008	35
	19		New sattar 1	2008	60
	20		New sattar 2	2008	45
	21	L/203	Un emarites	2009	60
	22	L/201	Un holand	2009	75
	23		Al-Rahma	2009	90
	24		Islamic relife	2009	50
	25	L/226	Turkish	2009	65
	26	L/223	Parents	2010	60
	27		Kawit	2011	80

Each well has its own pumping unit which consists of 2 to 4 pumps. On each pump station there is chlorination machine which injects the water with 1 mg/L or less of chloride. The current water supply system comprises water wells with its pumps, pipes which distributes water over the networks and others municipalities have elevated tanks as illustrate in the east area networks which is supported from an elevated tank covering the rest of Khan Younis Governorate populations.

Table (4.2): East Khan Younis governorate (supply from tank to network).

Municipality	numbers of wells support the system	Tank flow(m^3/hr)	Well No.	Well name	Year of construction	production m^3/hr
Abassan K	7 wells supporting one tank with capacity of 1000 m^3 and flow of 770 m^3/hr in total	240		AL-Najar	2003	80
				AL-Nowairy	2001	65
Abassan S		100		desalination station	2010	65
Khozaa		150	EV-01		1998	70
			EV-02		1998	70
Bani Sohella		280	EV-03		2000	70
			EV-04		2008	70

The current water supply system does not match between the water demand variations and the capacity of the wells pumps. Hence, during the peak periods the wells pump cannot provide adequate pressures due to the high demand. Consequently, the water system operators divide the community into distribution zones where each zone receives a specific water part of the daily parts for each municipality.

As a result of this distribution, the residents are used to reserve storage facilities over their roofs to meet their demand during the periods of shut off water supply. The current water distribution practice is not only uncomfortable to the customers but it requires a routine and tedious work of closing and opening isolating valves.

4.2.1. Operating of Khan Younis Water Distribution System

Operating the water distribution system in Khan Younis Governorate is not that difficult. Each member in each municipality needs to do his job to keep his eyes on measurements of system performance whether the measurements are in the form of pressure, flow or tank water levels.

Also, water system operations are inherently time-dependent and although the operations of a water distribution system appear to be simple, it may require a great deal of skill, especially if a system is complex especially in water and energy scarcity.

Water distribution systems can be operated either manually or automatically, but in the whole of Khan Younis governorate, the systems have been operated manually for years. Typically, operations are based on tank water levels. A liquid-level switch senses the water level in the water storage tanks. So, the operator will either turn a pump on or off depending on the water level in the tank. So, the ground water pump station in Khan Younis Governorate has human operators whose primary function is to monitor the pulse of the system and initiate actions based on system behavior. The criteria that the operator uses to indicate whether the system is operating properly largely depend on what is measured throughout the system.

Methods for distributing water networks depend on two methods of supporting the network with water as the following methods illustrate:

1. Direct Supply from Wells (DSW): this distribution scheme is used in 3 Municipalities.
2. Water Tanks Supply (WTS): In this scheme the water is being abstracted from 7 different wells at different times. And there is a unique water tank, which is 1000 m^3 in capacity and 770 in flow.

4.2.1.1. Operating Criteria

For all municipalities, operators operate pumps and valves so that wide pressures are maintained within acceptable limits. Although it is considered to be acceptable may vary from system to system, pressures in most cases should be kept above 207 kPa (2.07 bar) and below 689 kPa (6.89 bar) during normal operations. Pressures much be greater than 689 kPa tend to lose water through leaks and could damage residential and commercial plumping systems or possibly cause main breaks. A pressure of 207 kPa allows water to be supplied only to the top floors of a multistory building.

Depending on the nature of the water supply system, minimum pressures greater than 207 kPa may have to be maintained at certain locations within the system. For example, certain industries or hospitals may require a minimum pressure above 207 kPa so that equipment within the facility will function properly. If the water system sells bulk amounts of water to an adjacent communities, that community will require the water to be supplied at a minimum pressure of 345 kPa or higher. Operators must consider such unique circumstances in their operating decisions.

4.3. Water Production & Meter Readings in Khan Younis Governorate

Chronological data analysis revealed an existed gap between water production (pumped quantities) and the consumption (water meter readings). The following points will illustrate water production, consumption and the available gap for the previous three years of 2011, 2012 and 2013.

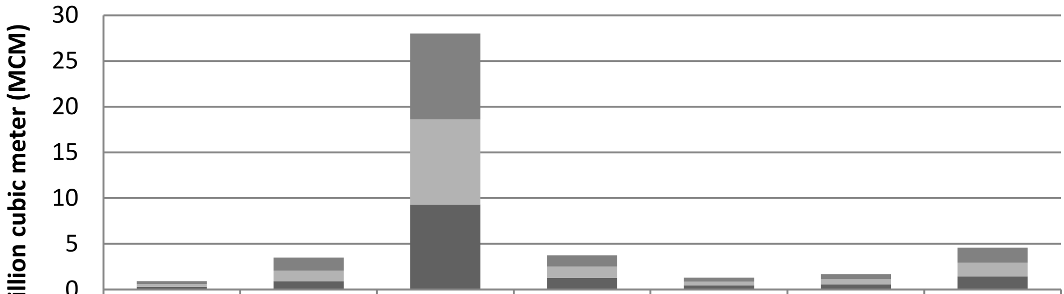
4.3.1. Water Supply

Structural interviews with water operation managers in the municipalities of Khan Younis governorate and the Costal Municipalities Water Utility (CMWU) who are the directors of the monthly variant production amounts.

Accuracy of the available data is a matter of concern, as before 2010, the data were recorded by field operators without the proper monitoring. So, more trusted data that was collected under a professional engineering supervision are available for the years of 2011, 2012 and 2013, as illustrated in the Figure (4.1 and 4.2).

The recorded production reached 14,322,328, 14,458,129 and 15,001,990 m3/year respectively for 2011, 2012 and 2013, respectively.

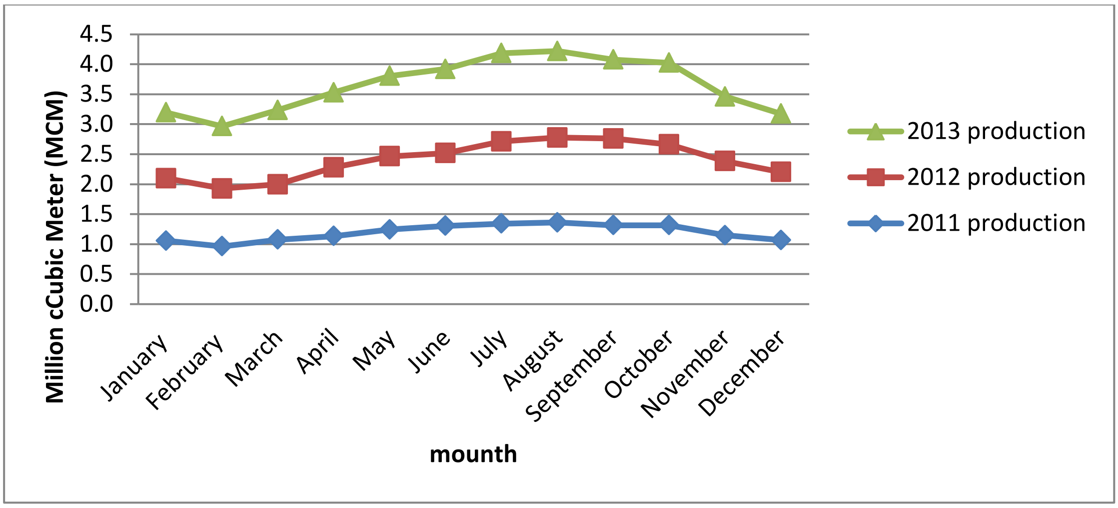
In Figure 4.1 it is clear that the water supplies quantity follow the population distributions. Where the highest population is in Khan Younis municipality. it is the only municipality has three camps in the governorate and due to the old city; So, it has the most population density over the whole governorate.



	AL-FOKHARIY	AL-QRARA	KAN-YOUNIS	ABSAAN k	ABSAAN n	KHOZAA	BANI SOHELA
2013	302,956	1,407,233	9,421,527	1,225,646	426,960	575,801	1,641,867
2012	322,800	1,154,065	9,278,072	1,242,439	413,690	535,270	1,511,793
2011	295,626	935,396	9,308,336	1,278,128	471,160	588,913	1,444,769

Figure (4.1): Annual supplied quantities per municipality (Municipalities,2014).

as seen in Figure 4.2 There is a slight chronological increment in produced water quantities in between each year which mean there is normal production due to increasing of populations. also another increasing per each year from June to October during three consequently years. This increasing is not very clear due to the short reference duration of three years, which lead to normal production due to the summer season where the production must increase.



Figure(4.2): Khan Younis governorate water production from municipal wells for years 2011,2012&2013 (Municipalities, 2014)

4.3.2. Water Distribution Zone in Khan Younis Governorate:

Water is being distributed in Khan Younis Governorate via two distribution techniques:

1. Direct supply system (DSS), in which the water is being pumped directly from the water wells to the distribution network.
2. Water Tanks supply system (WTSS), in which the water is being fed into the network from the storage tanks.

For information, there is some tanks in municipalities but it works as composite system with pump stations wells; so, the researcher decided to consider that as direct supply system. Also there is one unique tank fed only from wells and support area around 25% of whole governorate population. For this reason the research decided to study losses with system of distribution to ensure the system of distribution does not affect in water losses.

In this research Khan Younis Governorate is divided into two regions; the first region which use DSS in its municipalities including:-

1. Khan Younis Municipality.
2. AL- Foukhariy Municipality.
3. AL-Qarara Municipality.

And the second region which use WTSS in its municipalities including:-

1. Bani Sohaella Municipality.
2. Khozaa Municipality.
3. Abassan Kabera Municipality.
4. Abassan Saghera Municipality.

4.3.2.1. Direct Supply from Wells

The distribution scheme is used in 3 Municipalities out of the 7 Municipalities. Table (4.3) illustrates the water supply quantities for each Municipality.

Table (4.3): Direct supply from wells distribution scheme (including Khan Younis, AL-Foukhariy and AL-Qarara municipalities).

Municipality	Population (2013)	Water Supply (m^3/year)		
		2011	2012	2013
AL-Foukhariy	8256	295,626	322,800	302,956
AL-Qarara	22918	935,396	1,154,065	1,407,233
Khan Younis	242753	9,308,336	9,278,072	9,421,527

As noticed in the Table (4.3); the production of water due to each municipality does not follow the population distributions of each Municipality (notes these municipalities are form around 65% of the total abstracted water). even it does not follow increasing during yearly growth. So this system may cause losses but not within pumps station wells, also it happen within the network where it obvious from obsolescence of the networks itself. Moreover the municipal engineers mention that any losses may occur in the system (meaning from abstracted to the point before enter the network) can solved directly. it can detected by the deference between two meter readings one after abstraction well and the other directly before the water enter the network. After detect the losses it solve directly to avoid losses at this segment.

4.3.2.2. Water Tanks Supply

Water is being abstracted from 7 wells (different municipalities and at different times) to feed one storage tank of 1000 m^3 in capacity located in eastern region of Khan Younis governorate called Eastern Tank. There is some tanks in the other 3 municipalities but they work as composite system with pump stations wells. And in absence of production quantities, the researcher ignore them while they are working in a composite with DSS. But this Eastern Tank is fed only from the wells mentioned in Table (4.1) and the only resource for supporting the eastern near areas including 4 municipalities.

Table (4.4): Water tanks supply distribution scheme.

Municipality	Population (2013)	Water Supply (m^3/year)		
		2011	2012	2013
Abassan K	24760	1,278,128	1,242,439	1,225,646
Abassan S	8849	471,160	413,690	426,960
Khozaa	10589	588,913	535,270	575,801
Bani Sohaella	40062	1,444,769	1,511,793	1,641,867

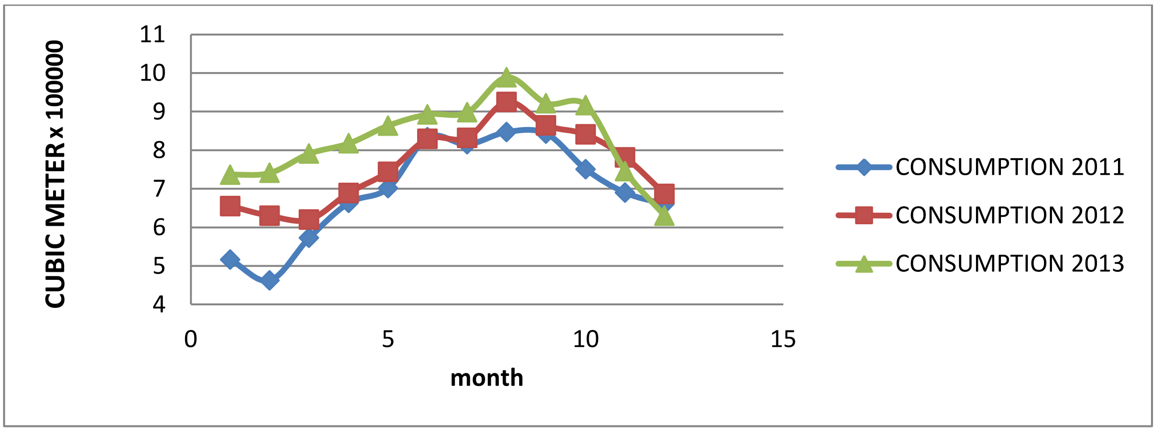
As noticed in the Table (4.4); in general in the distribution of water in Municipalities don't follow the population of each Municipality and it increase during years. Noting that these municipalities are form around 35% of the total abstracted water. Even it does not follow increasing during yearly growth. So this system may cause losses but not within pumps station wells even the storage tank, also losses happen within the network where it obvious from of the networks itself. Moreover in 2011 the CMWU invest 1 Million Dollar in rehabilitation the network and replacement of unfixed flow meter, leading to decrease losses and production quantities.

It is noticed that Khan Younis municipality represent two third of the total water supplied with 9,421,527 m^3 per year as (DSWS). Then Al-Qarara as (DSWS), Abassan K as (WTS) and Bani Sohaella as (WTS) are classified as around each other in terms of production quantities. Together are form more than one quarter of total water supplied.

So the losses do not related to the system of supporting the network distribution where the losses depend on the network itself. where the system of feeding for network as engineers of municipalities noticed that the meter readings after and before the water tanks are the same and if there is any losses it maintained directly, leading to ignore the effect of the division (DSWS) and (WTS).

4.3.3. Water meter readings

Structural interview with water operation manager and the collection department manager in municipalities of Khan Younis governorate revealed the monthly variant production amounts. To ensure the harmony between production and meter reading data; households' meter readings were collected for the past three years of 2011, 2012 and 2013. The recorded annual meter reading as illustrated in Figure (4.3) reached 8,355,122 m^3, 9,096,930 $m^3$and 9,942,298m^3 (Municipalities, 2013). Due to increasing in population, the annual meter reading (HHs' meter readings) is progressively increasing at the same period from June to October proportionally with water production quantities.



Figure(4.3): Khan Younis governorate water meter readings from municipalities for years 2011,2012&2013. (Municipalities, 2014)

Figure (4.4) illustrates the variant per capita consumed in terms of water meter readings quantity per each municipality. Khozaa is the municipality with the highest per capita meter reading during 2011, 2012 and 2013 with 126 L/c.d, 119 L/c.d and 106 L/c.d, respectively. And Khan Younis has the lowest per capita supply during 2011 and 2012 with 57 L/c.d and 65 L/c.d respectively, and AL-Qarara municipality has the lowest per capita supply of 60 L/c.d in 2013. All the lowest per capita meter reading is far below the world health organization.

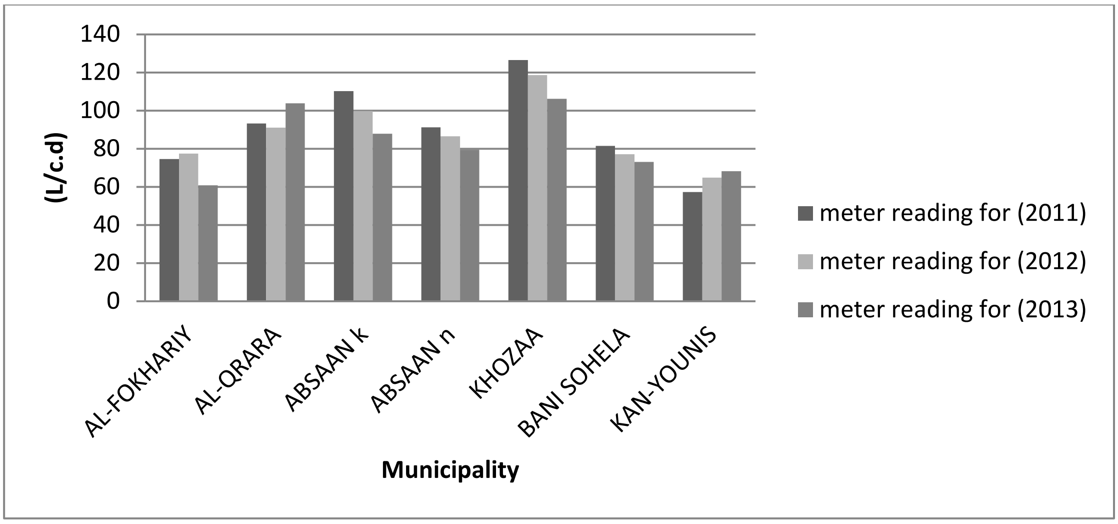


Figure (4.4): Meter reading per capital in each municipality of Khan Younis governorate municipalities.

Whereby these findings in Figure (4.4), match with the daily water supply rate in the developing countries, which is very low compared to the industrial world. In India, it ranges from 16 to 300 liters per day depending on the municipality and the economic strata (Singh, 2000), whereas. It ranges from 100 to 600 liters per day in the developed countries. Other populations that are not served by piped water supply receive even smaller amount of water.

4.3.4. Water Production vs. Meter Reading

Data analysis revealed that meter reading quantities verified by Households' water meter readings for the past three years in a way below the pumped quantities. The max average yearly gap between the produced and the actual meter reading quantities reached 5,967,206 m^3 in 2011, while 5,361,199 m^3in 2012 and 5,059,693 m^3 in 2013 Table (4.5).

This gap is considered as water losses which seems to be not really ok that amount is decreased along the increase of population and land use area; but all of this decreasing refer to CMWU investment over 4,500,000 US$ in all municipalities as engineer's notes.

The water losses reached 39.14% of the average produced water quantities during the three reference years over the governorate. So, domestic water consumers are receiving only 60.86% of their water entitlements.

Table (4.5): Production vs. Meter reading for KYG (2011-2013), (Municipalities, 2014)

	2011	2012	2013
Production (m^3)	14,322,328	14,458,129	15,001,990
Meter reading (m^3)	8,355,122	9,096,930	9,942,298
unaccounted (m^3)	5,967,206	5,361,199	5,059,692
Efficacy (%)	41.7	37.7	33.7

4.3.5. Water Distribution System Efficiency

For operation and maintenance purposes; Khan Younis Governorate is classified into 7 Municipalities. This classification is not representing the actual population concentrated over municipalities in Khan Younis Governorate, as the same municipalities are divided into different zones to ease the operational process. But in the lake of data for each zone the researcher prefer to deal with each municipality as one region.

Several interviews and meetings with Municipalities and CMWU- Khan Younis branch were conducted to retrieve the relevant data to calculate the network efficiency per each municipality. Water supplied quantities were calculated using the available records in the operation and maintenance department (see Appendix 1). The meter reading quantities were calculated by retrieving data from the water meter reading database in the collection department, during several long meetings with the database holder.

Table(4.6): Khan Younis water distribution network efficiency per municipality (2011).

Municipality	Production (m^3/yr) (2011)	Meter reading (m^3/yr) (2011)	Eff%	UFW%
Al-Foukhariy	295,626	198,850	67.3	32.7
Al-Qarara	935,396	690,780	73.8	26.2
Abassan K	1,278,128	996,158	77.9	22.1
Abassan S	471,160	294,607	62.5	37.5
Khozaa	588,913	488,761	83	17
Bani Sohaella	1,444,769	1,191,573	82.5	17.5
Khan Younis	9,308,336	4,494,393	48.3	51.7

Table(4.7): Khan Younis water distribution network efficiency per municipality (2012).

Municipality	Production (m^3/yr) (2012)	Meter reading (m^3/yr) (2012)	Eff%	UFW%
Al-Foukhariy	322,800	215,325	66.7	33.3
Al-Qarara	1,154,065	702,868	60.9	39.1
Abassan K	1,242,439	939,180	75.6	24.4
Abassan S	413,690	290,849	70.3	29.7
Khozaa	535,270	477,528	89.2	10.8
Bani Sohaella	1,511,793	1,174,237	77.7	22.3
Khan Younis	9,308,336	5,296,943	56.9	43.1

Table (4.8):Khan Younis water distribution network efficiency per municipality (2013).

Municipality	Production (m^3/yr) (2013)	Meter reading (m^3/yr) (2013)	Eff%	UFW%
Al-Foukhariy	302,956	182,951	60.4	39.6
Al-Qarara	1,407,233	867,596	61.7	38.3
Abassan K	1,225,646	896,664	73.2	26.8
Abassan S	426,960	289,585	67.8	32.2
Khozaa	575,801	462,863	80.4	19.6
Bani Sohaella	1,641,867	1,205,916	73.4	26.6
Khan Younis	9,421,527	6,036,723	64.1	35.9

Tables (4.6, 4.7 and 4.8) summarize the supplied and meter reading water quantities per each municipality during the three reference years of 2011, 2012 and 2013. Water distribution network efficiency was calculated per each municipality by dividing the metered (meter reading) water quantities on the supplied quantities. Unaccounted For Water (UFW) is the total water losses percentage.

Table(4.9): Khan Younis Governorate water distribution network efficiency per municipality in Average.

Municipality	Eff %			Av. Eff %	Av. UFW %
	2011	2012	2013		
Al-Foukhariy	67.3	66.7	60.4	64.8	35.2
Al-Qarara	73.8	60.9	61.7	65.5	34.5
Abassan K	77.9	75.6	73.2	75.6	24.4
Abassan S	62.5	70.3	67.8	66.9	33.1
Khozaa	83	89.2	80.4	84.2	15.8
Bani Sohaella	82.5	77.7	73.4	77.9	22.1
Khan Younis	48.3	56.9	64.1	56.4	43.6

Table (4.9) summarizes the average supplied and metered water quantities per municipality, in addition to the average efficiency and UFW percentages. Khan Younis is the municipality with the lowest efficiency 56.4%. It has two thirds of the population of the whole governorate. So, it is the municipality with the highest water losses. Followed by AL-Foukhariy and AL-Qarara. Abassan K, AL-Qarara and Bani Sohaella receive similar water quantities with huge differential efficiency. Khozaa, Bani Sohaella and Abassan K showed the highest efficiency with 84.2, 77.9 and 75.6%, respectively. Moreover, it illustrates that Khan Younis is the municipality with the lowest efficiency 56.4%, which means that 3,384,803 m^3 of the supplied water is being unaccounted for year 2013.

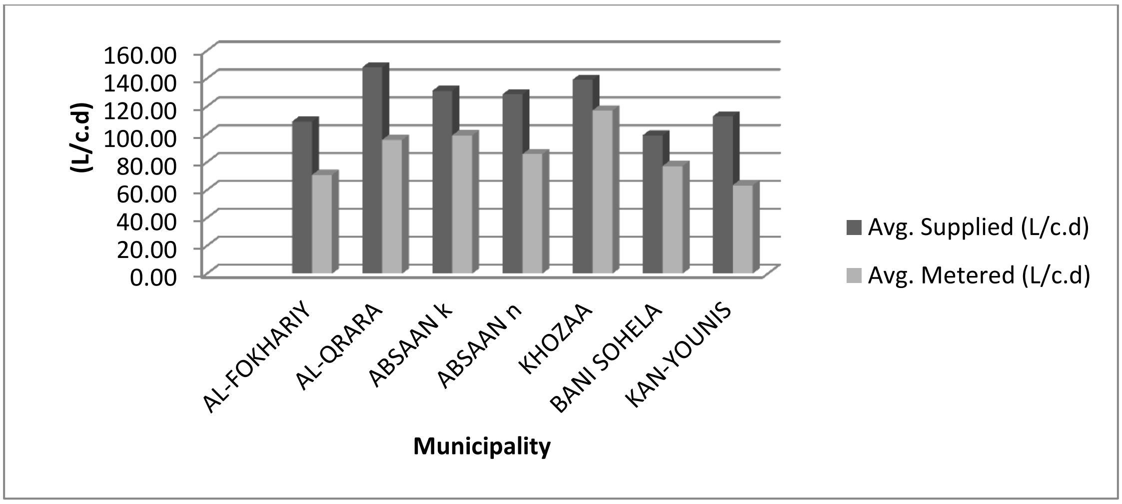
The Governorate UFW fits within an expected range of the MENA countries. UFW in MENA varies between 15% and more than 60%. UFW in well-run utilities is 15-20%, although the optimal level should vary depending on circumstances, such as particularly the cost of bulk water supply. The percentage of physical losses is influenced not only by the deterioration of the piped network, but also by the total amount of water used, system pressure, and the degree of supply continuity. The percentage of administrative losses depends on the degree of effort exerted in identifying illegal connections and in repairing meters (World Bank, 2009).

Dubai has reduced unaccounted-for water from 40% in 1990 to just 13% in 2004. Dubai has the best record on unaccounted-for water in the whole MENA region, beating Bahrain, which claims a Figure of approximately 15% as the difference between the amount of water produced and the amount of water meter reading(www.Globalwaterintel.com).

In comparison to Arab cities, Amman reached UFW of 34% in 2010, while Tunisia reached 18% since 2004 (Khan, 2011).

4.3.6. Water Per Capita in Khan Younis Governorate (2013)

According to Figure (4.5) and referring to Tables (4.6, 4.7 and 4.8) emphasize the critical per capita gap in the municipalities boarder for urban agricultural of huge holdings. Khan Younis is known for its small urban agricultural holdings. This municipality has the highest supplied water quantity and receives about double of the metered quantities. Followed by AL-Qarara, Abassan S and AL-Foukhariy.



Figure(4.5): Supplied vs. metered per capita meter reading for Khan Younis governorate municipalities.

It is obvious that there is a huge amount of water lost every day per person. So, it is unbelievable that the losses are only from leakages. There is some reason for these huge average losses (L/c.d) due to:-

1. This huge loss is reflecting two things in this area; the first thing is referring to the efficiency of the water pipe network system itself within the domestic area which obvious in old city and old zones and the problem with unfixed flow meter.
2. The other reason is referring to the Unaccounted For Water (UFW) which is seen in the illegal connections from the Municipality wells towards the agricultural area of Khan Younis without any monitoring or control.

Areas with agricultural activities at business scale are not consuming Municipality water as other areas with urban agriculture in different small holdings. Field visits and farmers interviews revealed that Business scale agriculture in the whole governorate depends totally on agricultural wells. This scale of intensive agriculture cannot cope with the scarcity of Municipality water.

4.4. Current Urban Agriculture Activities System

Urban agriculture is one of the most persistent approaches for supplying food in the Gaza Strip (Al-Najar, 2007). The quantity and quality of drinking water have deteriorated over the past two decades, due to the excessive use of irrigation water especially on the semi urban areas such as Khan younis, where farmers use the domestic network for irrigation purposes illegally. This leads to higher water supply per capita in AL-Qarara which apparently exceeds 168 L/c.d with lowest meter reading 60 L/c.d for 2013, leading to a huge amount of water were lost.

Accordingly, the urban agriculture will influence the efficiency of water network because it needs a huge amount of water, where it will discussed later. Agriculture is the prevalent sector of Gaza's economy and contributes to 32% of its Economic production (MoA, 2013).

"Agriculture in Gaza Strip is already more urban than rural" which was one of the conclusions of the Gaza Urban Agriculture Committee (GUAC) workshop in 2000, referring to the high degree of urbanization of the area, the potentials for urban agriculture in Gaza simply cannot be neglected.

Most of the agricultural areas are located within and surrounding the denser residential areas. Therefore, this type of agriculture could be classified as urban agriculture due to its location.

Moreover for Gaza Strip, olive and fruit trees (including:- Citrus and Fruits), vegetables and green houses are together cultivated close to the built up areas. Whereby the majority of irrigated area in Gaza Strip is estimated to be about 176,000 dounms and the total supply is estimated to be about 85MCM (Al-Najar, 2007).

This emphasized that, In the Gaza Strip irrigation practices are only based on the farmer's own experience. They determine when and how to irrigate crops based on the appearance of the soil. So, the irrigation practice exceeds the irrigation water requirement by 30% leading to overexploitation of groundwater and increasing the operational cost of water supply network (Al-Najar, 2011).

Gaza is still characterized by a rapid increase of population, expansion of cities and refugee camps. Large-scale export-oriented agricultural production has reached its limits of land-use availability At the same time, it confronted with the socio-economic demands related to food insecurity and the need for the coming generation. Chemically intensive, unsustainable farming practices are leading to soil degradation, depletion and contamination of the vulnerable water resources. Increasing competition among urban needs makes soil and especially water very limited resources.

The municipalities of Khan Younis have not a clear map showing the water distribution districts and the location of the wells. The proposed district division has been redrawn on the structure map of the municipalities.

All water wells were also redrawn on the structural map of whole municipalities. This map was not available for all municipalities on portable matter like arch map (GIS application) nor Auto Cade to the municipalities, but available in old documentation system with its final old constitutions and when the researcher tried to draw in familiar program some municipalities get ready but the data in that maps wasn't enough to get the aim specifying of agricultural holdings with their location.

So, using a team of 6 members selected from the urban areas to the survey. The team has good knowledge of urban and rural area. Using old Google map 2010 just to inform the team members and the helping of municipalities engineers**.** During the survey, the agricultural land in the areas each municipality water distribution has been well known by the team members and engineers of each municipality. Surveyed 100% of urban agriculture to make sure that it would be well distributed, known that the urban area does not depend on how far from residential. But if the area has reached a piping water services from the municipality or not, and Vice versa.

Determination of water distributions system have a significant impact in defining the water losses regions in the municipal water networks, leading to develops map for urban agriculture. This map was drawn and applied to the satellites map support by Google Earth 2010 of Khan Younis, which was completely different of the existed maps were used districts by Khan Younis Governorate nor municipalities water departments.

All maps were conducted by using the Google earth techniques which is available to the public with some assistances of researcher in cooperation with municipalities and local people as illustrate in Tables (4.10 and 4.11).

Table (4.10): Agricultural land in Khan Younis governorate districts by field survey (Municipalities; MoA, 2014).

Municipality	Area (dounms)	Built up area (dounms)	commercial area (dounms)	industrial area (dounms)	Agricultural area (dounms)
Al-Foukhariy	7082	942	6	0	6134
Al-Qarara	11746	2868	11	42	8825
Abassan K	10541	3320	14	0	7207
Abassan S	3951	1600	9	0	2342
Khozaa	4013	1473	8	0	2532
Bani Sohaella	5870	2073	15	0	3782
Khan Younis	54663	10517	644	201	42946
TOTAL	97866	22793	707	243	73768

Table (4.11): Types of agricultural land in Khan Younis governorate districts by type of cultivation (Municipalities; MoA, 2014).

MUNICIPALITY	Area (dounms)	Agricultural area (dounms)	Grains seasonal (dounms)	Vegetables in/out green house (dounms)	Fruits & olive cultivation (dounms)	Non cultivated area (dounms)
Al-Foukhariy	7082	6134	734	663	1193	3543
Al-Qarara	11746	8825	2662	516	1858	3789
Abassan K	10541	7207	2922	1248	1151	1886
Abassan S	3951	2342	506	366	336	1184
Khozaa	4013	2532	734	133	133	1531
Bani Sohaella	5870	3782	1143	538	593	1509
Khan Younis	54663	42946	4377	6770	6704	25448
TOTAL	97866	73768	13079	10234	11969	38890

It is clear that a field survey has been conducted by the researcher with the assistance of staff and held a workshop that aimed to understand the goals of the questionnaire. Besides, collecting data from municipalities, and making a survey on the farmers and their holding areas with the help of some volunteers. The field survey has been applied on more than 440 participants in the Municipalities of Khan Younis governorate. Its items focused on the proportion of the participant's land, and the type of agricultural cultivation areas, discussing the future of agriculture after the sea water desalination plant constructed and their effect on types of cultivation (The results of the questionnaire are shown in the appendix 4).

In addition, the division of the ownership into categories starting with 0 to 5 dounms, then from 5 to 20 dounms, from 20 to 50 dounms, from 50 to 100 dounms and finally more over 100 dounms. This portion system as a support as an advice from the engineer of MoA noted that the ministry use these categories as they held old studies that urban agriculture concentrate in the first and second categories, but there are some holding with more than 100 dounms and located in urban areas. Moreover, a lot of interviews have been held with engineers of MoA, engineers of the municipalities to discuss the questionnaire questions of the survey, to keep the variation of the final results from municipality to the other within the range, in addition to another meeting with engineers of the CMWU and other engineer from MoLG, Finally, several meetings with local people were held to understand the situation.

Table (4.12): Agricultural lands ownership in Khan Younis governorate districts by area of cultivation (municipalities; MoA, 2014).

Municipality	0 – 5 (dounms)	05 – 20 (dounms)	20 - 50 (dounms)	50 - 100 (dounms)	> 100 (dounms)
Al-Foukhariy	199	673	950	950	750
Al-Qarara	283	421	505	505	0
Abassan K	91	310	437	437	345
Abassan S	240	633	1274	1274	1006
Khozaa	253	904	1274	1274	1006
Bani Sohaella	221	492	650	650	0
Khan Younis	669	3024	4265	4265	3591

Table (4.12) means nothing in terms of losses, unless studying wells distribution in each municipality alone with their type of cultivation in each municipality to understand the relations between losses and urban agriculture. Khan Younis includes multi-communities that seems huge concentrations of residential like Khan Younis municipality, and other municipalities operates a policy of one clusters community that appeared in Abassan Kabera. Each municipality should be studied alone because each one has its own separated properties which means that each municipality will discuss its survey questionnaire result alone then discuss the result totally to develop a general equation connect current losses with current urban agriculture in Khan Younis governorate.

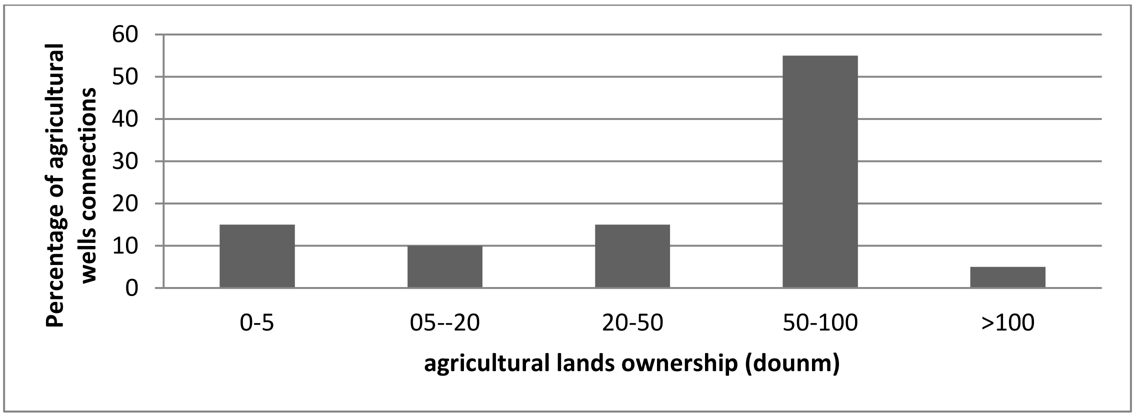
The survey will start with Khan Younis then Bani Sohaella, Abassan Kabera, AL-Qarara, Khozaa, Abassan Saghera and finally AL-Foukhariy. This sequence is due to the ascending arrange of capital distribution in each municipality over the governorate.

4.4.1. Khan Younis Municipality

According to the map of the municipality, we find that there is a large concentration of the population in the down town region, as well as the surrounding areas around the down town. The municipality represents approximately half of the area of the whole governorate, making it an important field of study.

Zones of agriculture formed in the outskirts of the city where the farmers plant grain, especially wheat. Before the Israeli withdrawal in 2005, most of the land belonged to the Israelis settlement, which are now known as liberated lands area.

The area of Khan Younis grain cultivation is concentrated in the western areas of the municipality. where the number of agricultural wells is about 172 wells abound where it concentrated in areas with olives and fruits trees cultivations areas where the north and south east areas of the municipality.



Figure(4.6): Relation between agricultural lands ownership and the percentage of irrigation wells connections depend on private wells in KYM.

When talking about agricultural wells and their relationship with agricultural holdings, there is huge concentrated due to new ownerships of liberated lands areas divided after the Israeli withdraw. Special for ownerships larger than 50 dounms up to 100 dounms, which are concentrated in the western regions, and spreads the cultivation of olives and fruits trees, where vegetables are less. The properties of more than 100 dounms cultivated with grains, so they do not need private wells because their crops depend on rain.

As for properties less than 5 dounms, the areas were not supported by water or fully services from the municipality as a result of its farness distance from residential areas of the population. These lands are distributed around Salah AL-Dien Highway, so people plant it as cash crops to gain capital cash. And they plant it depending on unlicensed wells generally for irrigation crops of olive and fruit trees in general.

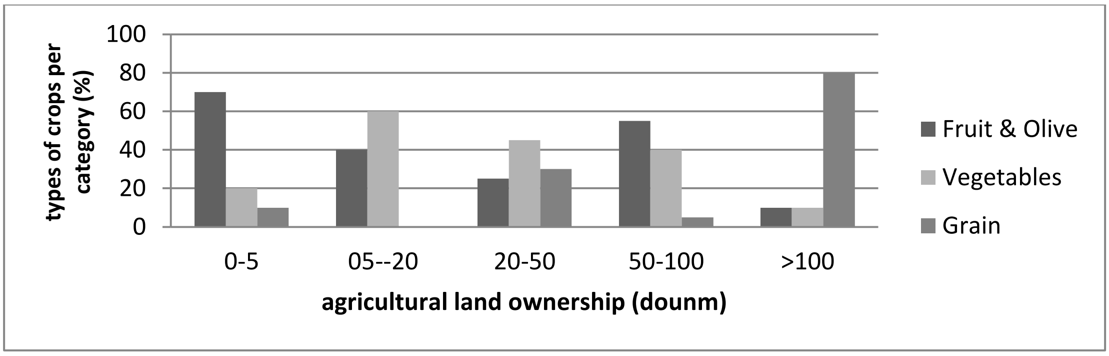


Figure (4.7): Relation between types of crop percentage per category and the ownership in KYM.

Tables (4.6, 4.7 and 4.8) showed the rates of losses during the past period stretching from 2011 to 2013, noting that the age of the network more than 80 years has to be said that most of the pipes decomposed. The municipality invested in the network, only 3.5 million US dollars over the specified period (2011-2013). Including renewal of some networks, as well as changing 820 flow meter in cooperation with the CMWU which led to improve in the efficiency of the network by (15.8%) and only during the period specified.

In general, the agricultural areas are relatively far from the municipal water system services where full concentration of population and the agricultural areas commonly are large agricultural holdings. Leading to spread cultivations of grains cultivation which classified as rainfed cultivation.

For year 2013, the amount of losses was (3,384,804 m^3) and the cost for one cube as the municipal tariff system was (1.5 NIS/m^3) as (0.42 US$/$m^3$). This is appeared semi-high for water that is not drinkable so the total price of lost water is (1,421,617 US$/year 2013). On the other hand, the large holdings depend on their own agricultural wells even their wells are licensed or not.

The total agricultural holding distribution for each type according to the questionnaire survey as general issue. The MoA helped to identify the summation of each category of agricultural lands for each municipality of the whole governorate the result was as illustrate in the following Table (4.13).

Table (4.13): Distribution of lands over holding category in KYM.

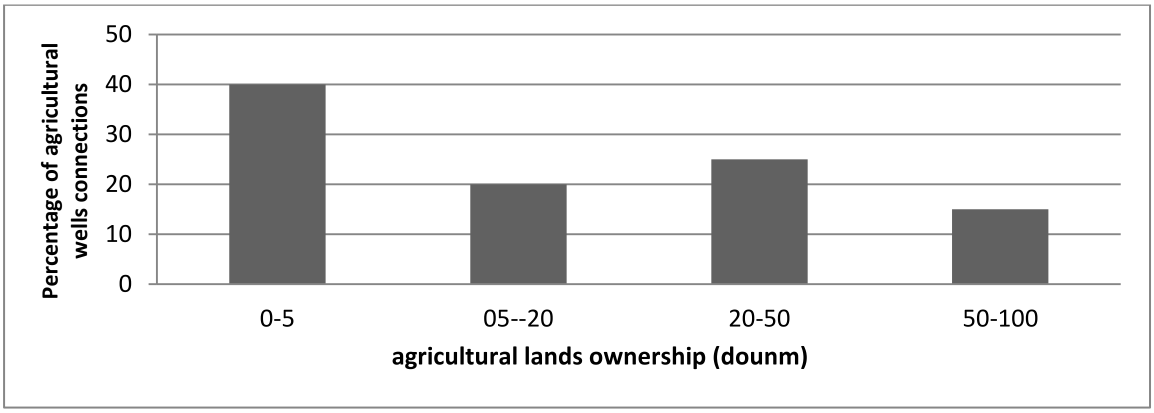
	Category	Area (dounms)			
		Fruits and Olives	Vegetables	Grain	TOTAL
Land owner ship	0-5	625	179	89	892
	05—20	1210	1814	0	3024
	20-50	1066	1919	1279	4264
	50-100	3467	2521	315	6303
	>100	337	337	2694	3366
TOTAL		6704	6770	4377	17852

From Table (4.13) it easy to identify the amount of crop water requirements and defining amount of water which is related to type of cultivation. And referring to appendix 4, where it illustrate the distributions of ownerships areas based questionnaire result. For example the fruits and olives trees required (4,947,773 m^3/year). And the Vegetables (including all type of vegetables inside and outside green houses) required (4,592,445 m^3/year) and for grins it does not require any water due to it rainfed agriculture.

4.4.2. Bani Sohaella Municipality

The municipality of Bani Sohaella is one of the relatively large municipalities in terms of area and population. It was noticed a decrease in the rate of losses during the year 2011 and rising losses on years 2012 and 2013 due to detecting of agricultural illegal connections.

The municipality does not distribute specific license for agriculture usage, but it is the only municipality that have coordinated with the MoA to license Agriculture wells located within the municipality borders. Where the domestic wells use to support the elevated tank that serve the surround domestic east areas located in the municipality border.



Figure(4.8): Relation between agricultural lands ownership and the percentage of irrigation wells connections depend on private wells in BSM.

When discussing the agriculture regions which depend on agricultural wells, it has reached to 14 privet agricultural wells and distributed logically, representing 100% of Figure (4.8). Concentrated in owning that less than 20 dounms, where they focusing their agriculture on fruit and olive trees. Although ownerships are near the municipal water services, and owners are facing massive problem to get water from agricultural licensed wells in that region. Moreover, the farmers need to buy water from local wells near their holding whatever if it licensed or not, so farmers need to achieve higher profit in their crops through the their cultivations. While the result of the questionnaire for the using of wells shows that these holder depend on their licensed wells but this is not true. They guess the questionnaire one tool of the powered institutions so there might be a bios for these result.

The original small agricultural areas would be divided to more and more small areas leading to end the career of agriculture. So ownerships and the farmers were aware that focused on the cultivation of fruits and olives trees. In addition this is normal where this types counter cash cultivation. Most of farmers worked in civilian careers non-agricultural ones, where they planting as possible to achieve maximum profit. Such small holdings where it need relatively little attention requirements and because they works in other jobs to reach relatively high profit increasing rates of their capital income.

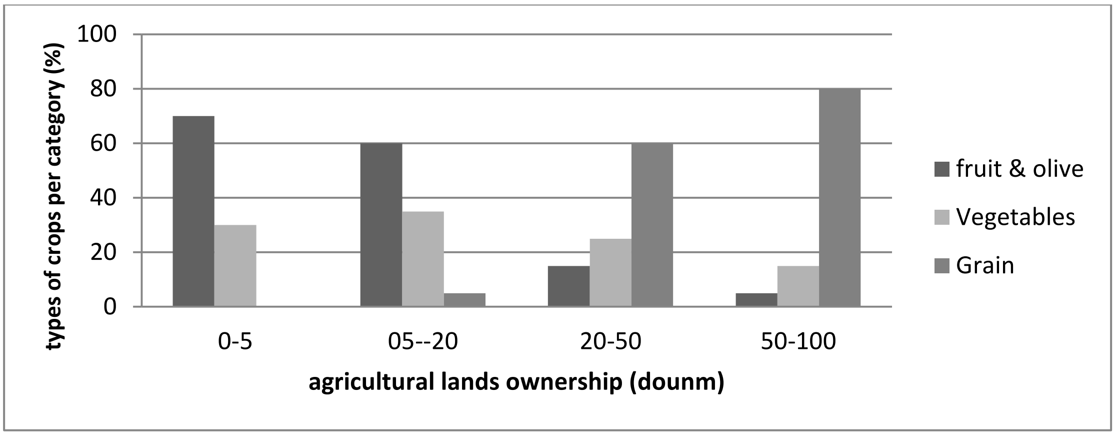


Figure (4.9): Relation between types of crop percentage per category and the ownership in BSM.

Farmers with holdings more than 20 dounms focused on the cultivation of grain because it is cheaper than any of the plantings types, where owing more land does not reflect the wealth. So, the low per capital income for the farmer's family in that holdings force them to plant these cultivation type leading to high profit percent.

For year 2013, the amount of losses was (435,951m^3) and the cost for one cube meter as the municipal tariff system was (1.8 NIS/m^3) or (0.51 US$/m^3). This is appeared too high relatively with water that is not fresh, so the total amount of water that lost is (222,335 US$/year 2013). In the other hand, defining the agricultural lands in the fundamental of holding with their type of agriculture with known the MoA helped to identify the summation of each category of agricultural lands. The total agricultural holding distribution for each type of crop depends on the survey as general issue for each municipality of the whole governorate as illustrate in the following Table(4.14).

Table (4.14): Distribution of lands over holding category in BSM.

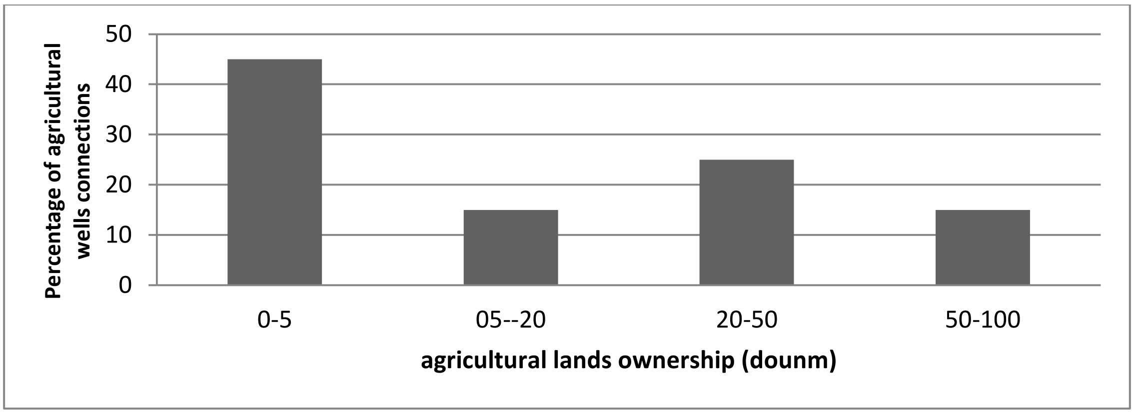
	Category	Area (dounms)			
		Fruits & Olives	Vegetables	Grain	TOTAL
Land owner ship	0-5	155	66	0	220
	05—20	295	172	25	492
	20-50	98	163	390	650
	50-100	45	136	728	909
	>100	0	0	0	0
TOTAL		593	537	1142	2273

From Table (4.14) it is easy to identify the amount of crop water requirements and defining amount of water which related to type of cultivation. Referring to appendix 4, where it illustrate the distributions of ownerships areas. Therefore, It illustrates that the total amount of water required is (437,707m^3/yr) for fruits and olives trees and (368,324 m^3/yr) for vegetables these notes are important in debussing situation over the whole governorate.

4.4.3. Abassan Kabera Municipality

Referring to the losses Tables (4.6, 4.7 and 4.8), they may be close to each other, and when you talk about this municipality you should note that it got last year certificate of best municipality processing losses over water distribution system. The municipality had to detect a lot of illegal connections, but the majority was used in domestic areas and for human usage.

The most private wells are considered agricultural in terms of the number and amounts of quantity produced relatively to the areas of cultivated land and the developed relation as in Figure (4.10). It's clear that, there is relatively acceptable distribution per holding where the owner of less than 5 dounms are considered the most user for wells although their holding are small ownerships.



Figure(4.10): Relation between agricultural lands ownership and the percentage of irrigation wells connections depend on private wells in AKM.

It is noted that the municipality did not give licenses to farmers to get water from the municipality. Because the municipality is facing difficulties in providing water supply for domestic, as the number of residents of the municipality is (27,952) inhabitant.

However, wells are concentrated in areas with properties less than 5 dounms, and it should be noted that the number of wells is 25 wells to irrigate crops and especially rain fed trees.

The properties of agricultural fructification trees are concentrated in holding which is less than 20 dounms, where the cultivated fructification trees constitute the best economic return.

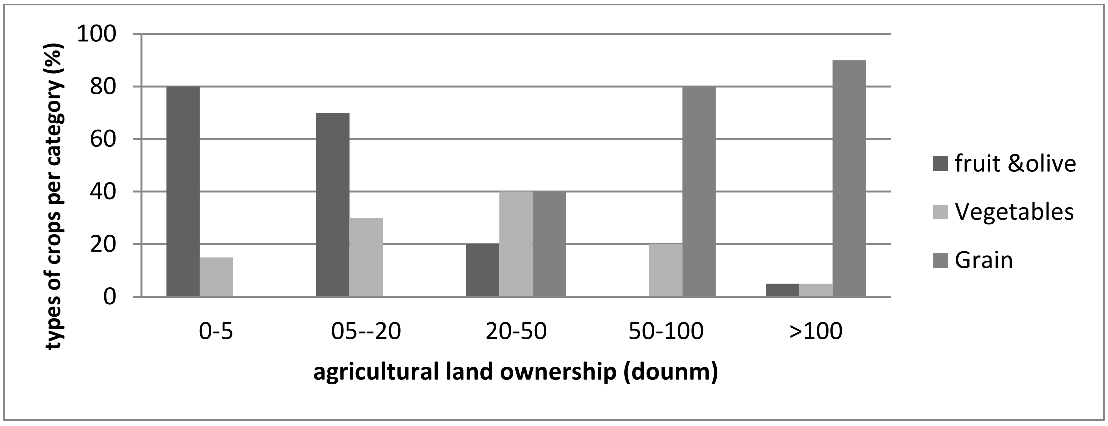


Figure (4.11): Relation between types of crop percentage per category and the ownership in AKM.

Concerning the agricultural holding greater than 20 dounms, the cultivation of grains is concentrated in those properties, especially the eastern areas. Where the fact that it has border with Israel, as the Israeli Bulldozers have been took off their cultivations. So, grains cultivation is the best use of their lands and private holdings where the form of grain cultivation considered as cash crops, where turning to other products to increase the products expired time more like wheat flour.

The population is concentrated in the area, where the city began with one group and others came and lived around this group and expanded in the form of semi-circular. Thus, the region became agricultural land outside the boundaries of municipal services which affected farmers to take their daily water by buying water from local wells or taking water through illegal unlicensed wells.

For year 2013, the amount of losses was (435,951m^3) and the cost for one cubic meter as the municipal tariff system was (1.8 NIS/m^3) = (0.51 US$/$m^3$) this is appeared too high relatively with water that is not fresh or drinkable so the total price of water that lost is (222,335 US$/year 2013). So, now defining the agricultural lands in the fundamental of holding with their type of agriculture is illustrated in Table (4.15).

From Table (4.15) it easy to identify the amount of crop water requirements and defining the amount of water which is related to type of cultivation (Al-Najar, 2007). And referring to appendix 4, where it illustrate the distributions of ownerships areas based questionnaire result.

Table (4.15): Distribution of lands over holding category in AKM.

	Category	Area (dounms)			
		Fruits & Olives	Vegetables	grain	TOTAL
Land owner ship per person	0-5	213	40	0	253
	05—20	633	271	0	903
	20-50	255	510	510	1274
	50-100	0	377	1507	1883
	>100	50	50	905	1006
TOTAL		1151	1247	2921	5320

Therefore, It illustrates that the total amount of water required is (849,438 m^3/yr) for fruits and olives trees and (854,743 m^3/yr) for vegetables. These notes are important in comparing the current and the future situation over the whole municipalities.

4.4.4. AL-Qarara Municipality

The importance of this municipality in the cultivation of wheat in the whole governorate is referred to:-

1. After the Israeli withdrawal in 2005, the area of the municipality increased about 2000 dounms which was holdings for public not for the government and fall under the ownership of relatively large holdings areas. This in turn led to the spread of the grain cultivation, especially wheat.
2. For the large areas added to the municipality, it is difficult to provide water services to those areas with large areas which need years to support with water services.
3. The presence of wheat mills in the local area encouraged farmers to plant wheat.

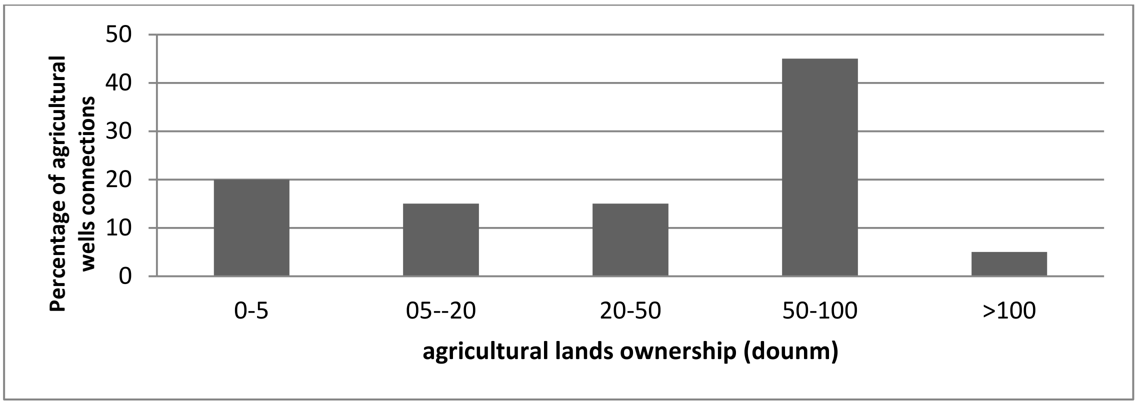


Figure (4.12): Relation between agricultural lands ownership and the percentage of irrigation wells connections depend on private wells in QM.

The number of agricultural wells has reached 11 agricultural wells. They are concentrated in the holding of 50 dounms and up to 100 dounms with cultivated of flower and fructification trees and vegetables leading to make the regression as zigzag line.

The availability of cash helps the farmer to cultivate similar types of crop cultivation that it does need high attention by larger farmers holding and generate relatively high profit. Leading to make farmers able to buy water from local wells, which reached to 7 agricultural wells surrounding those areas.

Thus, the salinity of the ground water in the municipality forced the farmers to be unable to irrigate their crops using ground water. Where availability of municipal water services are close to their lands, which encouraging them to use connect illegally to the municipal water distribution system for small ownerships. This means that category has ownerships less than 5 dounms, which seems to be neighboring with water distribution system network, it closed to urban residential areas.

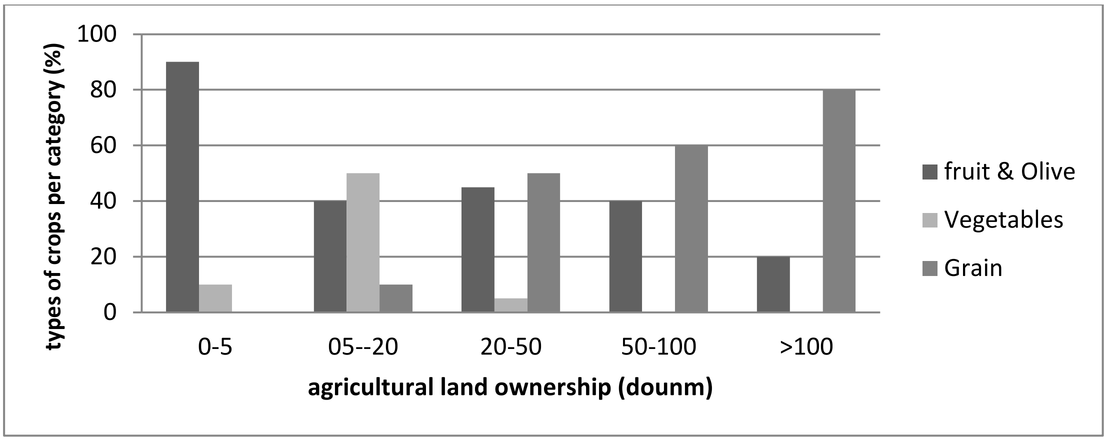


Figure (4.13): Relation between types of crop percentage per category and the ownership in QM.

As for the holding less than 5 dounms where fortification cultivation is common, it should be noted that there are 2 wells. The amount is not enough for irrigation in those areas.

Considering for year 2013, the amount of losses was (539,637m^3) and the cost for one cube as the municipal tariff system was (1.2 NIS/m^3) as (0.34 US$/$m^3$).

This appears relatively cheap with water that is not fresh or drinkable. So, the total amount of lost water is (183,476 US$/year 2013). So, it seems to be too much little due to the decrease of cubic meter cost. On the other hand, the lands are distributed to holding, the large holding depends on its own agricultural wells even their wells are licensed or not. Defining the agricultural lands in the fundamental of holding as illustrated in the Table (4.16).

Table (4.16): Distribution of lands over holding category in QM.

	Category	Area (dounms)			
		Fruits & Olives	Vegetables	grain	TOTAL
Land owner ship per person	0-5	240	0	0	240
	05--20	90	452	90	632
	20-50	573	64	637	1274
	50-100	753	0	1130	1883
	>100	201	0	805	1006
TOTAL		1858	515	2662	5036

From Table (4.16) it easy to identify the amount of crop water requirements and defining the amount of water which is related to type of cultivation (Al-Najar, 2007). And referring to appendix 4, where it illustrate the distributions of ownerships areas based questionnaire result. Therefore, It illustrates that the palm trees grows, it require more care in initial stage including irrigation until the roots directly start to search for ground water. After growing it doesn't need irrigation, so we are going to neglect it during the study. Thus, the total amount of required water is (1,371,499 m^3/yr) for fruits and olives trees and (353,117m^3/yr) for vegetables these notes are important in debussing situation over the whole governorate.

4.4.5. Khozaa Municipality

By discussing the rates of loss with municipal engineer, we noticed a decrease in the rate of losses during 2012. It is illustrated that during November and December 2011, the municipality detects 19 illegal links and all of them were in agricultural areas for agricultural usage, They were used for greenhouses, olive and citrus cultivation. During 2013, 9 illegal links have been shut down, in addition to replacing 22 unworkable flow meter, which leads to the value of losses expectations down during future referring to Tables (4.6, 4.7 and 4.8).

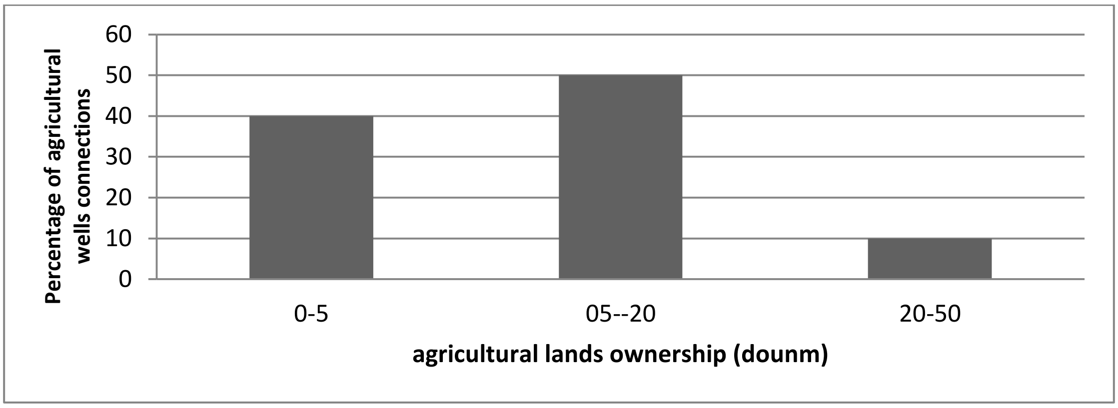


Figure (4.14): Relation between agricultural lands ownership and the percentage of irrigation wells connections depend on private wells in KM.

Detecting illegal links were one of the co-operations between the society and the municipality. It should be noted that the municipality has its international border with Israel, so, the region has been attacked by the IDF bulldozers in which the plant has been took off. Which leads to push the farmers to cultivate the eastern regions with grains and western regions with fruits and olives trees.

As for the small holdings, it should be noted that there are about 7 wells, which is not enough for irrigation where the developed relation is logical where owner of small holding have the most wells distributions.

And when talking about the types of crops in those areas, it is noted that plants of vegetables is controlled by categories with less than 20 dounms, which relatively was high, where farmers focus on the vegetables for this categories depending on their own privet agricultural wells.

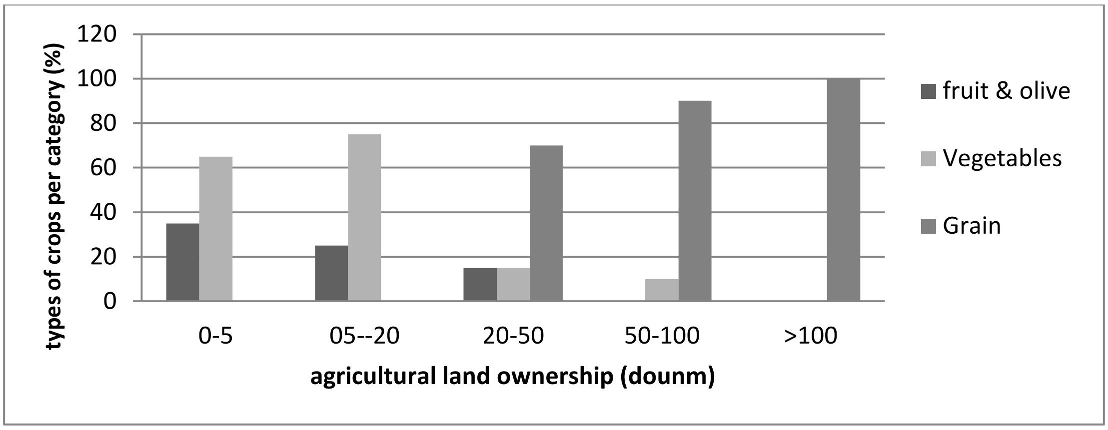


Figure (4.15): Relation between types of crop percentage per category and the ownership in KM.

As for the properties of more than 20 dounms, they mainly plant grains like wheat to cover their needs of market. It spread in the eastern region, which had been attacked by the IDF Bulldozers in which the plant areas has been took off.

Considering the amount of losses in (US$) for year 2013 and the relation with agricultural land, the amount of losses given from Tables (4.6, 4.7 and 4.8) was (112,938 m^3/year 2013). And the cost for one cubic meter as the municipal tariff system was (1.8 NIS/m^3) in dollar (0.51 US$/$m^3$). This is appeared high relatively to water that does not fresh nor drinkable so the total price of water that lost is (57,598 US$/year 2013). And referring to appendix 4, where it illustrate the distributions of ownerships areas based questionnaire result. The agricultural lands in the fundamental of holding according to their type of agriculture are illustrated in the following Table (4.17).

Table (4.17): Distribution of lands over holding category in KM.

	Category	Area (dounms)			
		Fruits and Olives	Vegetables	grain	TOTAL
Land owner ship per person	0-5	27	64	0	91
	05--20	62	217	31	309
	20-50	44	87	306	436
	50-100	0	65	581	645
	>100	0	0	345	344
TOTAL		133	432	1263	1829

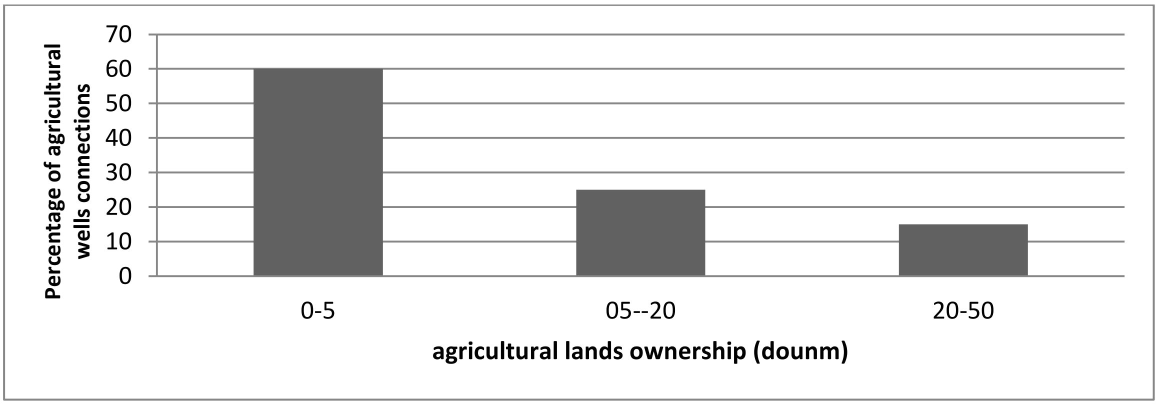
From Table (4.17) it is easy to identify the amount of crop water requirements and defining amount of water which related to type of cultivation. Therefore, It illustrate that the total amount of water required is (98,227 10^3 m^3/yr) for fruits and olives trees. And (296,536 m^3/yr) for vegetables these notes are important in debussing situation over the whole governorate (Al-Najar, 2007).

Some farmers purchase water from the unlicensed wells making it easier for owners of agricultural unlicensed wells to continue their illegal work.

4.4.6. Abassan Saghera Municipality

The Abassan Saghera municipality is one of the municipalities relatively small in terms of area. The arable area reaches two thirds of the total area of the municipality and the total area of cultivated lands about a quarter of the municipality.

The agricultural wells in the municipality are approximately eight. They are sufficient for crops needs. In Figure (4.16) shows the distribution of agricultural wells over holdings categories.



Figure(4.16): Relation between agricultural lands ownership and the percentage of irrigation wells connections depend on private wells in ASM.

The area is dominated by growing vegetables and grains with no access to water services of networks water. The farmers buy water from local wells near their households. On the contrary, water is not available in abundance in areas, where populations are not sufficient, for the purposes of irrigation of different types crops.

wells are concentrated in areas dominated by the properties less than 5 dounms by more than 60% in terms of the distribution of agricultural wells. Moreover, the farmers need to buy water from local wells near their holding whatever it licensed or not.

Moreover, the municipality contains more than 50 dounms holdings, but this municipality is the only one in which there is no cultivated ownerships for more than 50 dounms. So, the researcher excluded these households from the study.

Also, it is noted that this municipality have the least percentage in the number of farmers to the population (interview with MOA), because some of those who work as agriculture farmer join to civilian jobs. Therefore, the society became more civil society rather than agriculture.

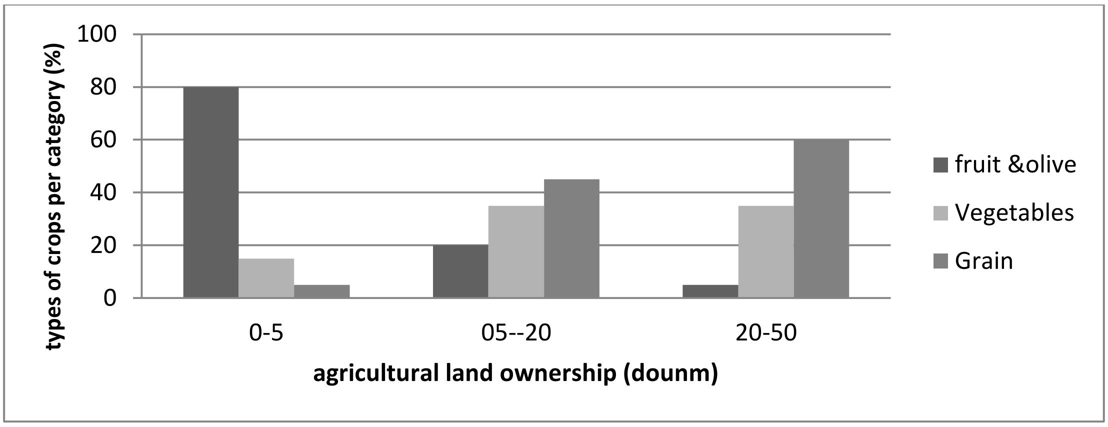


Figure (4.17): Relation between types of crop percentage per category and the ownership in ASM.

As for the farmers with their household less than 5 dounms, they focus more strongly on the fructification trees. The fact that they make them the highest profit and less attention in agricultural terms of working in civilian jobs not agriculture ones, which make high rates of income relatively.

Considering the amount of losses in (US$) for year 2013, and the relation with agricultural land, the amount of given from Tables (4.6, 4.7 and 4.8) losses was (137375 m^3/year2013) and the cost for one cubic meter as the municipal tariff system was (1.8 NIS/m^3) in dollar (0.51 US$/$m^3$). This is appeared high relatively with water that does not fresh nor drinkable so the total price of water that lost is (70,061 US$/year 2013).

Defining the agricultural lands in the fundamental of holding with their type of agriculture. Known that the total agricultural holding distribution for each type depend on the survey general issue for each municipality of the whole governorate known the summation is considered as illustrate in Table (4.18).

Table (4.18): Distribution of lands over holding category in ASM.

	Category	Area (dounms)			
		Fruits & Olive	Vegetables	grain	TOTAL
Land owner ship per person	0-5	227	43	14	283
	05—20	84	147	189	421
	20-50	25	177	303	504
	50-100	0	0	0	0
	>100	0	0	0	0
TOTAL		336	366	506	1209

It is illustrated that the total amount of water required for fruits and olives trees is (248,041 m^3/yr), and (251,052m^3/yr) for vegetables. These notes are important in debussing situation over the whole governorate. All water required is in average within relation to the of types of agriculture and the average of their amount of water required for the main type cultivation. Over Gaza Strip in general, and for grins it does not require any water due to it fruit and olives trees agriculture.

4.4.7. AL-Foukhariy Municipality

Referring to Tables (4.6, 4.7 and 4.8), and noting that the losses in the municipality have jumped from constant during 2011 and 2012 to an increase in UFW to more than 17 %, due to increasing in the cultivation of citrus fruits by 10 % as well as the cultivation of olives up to 3.5% in 2013. Moreover proportion of plants in nature fruit trees reached up to 5% of the total area which is relatively low. In addition to the number of agricultural wells in the area is zero due to the high salinity of the water. Which pushes farmers to import water from outside the municipality especially from the land north of Rafah governorate, and the neighboring municipalities for the western and north regions. Noting that the municipality does not grant special licenses for agricultural usage from the municipal networks, which forced some residents to sell part of their ownership to finance their farming or even mortgaged to banks for funding.

When considering farmers, who have tended to plant vegetables and grains, the fact that these farmers work as a professional of career not to increase their profit, where they import water from outside of the municipality boundaries. Because of the soil is appropriate for growing vegetables effectively and grain. They focus on the cultivation for wheat, where the cultivation of wheat depend on rain water.

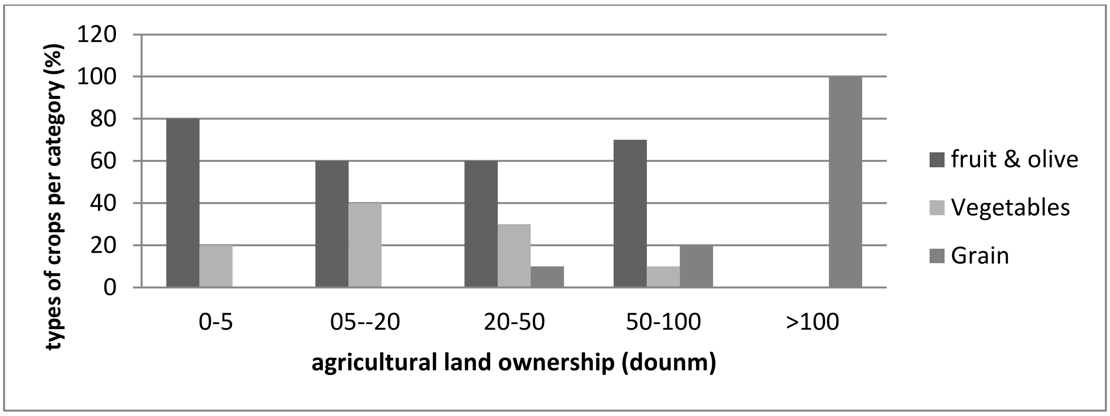


Figure (4.18): Relation between types of crop percentage per category and the ownership in FM.

Looking at the households of agricultural with more than 50 and up to 100 dounms, we found that the majority of cultivated fructification trees depend on imported water from southern regions. In addition to that there are some households belonging to householder who has lands in the Rafah governorate, which focused on planting the area by fructification trees where the water price goes down.

Regarding household with less than 20 dounms, it is used for planting fructification trees with low rate to achieve high level of per capital income in the family. The salinity of the water in that area pushed them to import water in order to grow fruit and olives trees with the grain to achieve the maximum possible profit.

After presenting these results to the engineers of the municipality, they confirmed that there is an annual rate for the detection of illegal links over 5 illegally links giving the impression that there are a lot of illegal links remaining without detection. Noting that the municipality is similar to the municipalities of the Gaza Strip which do not grant licenses for agricultural usage. Tables (4.6, 4.7 and 4.8) show that the amount of losses in (US$) and the relation with agricultural land, for year 2013 the amount of losses was (120,005 m^3) and the cost for one cubic meter as the municipal tariff system was (0.6 NIS/m^3) as (0.17 US$/$m^3$). This appeared high relatively to water that is not fresh nor drinkable so the total amount of water that lost is (20,400 US$/year 2013). It seems to be too much little due to the decrease of cube cost, in the other hand, the large holding depend on their own agricultural wells even their wells are licensed or not. The total agricultural holding distribution for each type depend on the survey general issue for each municipality of the whole governorate as illustrated in Table(4.19).

Table (4.19): Distribution of lands over holding category in FM.

	Category	Area (dounms)			
		Fruits and Olives	Vegetables	grain	TOTAL
Land owner ship per person	0-5	159	40	0	198
	05--20	404	269	0	673
	20-50	475	285	190	949
	50-100	983	140	281	1403
	>100	0	0	750	749
TOTAL		2020	734	1220	3975

From Table (4.19) it is easy to identify the amount of crop water requirements and defining amount of water which related to type of cultivation. And referring to appendix 4, where it illustrate the distributions of ownerships areas based questionnaire result. Therefore, It illustrated that the palm tree requires in initial stage for more care including irrigation but later the roots directly start to search for ground water. After growing it doesn't need for irrigation, so we are going to neglect it during the study. The total amount of water required is (1,490,98 m^3/yr) for fruits and olives trees and (502,995 m^3/yr) for vegetables, these notes are important in debussing situation over the whole governorate. (Al-Najar, 2007)

4.5. The Relation Between Urban Agriculture Area & the UFW

All the above interpretations lead to the conclusion that urban agriculture in small holdings is consuming huge amount of municipal water which is pumped for domestic usage. Such a water meter reading behavior, considering domestic water scarcity lead to threats of Khan Younis domestic water future.

In other expression, irrigating small urban agricultural holdings by the municipal water deprive residential from their right to achieve water quantities required.

Figures (4.19, 4.20, 4.21 and 4.22) illustrates the influence of the cultivation type's areas on the water losses regime. Due to the high profession of municipalities, water production and metered water for the same period of cultivation types data assume that the areas were cultivated in the three years are the same. A reference period of three years (2011 – 2013) was used.

Firstly, the influence of cultivated areas were studied separately per municipality then after collecting them together we can find a relation in between the losses of water which supplied from the municipalities. And that water meter reading by the residential house holdings to get the losses amount from one side referring to each municipality alone for years (2011 to 2013). The type of cultivation for each municipality with assumption for each type of cultivation area stilled cultivated Along 3 years due to the scarce of data that available from the Ministry Of Agriculture. Then, multi regressions for each type were studied simultaneously.

But, before developing the relation, and after referring to MoA and municipalities to estimate the cultivated areas; there was lake of similar information. In general, the change in cultivated areas during 2011, 2012 and 2013 ranged from 2.8% to 5% at all.

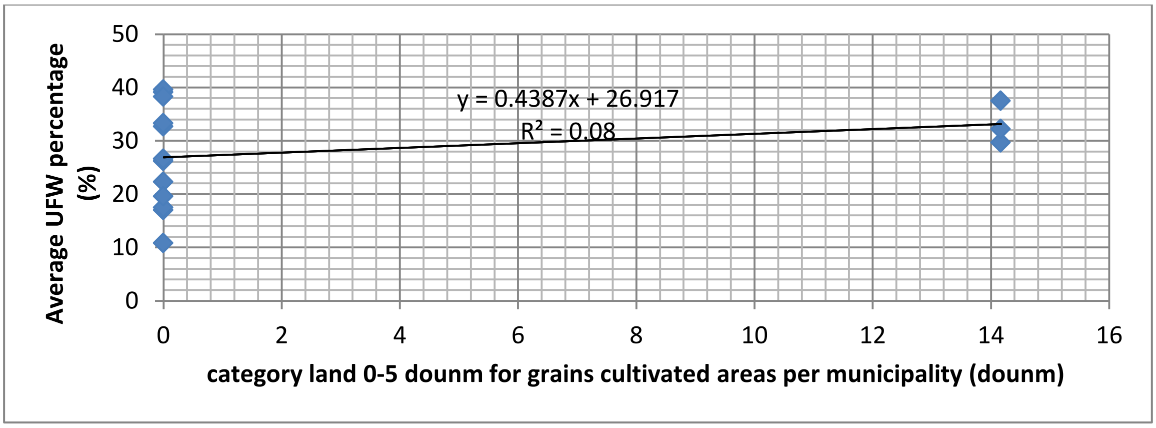
The variation percentage in the change of cultivated area was referred to two things; first, the MOA Engineers said that the agricultural general productions of cultivated areas increased by 2.8% due to increasing of cultivated areas. This assumption will ignored because there is another assumption that the farmers develop their cultivation using new technique, so their production increased by 2.8%. And the 5% came from municipalities whom directors said during the discussion interval that an increase in cultivation areas is noticed, but it does not exceed 5% of the total local cultivated areas noticing that most of similar new cultivated areas are rain fed agricultural like grains, where farmer try to increase their income (MoA and municipalities of Khan Younis governorate, 2014).

So, assuming that the cultivated areas are still fixed during the interval because there is no change in the whole governorate.

Now, excluding municipalities that depend on their own private wells to irrigate their cultivation, and after discussing the nature of cultivation in each municipality alone. It resulted that within two municipalities there is no any actual relation between unaccounted for water and urban agriculture so the researcher will neglect them in developing the general equation. The first municipality is Khan Younis municipality. Despite the fact that the municipality should rehabilitates the networks, most of the pipes were decomposed. Unfortunately, the municipality invested 3.5 million dollars over the specified period (2011-2013) which included the renewal of some networks, as well as changing of flow meters for residential use in cooperation with the (CMWU). All these actions led to improvement in the efficiency of the network by (15.8%) during the specified period which means that the municipality is suffering from leakage within pipes connections due to the age of the municipal network. The second municipality is Abassan Kabera where there is no actual relation between unaccounted for water and urban agriculture. It has a concentrated of population in the area, where the municipality operates a policy of one cluster community. Thus, the region became an agricultural area outside the boundaries of municipal services forming semi-rural agricultural community. So, the researcher will neglect it in developing the general equation.

The linear relation should be related to urban areas, and after discussing it with relevant institute managers, they advised to be in small holding only where the municipal water supply network reach to farmers lands with less than 5 dounms. Most of them were located inside the municipal water network. So, the researcher will develop a linear relation in lands with areas less than 5 dounms which are located in the urban areas.

Moreover, the researcher will neglect the grains cultivation because most of similar cultivation depends on the precipitations only as (MoA, 2014). In addition, much agricultural cultivation is rain fed cultivation. So, after developing a relation between grins cultivations areas for urban agricultural area which are less than 5 dounms in Figure (4.19) including (Bani Sohaella, AL-Qarara, Abassan Saghera, Khozaa and AL-Foukhariy municipalities) to get more better regression. In the X-axis represents cultivated area for the three years due to the lack of changes in this governorate in one side, so it stilled fixed. And relation with UFW percentage meaning of water losses percentage from the network referring to three years (2011 until 2013) as for the Y-axis, we find out very low regression which does not mean there is a serious relation.



Figure(4.19): Developing relation between grains cultivated (areas/year) and averages losses (percentage) for (2011,2012 & 2013).(Including Bani Sohaella, AL-Qarara, Abassan Saghera, Khozaa and AL-Foukhariy municipalities)

From Figure (4.19), it seemed there is no any relation seems this relation's point is located in zero cultivated area, moreover the regression is very low, which leads to ignore this relation.

Figure (4.20) shows that by the summation of fruit and olive trees cultivated areas adding vegetables cultivations areas for urban agricultural area for category of less than 5 dounms (including Bani Sohaella, AL-Qarara, Abassan Saghera, Khozaa and AL-Foukhariy municipalities),in the X-axis in one side. And relation with UFW percentage meaning of water losses percentage from the network referring to three years (2011 until 2013) by Y-axis and by regressions we find out;

$$Q_{\text{LOSSES (Percentage/Year)}} = 0.653\,(X)^{0.704} \quad \text{.........Equation 1}$$

Where x = (summation of fructifications and vegetables cultivated areas/year)

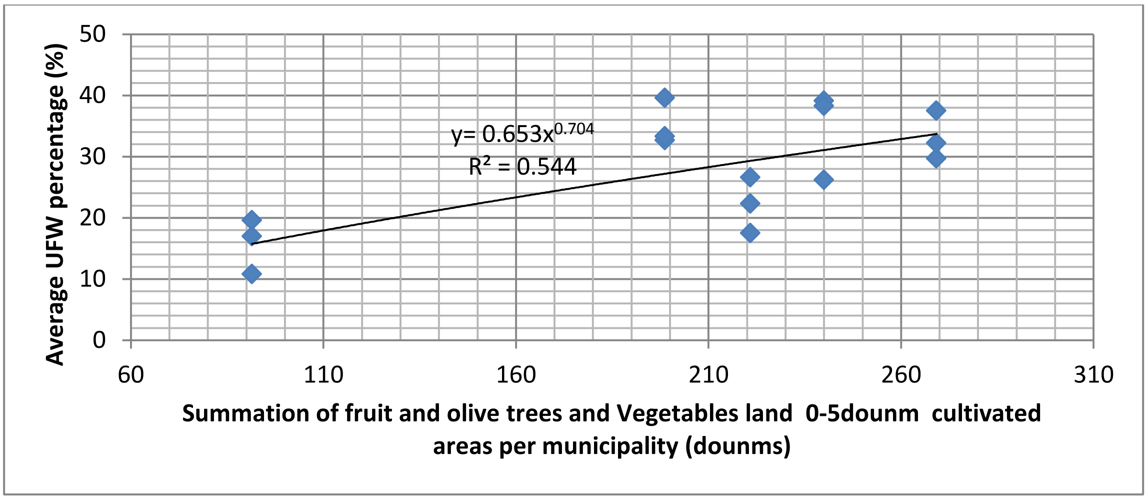


Figure (4.20): Developing relation (equation 1) between summation of fruit and olive trees and vegetables cultivated (areas/year) and averages losses (percentage) for (2011,2012& 2013). (including Bani Sohaella, AL-Qarara, Abassan Saghera, Khozaa and AL-Foukhariy municipalities)

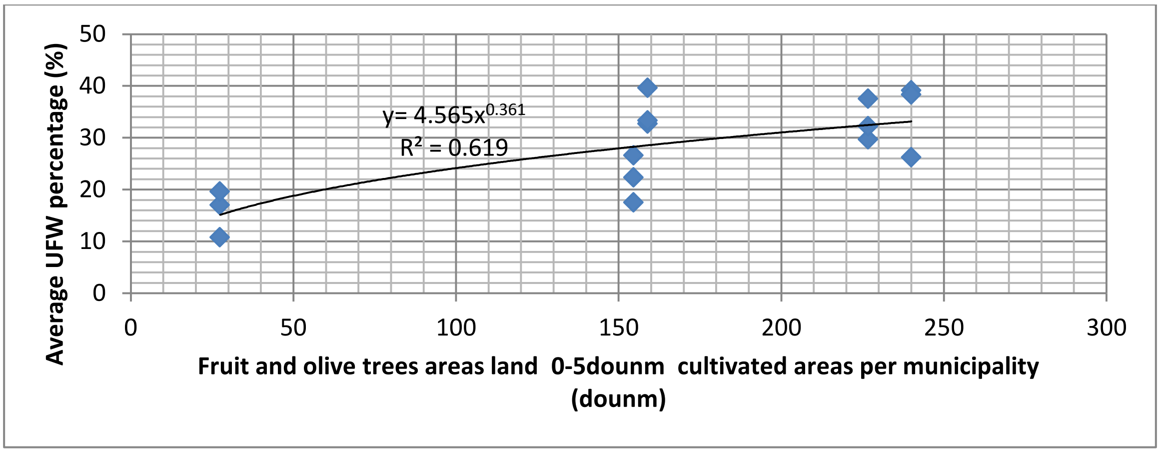
It is clear from equation (1), that there is a positive behavior (R= 0.73). Although there is an increase in municipal cultivated areas leaded to incredible increasing of municipal water losses which leaded to a result that, there is a behavior of using municipal water in irrigation purposes.

Moreover, the regression is high relatively which means that some farmer's social community did the same way by connecting illegally from municipal network. Also, the small holdings are affected by the freshness of water that pumped from the municipality more than other big holdings. First of all, the owners of huge holdings have their own private wells or they planting rain fed cultivation. The second issue is the near of similar small holdings to the municipal networks make it easier for farmer to connect illegally to the municipal water service networks especially for this category. In general, the whole small holding which use municipal water for agriculture purposes affect strongly of unaccounted for water. The above interpretations lead to the conclusion that urban agriculture in small holdings is consuming lots of municipal amounts that are pumping for domestic use but farmer use it for agricultural purposes helping them the closing of their lands to municipal networks due to their lands are approximately small and municipalities are obligate to serve these similar areas.

Continuously, fruit and olive trees cultivations areas for urban agricultural area with less than 5 dounms (including Bani Sohaella, AL-Qarara, Abassan Saghera, Khozaa and AL-Foukhariy municipalities) in the X-axis in one side. And relation with UFW percentage meaning of water losses percentage from the network referring to three years (2011 until 2013) by Y-axis and by regressions we find out;

$$Q_{\text{LOSSES (Percentage/Year)}} = 4.565\,(X)^{0.361} \quad \text{..........Equation 2}$$

where x = (fruit and olive trees cultivated areas/year)



Figure(4.21): Developing relation (equation 2) between fruit and olive trees cultivated land 0-5dounm(areas/year) and averages losses (percentage) for (2011,2012 & 2013).(including Bani Sohaella, AL-Qarara, Abassan Saghera, Khozaa and AL-Foukhariy municipalities)

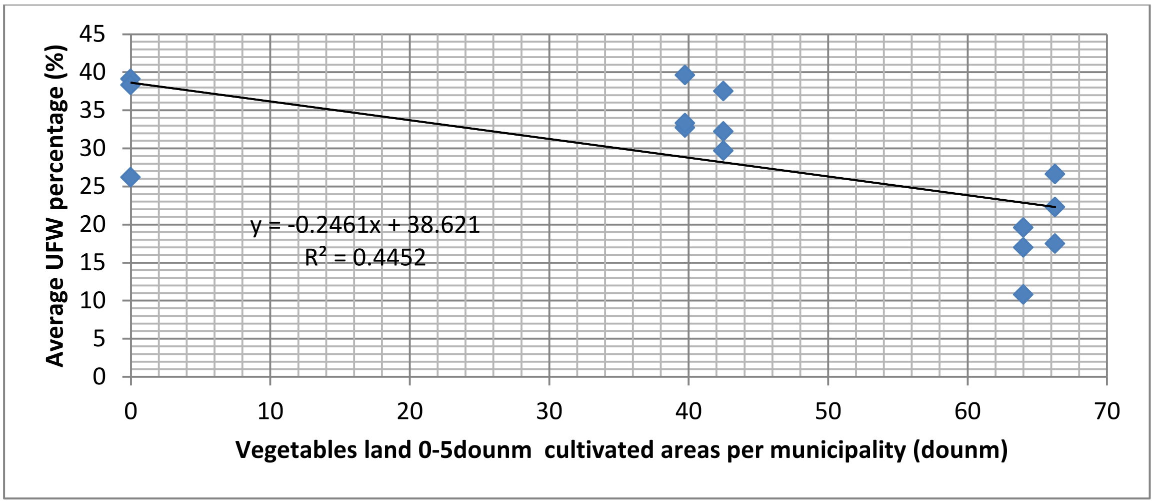
From Figure (4.21) we can defined that positive relationship (R= 0.79) between fruit and olive trees cultivation and municipal water yearly average losses with high regression relativly, which mean that the fruit and olive trees cultivation area increase the unaccounted for water average losses. This happened in the absence of law hand and monitoring hand of municipalities so the future going to be disaster seems to the most of farmer in most of municipalities who are looking forward to plant similar crops.

Known that the regression is relatively high which mean the farmer social community do the same way in connecting illegally to the municipal water services. Also the small holding affected the freshness of water that pumped from the municipality larger than other huge holding due to some issues like low income per capital which almost low for this category of holding less than 5 dounms. But in general the whole small holdings which theft water affect strongly by the freshness of municipal water.

Finally, with urban agricultural vegetables cultivation areas for category with less than 5 dounms (including Bani Sohaella, AL-Qarara, Abassan Saghera, Khozaa and AL-Foukhariy municipalities) the X-axis in one side. And the relation with UFW meaning of water losses from the network referring to three years (2011 until 2013) by Y-axis and by regressions we find out;

$$Q_{\text{LOSSES (Percentage/Year)}} = 0.246\,(X) + 38.62 \; \ldots\ldots\ldots\text{Equation 3}$$

where x = (vegetables cultivated areas/year)



Figure(4.22): Developing relation (equation 3) between vegetables cultivated land 0-5dounm (areas/year) and averages losses (percentage) for (2011,2012 & 2013).(including Bani Sohaella, AL-Qarara, Abassan Saghera, Khozaa and AL-Foukhariy municipalities)

Figure (4.22) shows a negative relationship (R=0.667) between yearly vegetable cultivation and municipal water yearly average losses. It was found that the vegetable cultivation area decrease over the unaccounted for water percentage. This happened due to the farmer who prefers to plant fruit and olives trees more than vegetables cultivation. So, the relation become inversed, but from the questionnaire it seems that farmer in all municipalities are looking forward to plant vegetables after stopping rain fed crops for huge holdings. This similar cultivation depends on agricultural private wells in the whole Gaza strip (Al-Najar, 2007). But most of farmers who were surveyed have been changed their crop to fruit trees which lead to two things. First, it assures that people planting vegetables depend on their own water “They do not use municipal water for agriculture purposes”. The second thing is that the gross productions of vegetables is going to decrease as it was cleared from the survey and they are going to plant fruits trees which depend in fresh water more than vegetables**.**

4.6. Future of Water Losses After Desalination Process

Desalination of sea water is considered as one of the man kind's earliest form of water treatment, and it has become one of the most sustainable alternative solution to provide fresh water for many communities and industrial sectors. Accordingly water desalination process lay down as a solution for shortage of fresh water.

After discussed the current situation for urban agriculture for each municipality, and developed relations between the current cultivated areas and losses for municipalities. Only the municipalities that did not enter the developed relation would not be adequate for equations, which are Khan Younis and Abassan K. municipalities. Knowing that developed equation (1) represents the summation of fruits and olives trees and vegetables cultivated areas in urban areas to get the expected losses. While equation (2) is another relation to get the expected losses, also by substitute in equation for fruit and olive trees cultivated areas only in urban areas to get the expected losses. And equation (3) for vegetables cultivated areas only in urban areas to get the expected losses.

Refer to questionnaire survey (see appendix 4) which represent the farmers who have holdings less than 5 dounms located in urban areas were affected by salinity of water (after existing of GSWDP). Leading to redistribute their holding cultivation type in case of fixing their total holdings areas due to farmers have a specific segment areas and they are going to change type of crops not the areas of their lands

After studying the changes in farmers crops (after existing of GSWDP), which lead to change of crops over their cultivated areas. Referring to equations (1, 2 and 3) from Figures (4.20, 4.21 and 4.22) were developed relations between cultivated area (areas/year). And the expected future yearly loses percentile after existed SWDP, discussing the effect of changing crops on in all of equation each one per its cultivations, as seen in Table (4.20).

Table(4.20): Type of future cultivations areas and the expect future average yearly losses for equations (1, 2 and3).

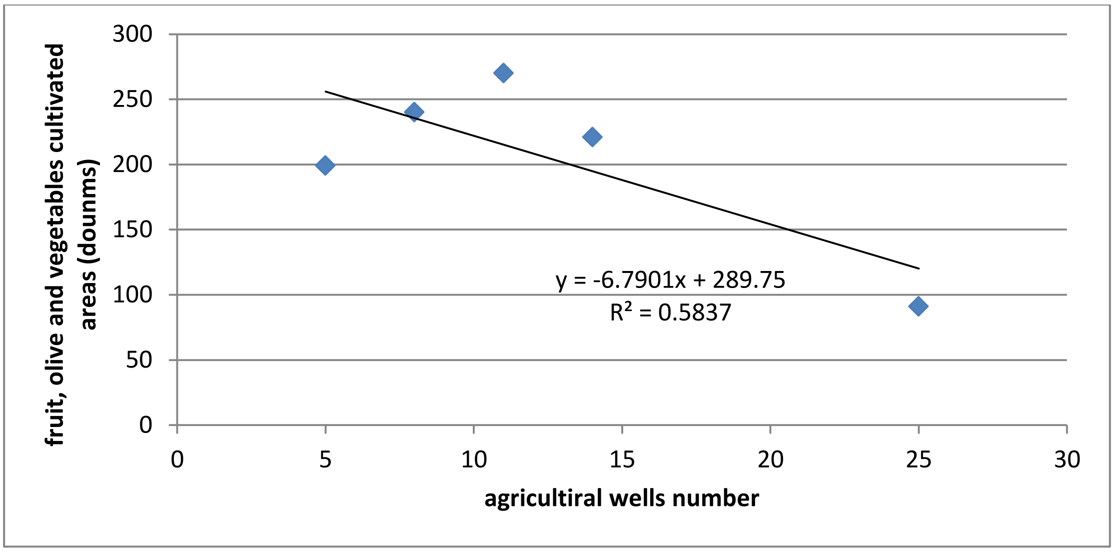
Municipality	future fruit, olive and vegetables areas (dounm)	water losses due to equation1 (%)	future fruit & olive areas (dounm)	water losses due to equation2 (%)	Future vegetables areas (dounm)	water losses due to equation3 (%)
AL-FOKHARIY	199	27	199	31	0	39
ABSAAN S	283	35	283	35	0	39
KHOZAA	179	25	59	20	32	31
AL-QRARA	240	31	240	33	0	39
BANI SOHELA	243	31	199	31	22	33

There are three methods of checking to identify which equation is adequate for expectation of future losses percentage. One of these method is numerical and the other is logical, and the last method for worst case. known the second and the third methods play main rule for expectations.

From the Table(4.20) it appears that equation 1 represents a middle or minimum value for average losses per municipality, leading to be more than adequacy for other equation. So, it is important and feasible to take equation 1 as guide for comparing these result with the final average year water losses.

To prove the correction of this relation, it is necessary to develop a relation between the number of wells in each municipality and the summation of fruit, olive trees and vegetables cultivated areas for the same category. Without municipality that have been excluded from equation (1) which are Khan Younis and Abassan Kabera municipalities as shown in Figure (4.23).

To check the (assumptions of excluding equation 2 and 3) logic accuracy from other side. In other words, equation (1) is not developed by chance, so developing this relation will lead to more checking of assumption of equation 1 in Figure (4.23).



Figure(4.23): Developing a relation between licensed agricultural wells number and the summation of fruit, olive and vegetables cultivated areas without KYM and AKM.

As seen in Figure (4.23) it is clear that there is negative relation with (R = 0.76) between the summation of fruits, olives and vegetables cultivated areas for category which is less than 5 dounms ownerships. Without Khan Younis and Abassan Kabera municipalities from one side and the number of wells in each municipality from other side. It resulted that, although the summation of fruits, olives and vegetables cultivated area in some municipalities increase the licensed agricultural wells decrease.

After discussing the result with relevant institutions engineer's, they were supposed that there were two explanations for this relation. First of all farmers of similar categories prefer to irrigate their crops using unlicensed agricultural wells, While the second explanation which is familiar with the research results that the farmer may connect illegally to the municipal networks and they were proving this explanation by the average annual detection of 45 illegal connection for irrigation purposes.

So the most proprate equation to use in expectation the future losses is equation (1) which has the most numerical and logical familiar issues.

For more checking and known that the amount of water pumped during 2013 and assuming that the sea water desalination plant is already existed in 2013 with excluding municipality that do not enter the equations. To touch the amount of water that will be lost in the network where it shows in Table (4.21) where the max amount of water losses due to three equations.

It is clear that, equation 1 represents the most worst case over three equation as illustrated in Table (4.21). In quantitative expression, the irrigation for urban small agricultural holdings by fresh municipal domestic water may incredibly increase the supplied water quantities.

Table(4.21): Amount of losses due to equ.1, 2 & 3 (CM) for (2013).

Municipality	water losses due to equation1 (m^3)	water losses due to equation2 (m^3)	water losses due to equation3 (m^3)	max amount of losses due to equ.1, 2 & 3 (m^3)
AL-FOUKHARIY	117002	81798	93435	117002
ABASSAN S	543473	408098	493305	543473
KHOZAA	376839	294155	244486	376839
AL-QARARA	164892	119549	140963	164892
BANI SOHELLA	544853	443304	506454	544853

Now comparing the future situation assuming that the sea water desalination plant is already existed in 2013 to touch the amount of water that losses in the network by illegal urban agricultural connections as illustrated in Figure (4.24). It is clear that most municipalities which use municipal water for irrigation like Abassan Saghera reaching 3 times in comparing with losses in 2013 around 112,938m^3. But if the desalination plant existed in the same year it would reach 543,473m^3. But other municipalities like Al-Qarara the losses will decrease one third if the desalination plant existed reaching 164,892m^3.

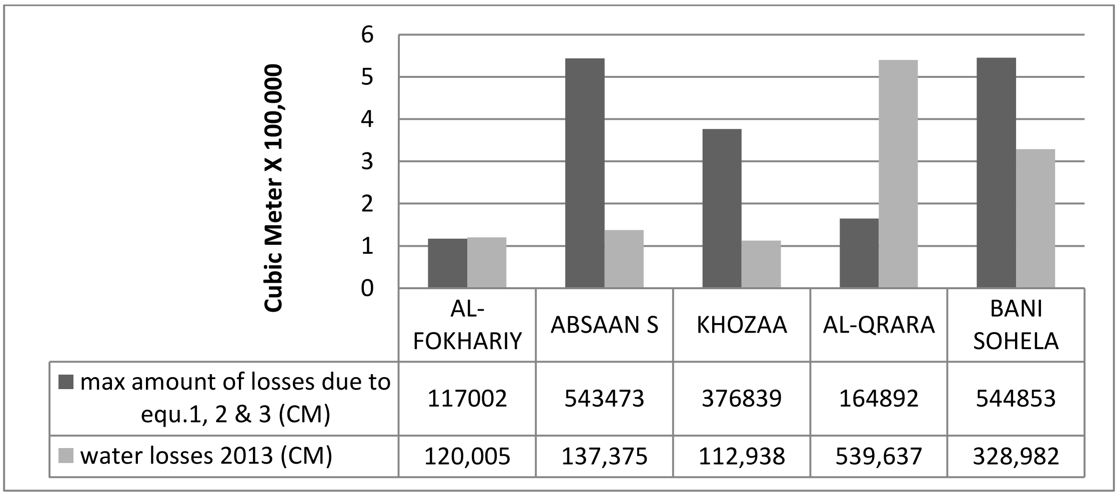


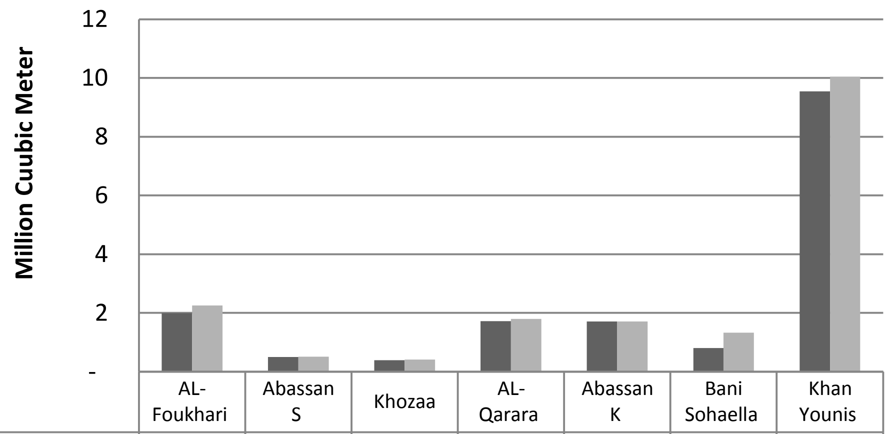
Figure (4.24): Amount of future losses after sea water desalination plant constructed and losses of 2013.

After calculating the differences between unaccounted for water in 2013 as seen in Figure (4.24) and the expected future losses after the sea water desalination plant exist there are 508,122 m^3 are considered as additional losses fixing current and future losses in Khan Younis and Abassan Kabera municipalities due to that municipality are considered out of relations, leading to additional 10.1% of the total losses during 2013 which was 5,012,680 m^3 For the whole governorate.

4.7. Future of Urban Agriculture Requirements After Desalination Process

After discussing the average yearly losses, it is important to discuss the questionnaire from other side which dealt with the changes in cultivated areas after the sea water desalination plant will exist to achieve the future crop water requirements.

The agricultural activities form one of the basic income sources for Khan Younis's population, in addition to being the largest water consumer. So, the future Agricultural crop water requirements consumption will be discussed for each municipality for all categories of ownerships after the sea water desalination plant exist, by comparing between the current and the future water requirements to expect how the future would be.



	AL-Foukhari	Abassan S	Khozaa	AL-Qarara	Abassan K	Bani Sohaella	Khan Younis
Current water crop requirement	1,993,977	499,094	394,764	1,724,617	1,704,181	806,032	9,540,219
Future water crop requirement	2,249,079	511,826	418,152	1,791,332	1,706,577	1,331,625	10,042,163

Figure (4.25): Amount of current and future water crop requirement in MCM for each municipality.

As seen in Figure (4.25), and referring to section 4.4 the identified the current total crops water requirements, and comparing with future crops water requirements Leading to expect the future situation after the desalination plant existed.

As the fresh water is available in municipal networks, the farmers are going to other crops as the questionnaire results. This means the farmers affected to the freshness of municipal water. Or they were guess that after the desalination plant existed the domestic abstraction will decrease which lead to improvement in the freshness of the ground water, leading to change their crops. Leading to use additional water quota from the ground water

So the researcher estimates that water are lost in irrigation purposes. To define the amount of water according to the survey resulted that the amount of water that Khan Younis Governorate needs for irrigation is (18,050,753m^3/yr), and increasing by (1,387,869 m^3/yr) which it is not familiar with additional water for cultivation usage due to the fixation of income flows of the groundwater table.

To study the effect of additional quota, known that the farmers use agricultural wells to irrigate their crop so it is important to study the effect of the ground water table.

Known that Gaza Strip uses only the ground water, so it is important to study the Gaza Strip ground water table in general. The renewable amount of Gaza Strip ground water is about 91 MCM in 2009, where 40 MCM comes from direct infiltration of rainfall. The remaining amount (51 MCM) comes from irrigation return flow, leakage from non-sewered areas and brackish trans-boundary flow that crosses the eastern side of the Gaza Strip (PWA, 2010).

Total recharge was at 91MCM/year and the total agriculture use 80MCM/year for irrigation purpose. Known that after existing of future desalination plant the groundwater table will support by (10MCM/year) for domestic usage. This means that the amount of ground table which supply the agriculture is still the same amount of water supported for agricultural irrigations. While the changing in cultivation increase the crops water requirements by 8.5%, which mean there would be a defects in the ground water table. In order to identify the amount of water which would be used after the desalination plant is constructed.

4.8. Soci-Economic Analysis

The Gaza Strip has over 45 years of unstable political conditions due to the Israeli occupation, which is reflected directly on the social life. People practiced a type of survival life. Also the economy of the Gaza strip is linked directly with Israel; the standard of living in the Strip is deteriorating due to boarder closures and opening restrictions. As a result, the number of unemployed people increases. Other requirements such as housing, health care, water and wastewater services are mostly below the minimum of international standards.

The municipal water pumped to people in Khan Younis has high concentration of chloride and nitrate that exceeds the international standards. So, water quality in terms of nitrate and chloride has negative significant impacts on people life and development.

The responsibility of the PWA with relevant Palestinian institutions is to provide people with an accepted quantity and quality of water at affordable price. This can be achieved through desalination projects such as sea water desalination plant with the participation of the public sector. As discussed before the unaccounted for water leads to disaster, so there is a need to discuss and evaluate its reflection on the project.

Municipalities of the Gaza Strip do not grant license and links for agricultural usage because of fact that water scarce and the high cost of the withdrawal of water from the aquifer makes it difficult to provide water. Leading to cancels license for agricultural use.

Even the municipalities facing difficulties in bells cost collection from the participant of the networks in all municipalities which the main reason that threat the sea water desalination project.

For traded commodities, the money valuation of welfare gains or losses is generally observable via prices paid in day- to- day transactions for goods and services. However, for non-traded goods, including health care, the trade-offs that appropriately reflect the money value that people attach to specified improvements in welfare are usually non-observable in market transaction.

Finally, Willingness to pay is a type of valuation technique for non-market goods. Different survey methods are available for generating willingness to pay data. However, cost evaluation per desalinated cubic meter is more difficult, where there were two techniques of evaluation costs.

The first technique of cost analysis discuss two methods one of them mention that the user pay 3-4% of the individual yearly income. And the other related to family income where defined the old cost adding another limited cost for supporting by drinkable water referring to related institutes.

And the second technique of cost analysis also discuss two methods one of them mention that the old cost of undrinkable water which pumped to the municipal water distribution system. Adding 25% of old cost to get the desalination cost per cubic meter. And the second method of evaluation the cost of desalinated cubic meter related to operation and maintaining costs.

Now discussing the first technique of cost analysis, discussing the first method of paying 3 – 4 % of the individual yearly income. But for residential consumed meter readings there will be increasing of 9% of the original water meter reading after desalination. But all of these additional quantities would cover from the residential (Morin, 1999).

The following calculations test the individual capability to afford for water that is produced after the sea water desalination plant construct. The result that individual with annual income 400 US$/year can afford 7.4 % to 43% extra of the current municipal water tariffs as shown in Table (4.22).

Table (4.22): Pricing as per individual after the sea water desalination plant existed.

Description	Qualitative Expression
Average cost of the current municipal water tariffs	0.335 US$/$M^3$
Gross Domestic Product (GDP) /2002	400 US$/individual/year
3% -4% of annual income is paid for the water bill (WB assumption)	Cost of the municipal water bill 12 US$/year to 16 US$/year
Per individual water consumption	90.5 L/c.d (in average+9%)
Total individual water consumption	33.03 M^3 /year
Cost of M^3	0.36 US$ to 0.48 US$

And the other related to family income where defined the old cost adding another limited cost for supporting by drinkable water referring to related institutes.

The World Bank estimated the Gross Domestic Product (GDP) in the Gaza Strip at 860 US$ per capita in 1994. Due to Intifada and the unstable political situation, the income per capita was dropped to 600 US$ in 2002, and 60% of the population have fallen below the poverty line (CIA, 2003). Recently, it is reasonable to assume that the GDP in the Gaza Strip is at 400 US$ per capita per year. (MoLG, 2014)

From Table (4.23), it can be concluded that people with a family of 6 members and a monthly income of 430 US$/month and a rate of water consumption of 90.5L/c.d, they will pay 0.95 US$/$m^3$.

Table (4.23): Pricing as per family after the sea water desalination plant existed.

Description	Qualitative Expression
Average family members (PCBS, 2013)	6 members
Average family income	430 US$/month
Per capita water consumption	90.5 L/c.d (in average+9%)
Total water consumption per family	198.2 M^3/year
Family paid	
For the municipal water bill	30 NIS/month
For purchasing a potable water for drinking (PWA)	25 NIS/month
Total paid by family for water	55 NIS/month=188.5 US$/year
Total cost is to be paid for water (municipal & potable)	0.95 US$/ M^3

Regarding the municipal water bills, answers showed that 30 NIS/months is paid for the municipal water bill, which represents around 2% of their average monthly income. About 25 NIS/month is paid in addition to the municipal bill to purchase sweet water for drinking purposes (PWA, 2011; municipalities, 2014), which represents 1.67% of their monthly income which is acceptable for the world bank fundamentals.

Finally the cost estimated by two methods are fallen within the range of world bank fundamentals 3 – 4 % of the individual income or the family income which appropriate for the residential use.

However, referring to section 3.2.4.5. the second technique of cost analysis, also discuss the first method, that the old cost of undrinkable water which pumped to the municipal water distribution system. Adding 25% of old cost to get the water desalination cost per cubic meter.

At present, the water sector in the Khan Younis Governorate is operated and managed in cooperation between Khan Younis municipalities and CMWU, who both have their own water sources and distributions systems. Each municipality has its own tariff structure. In general, the maximum tariff charged to domestic users ranges from 0.17 US$/$M^3$ to 0.51 US$/$M^3$. This means that the average tariff is 0.335 US$/$M^3$. By adding the 25% of the old cost it result the new cost of 0.47 US$/$M^3$.

The cost of cubic meter produced from desalination affects affordability and willingness to pay by the consumers. Recommended the same issues, so able to pay 0.42US$/m^3 seems the same value as the Palestinian water authority suggested in (PWA, 2011). From the above defining cost the value of market departing along the next years until the sea water desalination plant constructed in US$ is 12.5% resulting the aim final cost is 0.47US$/M^3 which is the same for 25% of the water desalinated cost per cubic meter.

The second method of evaluation for the same technique is the cost of desalinated cubic meter related to operation and maintaining costs. based on average cost of 0.75 US$ per M^3. the 0.75 US$ as operation and maintenance cost (Ismail, 2003). But if it works with full capacity (55MCM/year) it will cost around 0.42US$ as the PWA recommended if the sea water desalination plant full constructed; but the cost will increase if the donors used partial construction. (PWA, 2011)

Here we have two costs; one as PWA (2011) same as 25% increasing of the old bill which around 0.47US$/m^3 and the other cost as mention 0.75 US$/m^3 as operation and maintenance cost (M.Ismail,2003).

Known the additional unaccounted for water losses amount will be added to the cost directly to the cost. Known; it include 10 % only as world health organization (WHO) to the cost to be acceptable and this cost is also added to cost of cubic meter so the researcher will discuss the losses in US$ to be more touchable.

Now comparing the future situation of additional unaccounted for water losses in (US$) and assuming that the sea water desalination plant already existed for year 2013 to touch the amount of water that losses in the network by illegal urban agricultural connections for tow price; one as the PWA of 0.47 US$/m^{3}and as operational cost at 0.75US$/m^3 as (M.Ismail,2003); fixing that unaccounted for water for Khan Younis and Abassan Kabera for the year of 2013 due to the losses related to maintenance of the water distribution system network.

Table (4.24): PWA price and the operational cost assuming the sea water desalination plant existed and fixing UFW for KYM and AKM for the year of 2013.

Municipal	amount of unaccounted for water losses (M^3/year)	PWA price (0.47US$/M^3)	operation and maintenance cost (0.75US$/M^3)
Khan Younis	3,384,804	1,590,858	2,538,603
Bani Sohaella	544,853	256,081	408,640
Abassan K	328,982	154,622	246,737
AL-Qarara	164,892	77,499	123,669
Khozaa	376,839	177,114	282,629
Abassan S	543,473	255,432	407,605
AL-Foukhariy	117,002	54,991	87,751
TOTAL	5460845	2,566,597	4,095,634

Table (4.22) illustrate that; if we use PWA pricing at 0.47US$/M^3 which is 25% of the origin of the supposed bill adding the market interest rate at 12.5%, the total amount of unaccounted for water losses is (2,566,597 US$) and for the cost of water by the operation and maintenance cost at (0.75 US$/$M^3$) was (4.095634 US$). This would make a gap over (1,529,037 US$), This mean the sea water desalination plant should constructed fully construction directly or there will be double the amount of losses in US$ and there would be less willing to pay the bill.

Chapter 5: Conclusion & Recommendations

Chapter 5: Conclusion & Recommendations

5.1. Conclusion

The following points conclude the research main data and findings are divided into 4 main parts:
The first conclusion – and one of the most important – from the experience of survey is that the continuation of the status in the water sector in Khan Younis Governorate as illustrate in these points:-

- In Khan Younis Governorate there is 37 well with total production around 15 Million Cubic Meter in 2013, and the meter readings was 10 MCM, which means that the percentage of efficiency is (66%). Over (99.7%) of Khan Younis residents currently have access to water services, but unfortunately not receiving appropriate water quantities or qualities. As a result of this distribution, the residents are used to reserve storage facilities over their roofs to meet their demand during the periods of shut off water supply. Water is normally abstracted from wells and discharged directly into the network in the west area which covered 242,753 inhabitants (around 66% of total population). And the rest of the inhabitants were located in the east area of the municipality, which used to use a unique water tanks to supply the network with municipal water. In this scheme the water is being abstracted from 7 different wells in different times, this water tanks have 1000 m^3 in capacity and 770 m^3 /hr in flow.
- The recorded production for Khan Younis Governorate reached (14,322,328), (14,458,129) and (15,001,990) m^3/year for 2011, 2012 and 2013 respectively. Where the recorded annual meter reading reached (8,355,122), (9,096,930) and (9,942,298) m^3/year for 2011, 2012 and 2013 respectively. As illustrated due to increasing in population, the annual meter reading is progressively increased. Where the max average monthly gap between the produced and the actual meter reading quantities reached 5,967,206 m^3 in 2011, 5,361,199 m^3 in 2012 and 5,059,693 m^3 in 2013. The water losses reached 39.14% of the average produced water quantities during the three reference years. So, domestic water consumers are receiving only (60.86%) of their water entitlements.
- To summarize the average supplied and metered water quantities per municipality, in addition to the average efficiency and UFW percentages. Khan Younis is the municipality with the lowest efficiency (56.4%) while It has two thirds of the population of the whole governorate. So, it is the municipality with the highest water losses. Followed by AL-Foukhariy then AL-Qarara, Abassan S, Abassan K and Bani Sohaella at the efficiency range of 64% - 77.9 %.
- As well, the daily average per capita water production is (111 L/c.d) but actually the real usage is (74 L/c.d) far below the World Health Organization (WHO) recommendations for urban populations. As illustrated the variant per capita supplied water quantity per each municipality. Al-Qarara is the municipality with the highest per capita supply during 2012 and 2013 and Khozaa has the highest per capita supply during 2011 and Khan-Younis has the lowest per capita supply of 99 L/c.d.
- Khozaa is the municipality with the highest per capita meter reading during 2011, 2012 and 2013 with 126, 119 and 106 L/c.d, respectively. And Khan Younis has the lowest per capita supply during 2011 and 2012 with 57 L/c.d and 65 L/c.d

respectively, and AL-Qarara municipality has the lowest per capita supply of 60 L/c.d in 2013. All the lowest per capita meter reading is far below the world health organization (WHO).

- This bad efficiency is reflecting two things in this area; the first thing refers to the efficiency of the water pipe network system itself within the domestic area which is obvious in the old city and old zones. The second reason refers to the Unaccounted For Water which is seen in the illegal connections from the Municipality wells towards the agricultural area of Khan Younis without any monitoring or control which is clear in the relations between fructifications trees agricultural and the problem with unfixed flow meter.

The 2nd conclusion part –The problems with leakage and infiltration are much less intractable in Khan Younis municipalities in relation to the agricultural use of groundwater, compared to domestic water supply. There are several reasons as illustrate in these points:-

- The urban agriculture will influence the efficiency of water network because it needs a huge amount of water, where farmers may use the domestic network for irrigation purposes illegally. This leads to higher water supply per capita as illustrate in AL-Qarara which apparently exceeds (168 L/c.d).
- The municipalities of Khan Younis have not a clear map showing the water distribution districts and the locations of the wells. So, using a team of 6 members selected from the urban areas to the survey who have known well of the area with helping from the engineers of municipalities**.** The cultivated area in Khan Younis is 37.306 km^2, where 10.702 km^2 were cultivated via green houses, in addition to 13.709 km^2 were dedicated to grains crops in open fields and 12.896 km^2 were dedicated to fruit and olives trees cultivation.
- The ownerships are divided into categories starting with 0 to 5 dounms with total area of 669 dounms, then from 5 to 20 dounms with total area of 3024 dounms, from 20 to 50 dounms with total area of 4265 dounms, from 50 to 100 dounms with total area of 4265 dounms and finally more over 100 dounms with total area of 3591 dounms.
- The field survey has been conducted by the researcher with the assistance of staff and held a workshop that aimed to understand the goals of the questionnaire. The field survey has been applied to more than 440 participants in the Municipalities of Khan Younis governorate. Its items focused on the proportion of the participant's current lands, and the type of agricultural cultivation areas, discussing the future of agriculture after the sea water desalination plant constructed and their effect on types of cultivation.
- The researcher achieve to fixed the areas were cultivated in the three years are the same as nothing change in affective issues (like policy, social issue, …etc). a reference period of three years (2010 – 2013) was used, finding a relation in between the losses percentile for years (2011 - 2013) and type of cultivation areas for each municipality for the same period. During developing the relation, and after referring to MoA and municipalities there were excluded for municipalities that depend on their own private wells to irrigate their cultivation like Khan Younis and Abassan K municipalities. The linear relation should be related to urban areas, and after discussing it with relevant institute managers, they advised to be in small holding only where the municipal water supply network reach to

farmers lands with less than 5 dounms. Most of them were located inside the municipal water network.

- The above conclusion indicated that there is a serious relation between the summation of fruits and olives trees and vegetables cultivated areas in urban areas to get the expected losses in urban agriculture areas. Considering domestic water scarcity lead to threats of Khan Younis domestic water future specially after the sea water desalination plant existed.

The 3rd conclusion part –The problems with desalination of sea water future expectation of losses and the water crops requirements and effects with ground water table. There are several points to illustrate the expectations:-

- Discussing the yearly future average losses in case of existing of SWDP with reference to questionnaire survey. And after substitutes in developed equation 1 for municipalities. It result that the losses were 27%, 35%, 25%, 31% and 31% for AL-Foukhariy, Abassan Saghera, Khozaa, and Bani Sohaella municipalities respectively. Which mean that it is look like bad future for desalination. In quantitative expression, the irrigation for urban small agricultural holdings by Municipal domestic water may incredibly increase the per capita supplied water quantities. But, for residential consumed meter reading there would be increasing of 9% of the original water meter reading, but all of these additional quantities would be covered from the bills directly. It is clear that most municipalities which use municipal water for irrigation like Abassan Saghera double 3 times in comparing with losses in 2013 reaching 543,473 m^3. But other municipalities like Al-Qarara the losses will decrease to one third which mean that farmers are not affected by freshness of water while they are mainly depend on grains in their cultivations.
- The crops water requirements was important to discuss for the future Agricultural crops water requirements consumption for all categories of ownerships after the sea water desalination plant exist. When it is important to expect the groundwater table future situation by comparing between the current and the future water requirements to expect the future. It would be increasing in the crops water requirement by 8.5%, which mean there would be defects in the ground water table.
- Gaza Strip have total recharge at 91 MCM/year where agriculture use 80 MCM/year for irrigation purpose. Known that after existing of future desalination plant the groundwater table will support by 10MCM/year for domestic. This means that the amount of ground table which supply the agriculture is still the same amount of water supported for agricultural irrigations while the changing in cultivation.

Finally, the 4th conclusion part –The discussing the socio-economic factor

- The researcher discussed the socio-economic factor and used two techniques. One technique divided into two methods, it depend of the users would pay 2-3% of their individual income leading to 0.36 – 0.48 US$/$M^3$, the other related to the familial income reaching 0.59 US$/$M^3$. Both achieve surround pricing. The other technique either divided into two method one for operation and maintenance cost leading to 0.75 US$/$M^3$ and the other method for additional 25 % of old cost reaching 0.47 US$/$M^3$.

- After compared the future situation for unaccounted for water in US$ assuming the sea water desalination plant already existed for year 2013 to touch the amount of water that losses in the network by illegal urban agricultural connections for tow price one as the PWA and the researcher achieved 0.47US$ per desalinated cube of water and as operational cost 0.75US$ per desalinated cube of water. After discussion these two cost method the researcher achieved to shortage of collection bells and the Deficiency is 2,566,597 US$ cost at 0.47 US$/M^3 and the cost of water by the operation and maintenance cost at 0.75 US$/M^3 was 4.095634 US$ this would make a gap over 1,529,037 US$.

5.2. Recommendations:

The research recommendations are stated on the light of all the discussions above, as follows:

1. Increase the consciousness for community and increase the power of law in detection of illegal connections specially for agricultural purposes.
2. The research can be utilized by the relevant authorities and institutions in prioritizing their focus on the problems.
3. Support the agricultural sector by uncongenial water source to avoid agricultural illegal connection to the municipal water networks.
4. For water operators in Khan Younis Governorate (CMWU & Khan Younis Municipalities) It is recommended to conduct a detailed field survey in order to identify the exact holdings in urban areas and developing a new familiar municipal water networks maps, which will provide a decision support system for the policy makers.
5. The sea water desalination plant should be constructed fully construction directly, while the proposed project must be finished in 2015. Moreover there will be double the amount of losses in US$ and there would be less willing to pay the bills, in order to decreasing of desalinated water amount will increase the bill cost.
6. Close monitoring to the water distribution network is recommended, especially for district with low efficiency and higher portion of the supplied water.
7. It is recommended to consider modifying the current water distribution schedule to ensure equal access to domestic water for all governorate citizens.
8. Governmental and Non-Governmental organizations should promote the culture of reusing of grey water for irrigation purposes after adequate treatment inside the household.
9. This research applies decision support system for planners, designers and technicians in Khan Younis municipalities to address uncertainties about water losses and which municipalities are suffer from thefts helping to detect these illegal connections.
10. Integration on local level between the regulatory parties (Palestinian Water Authority, Ministry of Health and Environment Quality Authority and Khan Younis municipalities) is crucial and vital in order to regulate and organize the desalination industry. Moreover, cooperation, data exchange and experience are required between relevant institutions.
11. Desalination projects need high capital investment; for this purpose integrated cooperation between public and private sector is highly recommended in order to increase the efficiency of water supply operational conditions, which will reflect positively on customers.

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Annexes

Annexes

Annex 1: Water production & Meter reading in Khan Younis municipality

1. Khan Younis municipality

water production

Month	2011 (m^3)	2012 (m^3)	2013 (m^3)
January	687,199	696,669	726,911
February	606,928	618,952	669,157
March	710,855	598,646	775,391
April	714,098	712,329	776,829
May	796,239	770,714	813,935
June	824,656	787,577	885,053
July	860,055	845,463	927,983
August	893,908	953,395	921,960
September	888,495	907,790	840,605
October	843,639	837,760	847,462
November	782,082	810,236	646,734
December	700,182	738,541	589,507
Total	**9,308,336**	**9,278,072**	**9,421,527**

water consumption

Month	2011 (m^3)	2012 (m^3)	2013 (m^3)
January	256,758	403,305	466,236
February	217,384	373,680	461,939
March	295,488	372,421	475,553
April	352,617	399,157	504,747
May	356,621	414,944	525,022
June	426,251	476,712	546,493
July	424,475	448,793	544,331
August	482,380	535,655	601,806
September	471,776	500,992	556,280
October	392,843	489,261	549,628
November	418,283	476,139	435,914
December	399,517	405,884	368,774
Total	**4,494,393**	**5,296,943**	**6,036,723**

2. Bani Sohaella municipality

Water production

Month	2011 (m^3)	2012 (m^3)	2013 (m^3)
January	118,077	113,071	102,240
February	113,288	107,323	116,170
March	94,400	83,520	135,600
April	140,799	138,820	132,710
May	127,592	138,449	172,020
June	133,935	106,048	153,539
July	109,924	169,203	164,568
August	108,158	123,702	147,900
September	136,006	160,612	145,930
October	128,177	139,320	160,910
November	115,380	127,106	114,080
December	119,033	104,619	96,200
Total	**1,444,769**	**1,511,793**	**1,641,867**

Water consumption

Month	2011 (m^3)	2012 (m^3)	2013 (m^3)
January	93,368	81,322	94,241
February	88,412	90,675	94,083
March	83,657	73,139	94,399
April	95,072	91,500	79,599
May	102,609	99,810	103,624
June	140,297	109,640	112,672
July	123,954	112,771	104,190
August	89,296	112,022	126,026
September	110,532	114,550	101,089
October	96,425	115,874	118,167
November	87,683	86,596	103,196
December	80,268	86,338	74,630
Total	**1,191,573**	**1,174,237**	**1,205,916**

3. Abassan Kabera municipality

Water production				Water consumption			
Month	**2011 (m^3)**	**2012 (m^3)**	**2013 (m^3)**	**Month**	**2011 (m^3)**	**2012 (m^3)**	**2013 (m^3)**
January	83,823	71,820	83,960	January	57,304	59,552	63,040
February	83,823	71,820	83,960	February	57,304	59,552	63,040
March	94,984	88,423	105,701	March	72,114	65,929	77,597
April	94,984	88,423	105,701	April	72,114	65,929	77,597
May	126,465	117,646	111,752	May	93,939	87,277	70,749
June	126,465	117,646	111,752	June	93,939	87,277	70,749
July	143,861	115,808	108,128	July	99,407	97,486	84,231
August	143,861	115,808	108,128	August	99,407	97,486	84,231
September	114,260	116,399	110,388	September	106,621	84,077	82,696
October	114,260	116,399	110,388	October	106,621	84,077	82,696
November	75,671	111,124	92,894	November	68,694	75,269	70,019
December	75,671	111,124	92,894	December	68,694	75,269	70,019
Total	**1,278,128**	**1,242,439**	**1,225,646**	**Total**	**996,158**	**939,180**	**896,664**

4. Al-Qarara municipality

Water production

Month	2011 (m^3)	2012 (m^3)	2013 (m^3)
January	76,925	77,405	91,900
February	74,342	76,500	87,510
March	74,896	78,707	126,580
April	68,875	100,343	131,810
May	81,592	81,790	131,414
June	83,665	95,000	142,540
July	92,969	120,000	142,490
August	92,690	84,870	139,140
September	47,380	126,000	105,089
October	89,311	126,700	118,710
November	72,511	93,310	106,160
December	80,240	93,440	83,890
Total	**935,396**	**1,154,065**	**1,407,233**

Water consumption

Month	2011 (m^3)	2012 (m^3)	2013 (m^3)
January	46,962	49,255	52,490
February	46,377	47,698	64,886
March	56,447	53,122	76,651
April	64,877	62,177	79,856
May	63,534	58,998	80,000
June	68,583	60,558	73,044
July	67,055	70,089	79,537
August	66,735	65,446	81,652
September	55,093	64,000	89,535
October	60,545	62,342	73,169
November	45,200	54,823	61,216
December	49,372	54,360	55,560
Total	**690,780**	**702,868**	**867,596**

5. Khozaa municipality

Water production

Month	2011 (m³)	2012 (m³)	2013 (m³)
January	37,560	32,320	37,350
February	35,690	33,490	35,050
March	45,020	30,270	38,540
April	44,020	52,910	48,000
May	47,320	51,620	50,270
June	59,430	40,330	45,690
July	62,833	55,290	55,530
August	51,370	63,480	50,180
September	62,100	56,880	55,960
October	66,200	47,390	52,269
November	39,110	36,260	53,481
December	38,260	35,030	53,481
Total	**588,913**	**535,270**	**575,801**

Water consumption

Month	2011 (m³)	2012 (m³)	2013 (m³)
January	29,256	26,179	29,640
February	27,528	27,064	26,939
March	35,053	27,276	34,221
April	38,366	35,707	40,950
May	42,347	41,635	41,712
June	53,137	45,917	42,937
July	48,078	51,034	38,090
August	49,610	58,106	48,691
September	56,071	48,153	43,968
October	44,772	38,684	46,359
November	34,015	46,256	38,965
December	30,528	31,517	30,391
Total	**488,761**	**477,528**	**462,863**

6. Abassan Saghera municipality

Water production

Month	2011 (m^3)	2012 (m^3)	2013 (m^3)
January	30,840	25,430	30,570
February	30,250	34,170	29,150
March	35,180	26,000	41,100
April	45,320	35,160	28,130
May	39,450	38,000	35,000
June	49,140	36,000	35,000
July	42,610	36,350	45,000
August	41,000	36,100	45,000
September	41,000	42,540	28,520
October	43,680	42,540	39,900
November	39,540	30,630	39,620
December	33,150	30,770	29,970
Total	**471,160**	**413,690**	**426,960**

Water consumption

Month	2011 (m^3)	2012 (m^3)	2013 (m^3)
January	18,962	18,387	17,601
February	15,805	18,309	18,460
March	19,016	19,178	22,733
April	22,720	22,258	21,164
May	24,998	25,031	27,311
June	31,967	29,843	27,343
July	33,292	32,798	29,729
August	37,387	30,752	28,554
September	26,128	27,687	28,620
October	26,401	27,088	28,787
November	19,729	20,044	20,301
December	18,202	19,474	18,982
Total	**294,607**	**290,849**	**289,585**

7. AL-Foukhariy municipality

Water production / Water consumption

Month	2011 (m^3)	2012 (m^3)	2013 (m^3)	Month	2011 (m^3)	2012 (m^3)	2013 (m^3)
January	21,200	25,860	24,950	January	13,767	16,962	13,160
February	19,460	21,680	17,350	February	9,663	12,807	11,504
March	18,860	16,050	16,020	March	11,114	9,029	9,716
April	24,608	19,890	24,740	April	17,664	12,598	13,371
May	25,600	21,600	25,640	May	17,667	16,403	15,189
June	27,600	28,900	29,200	June	19,083	19,306	19,348
July	28,650	29,600	28,655	July	18,862	19,172	18,138
August	29,890	38,600	27,890	August	22,282	25,486	17,773
September	26,202	35,400	28,925	September	16,557	24,692	19,341
October	30,600	34,600	32,580	October	22,856	23,467	17,932
November	22,356	28,500	22,356	November	16,093	21,840	16,093
December	20,600	22,120	24,650	December	13,242	13,563	11,386
Total	**295,626**	**322,800**	**302,956**	**Total**	**198,850**	**215,325**	**182,951**

Annex 2: Populations of each municipality during (2011, 2012 and 2013)

Municipality	2011	2012	2013
AL-FOKHARIY	7313	7618	8256
AL-QRARA	20301	21148	22918
ABSAAN k	24760	25793	27952
ABSAAN n	8849	9218	9990
KHOZAA	10589	11031	11954
BANI SOHELA	40062	41732	45225
KHAN-YOUNIS	215037	224004	242753
TOTAL	326911	340544	369048

Annex 3: Distribution of lands in each municipality

Municipality	Area (donum)	# of connection from Municipality	domestic area (donum)	commercial area (donum	industrial area (donum)	Agricultural area (donum)	Grain seasonal (donum)	Vegetables in/out green house (donum)	fructification cultivation (donum)	open area (donum)	Agricultural wells
AL-FOKHARIY	7082	1010	942	6	0	6134	734	734	2020	2646	5
AL-QRARA	11746	4408	2868	11	42	8825	2763	613	1958	3491	11
ABSAAN k	10541	4131	3320	14	0	7207	2922	1248	1151	1886	25
ABSAAN n	3951	841	1600	9	0	2342	506	366	336	1184	8
KHOZAA	4013	1453	1473	8	0	2532	1263	433	133	703	11
BANI SOHELA	5870	5482	2073	15	0	3782	1143	538	593	1509	14
KHAN-YOUNIS	54663	17139	10517	644	201	42946	4377	6770	6704	25448	183
TOTAL	97866	34464	22793	707	243	73768	13709	10702	12896	36866	257

Annex 4: Questionnaire analysis result

1. Khan Younis municipality

Holding category (Dounms)	Percentage Of Supported water(%): Munc	Percentage Of Supported water(%): private well	Family Membership(%): <2	2 to 4	4 to 6	6 to 8	8 to 10	>10
0-5	0	15	5	10	75	5	5	0
05—20	0	10	0	10	55	30	5	0
20-50	0	15	5	5	10	55	25	0
50-100	0	55	5	5	25	45	20	0
>100	0	5	0	10	5	60	25	0

Holding category (Dounms)	FARMING NOW (%): palm dates	Fruit and olives trees	Vegetable	Grain	FARMING AFTER DESALINATION (%): palm dates	Fruit and olives trees	Vegetable	Grain	IRRIGATION SOURCE (%): Munc	private well	WWTP
0-5	0	70	20	10	0	80	15	5	0	100	0
05--20	0	40	60	0	0	60	40	0	0	100	0
20-50	0	25	45	30	0	25	45	30	0	100	0
50-100	0	55	40	5	0	60	35	5	0	100	0
>100	0	10	10	80	0	25	10	65	0	100	0

2. Bani Sohaella municipality

Holding category (Dounms)	Percentage Of Supported water(%)		Family Membership(%)					
	Munc	private well	<2	2 to 4	4 to 6	6 to 8	8 to 10	>10
0-5	0	40	0	20	70	10	0	0
05—20	0	20	0	10	80	10	0	0
20-50	0	25	0	0	70	20	10	0
50-100	0	15	0	0	50	30	20	0
>100	0	0	0	0	0	0	0	0

Holding category (Dounms)	FARMING NOW (%)				FARMING AFTER DESALINATION (%)				IRRIGATION SOURCE (%)		
	palm dates	Fruit and olives trees	Vegetable	Grain	palm dates	Fruit and olives trees	Vegetable	Grain	Munc	private well	WWTP
0-5	0	70	30	0	0	90	10	0	0	100	0
05—20	0	60	35	5	0	85	15	0	0	100	0
20-50	0	15	25	60	0	75	15	10	0	100	0
50-100	0	5	15	80	0	20	40	40	0	100	0
>100	0	0	0	0	0	0	0	0	0	100	0

3. Abassan Kabera municipality

Holding								
Holding category (Dounms)	Percentage Of Supported water(%)		Family Membership(%)					
	Munc	private well	<2	2 to 4	4 to 6	6 to 8	8 to 10	>10
0-5	0	45	0	20	80	0	0	0
05—20	0	15	0	10	70	20	0	0
20-50	0	25	0	0	70	20	10	0
50-100	0	15	0	0	50	30	20	0
>100	0	0	0	0	0	0	0	0

Holding											
Holding category (Dounms)	FARMING NOW (%)				FARMING AFTER DESALINATION (%)				IRRIGATION SOURCE (%)		
	palm dates	Fruit and olives trees	Vegetable	Grain	palm dates	Fruit and olives trees	Vegetable	Grain	Munc	private well	WWTP
0-5	5	80	15	0	5	80	15	0	0	100	0
05--20	0	70	30	0	0	75	25	0	0	100	0
20-50	0	20	40	40	0	20	40	40	0	100	0
50-100	0	0	20	80	0	0	20	80	0	100	0
>100	0	5	5	90	0	5	5	90	0	100	0

4. Al-Qarara municipality

Holding

Holding category (Dounms)	Percentage Of Supported water(%) Munc	Percentage Of Supported water(%) private well	Family Membership(%) <2	2 to 4	4 to 6	6 to 8	8 to 10	>10
0-5		20	0	10	80	10	0	0
05—20		15	0	0	60	20	20	0
20-50		15	0	20	40	40	0	0
50-100		45	0	0	40	40	20	0
>100		5	0	0	0	100	0	0

Holding

Holding category (Dounms)	FARMING NOW (%) palm dates	Fruit and olives trees	Vegetables	Grain	FARMING AFTER DESALINATION (%) palm dates	Fruit and olives trees	Vegetables	Grain	IRRIGATION SOURCE (%) Munc	private well	WWTP
0-5	10	90	0	0	10	90	0	0	0	100	0
05--20	30	10	50	10	20	20	50	10	0	100	0
20-50	0	45	5	50	0	45	5	50	0	100	0
50-100	0	40	0	60	0	40	0	60	0	100	0
>100	0	20	0	80	0	20	0	80	0	100	0

5. Khozaa municipality

Holding category (Dounms)	Percentage Of Supported water(%): Munc	Percentage Of Supported water(%): private well	Family Membership(%): <2	Family Membership(%): 2 to 4	Family Membership(%): 4 to 6	Family Membership(%): 6 to 8	Family Membership(%): 8 to 10	Family Membership(%): >10
0-5	0	40	10	30	40	20	0	0
05—20	0	50	10	0	60	20	0	0
20-50	0	10	0	0	10	70	20	0
50-100	0	0	0	0	10	80	10	0
>100	0	0	0	0	10	90	0	0

Holding category (Dounms)	FARMING NOW (%): palm dates	FARMING NOW (%): Fruit and olives trees	FARMING NOW (%): Vegetable	FARMING NOW (%): Grain	FARMING AFTER DESALINATION (%): palm dates	FARMING AFTER DESALINATION (%): Fruit and olives trees	FARMING AFTER DESALINATION (%): Vegetable	FARMING AFTER DESALINATION (%): Grain	IRRIGATION SOURCE (%): Munc	IRRIGATION SOURCE (%): private well	IRRIGATION SOURCE (%): WWTP
0-5	0	30	70	0	0	35	65	0	0	100	0
05--20	0	20	70	10	0	25	75	0	0	100	0
20-50	0	10	20	70	0	15	15	70	0	100	0
50-100	0	0	10	90	0	0	10	90	0	100	0
>100	0	0	0	100	0	0	0	100	0	100	0

6. Abassan Saghera municipality

Family Membership(%)						Percentage Of Supported water(%)		Holding category (Dounms)	Holding
>10	8 to 10	6 to 8	4 to 6	2 to 4	<2	private well	Munc		
20	40	20	20	0	0	60	0	0-5	
0	10	50	40	0	0	25	0	05—20	
0	0	30	50	20	10	15	0	20-50	
0	0	0	0	0	0	0	0	50-100	
0	0	0	0	0	0	0	0	>100	

(%)			FARMING AFTER DESALINATION (%)				FARMING NOW (%)				Holding category (Dounms)	Holding
WWTP	private well	Munc	Grain	Vegetable	Fruit and olives trees	palm dates	Grain	Vegetable	Fruit and olives trees	palm dates		
0	60	0	0	0	100	0	5	15	80	0	0-5	
0	15	0	45	35	20	0	45	35	20	0	05--20	
0	5	0	60	35	5	0	60	35	5	0	20-50	
0	0	0	0	0	0	0	0	0	0	0	50-100	
0	0	0	0	0	0	0	0	0	0	0	>100	

7. AL-Foukhariy municipality

Family Membership(%)						Percentage Of Supported water(%)		Holding
>10	8 to 10	6 to 8	4 to 6	2 to 4	<2	private well	Munc	Holding category (Dounms)
0	0	10	70	10	0	35	0	0-5
0	0	60	40	0	0	25	0	05—20
0	20	40	40	0	0	20	0	20-50
10	30	60	10	0	0	15	0	50-100
0	30	40	30	0	0	5	0	>100

IRRIGATION SOURCE (%)			FARMING AFTER DESALINATION (%)				FARMING NOW (%)				Holding
private well	Import	Munc	Grain	Vegetable	Fruit and olives trees	palm dates	Grain	Vegetable	Fruit and olives trees	palm dates	Holding category (Dounms)
0	100	0	0	0	100	0	0	20	80	0	0-5
0	100	0	0	30	70	0	0	40	60	0	05—20
0	100	0	5	30	65	0	10	30	60	0	20-50
0	100	0	5	25	70	0	20	10	70	0	50-100
0	100	0	100	0	0	0	100	0	0	0	>100

Annex 5: Questionnaire in Arabic.

أهلا بكم في استبيان حول استخدام المياه للزراعة. يهدف هذا الاستبيان إلى الخروج بمؤشر حول مدى السلوك النوعي لسكان محافظة خان يونس في الزراعة و الري في ظل أزمة المياه من الكم و النوع حيث عن طريق معرفة أنواع المزروعات يمكن التنبؤ بمعدل الاستهلاك المفترض. وليس إلى هذا الحد بل دراسة السلوك المتوقع بعد إنهاء سيناريو مشروع محطة التحلية المركزية حيث سيتم دراسة السلوك الزراعي المتوقع مستقبلا.

1. لمقترحاتكم ولمزيد من المعلومات يرجى مراسلتنا على البريد الالكتروني y.shaheen@teachers.org
2. المصدر الرئيسي لإمدادات المياه المنزلية في بيتك: ☐ البلد ☐ بئر خاص ☐ لا يوجد
3. أفراد الأسرة ☐ 2 ☐ 4 ☐ 6 ☐ أكثر من ذلك
4. متوسط الدخل الشهري .... شيكل
5. هل توجد أرض زراعية تابعة للسكن ☐ نعم ☐ لا ☐ ذكر المساحة بالمتر المربع

إذا كانت الإجابة بنعم في السؤال رقم 4 انتقل للسؤال رقم 5 و حتى سؤال رقم 7:

6. مصدر مياه الري الخاص بالمزروعات:

☐ البلدية ☐ بئر خاص ☐ مياه عادمة (صرف صحي) معالجة

7. ضع إشارة ( ) أمام ما تزرعه في مزرعتك:

☐ النخيل ☐ الأشجار المثمرة (الفاكهة، الزيتون، العنب) ☐ الخضراوات ☐ الحبوب

- في حال تم تحسين نوعية المياه بحيث تصبح عذبة و صالحة للشرب، كما و تم تحسن في كمية المياه المزودة من البلدية فإلى أي مدى سينعكس على أنواع المحاصيل لمزرعتك.

8. ضع إشارة ( ) أمام ما تزرعه في مزرعتك:

☐ النخيل ☐ الأشجار المثمرة (الفاكهة، الزيتون، العنب) ☐ الخضراوات ☐ الحبوب

Annex 6: Technical people and data providers.

No.	Name	Job title	Organization
1	Eng. Mahmoud Ismail	Water desalination department	Palestinian Water Authority (PWA)
2	Eng. Yahia AL-Astal	Mayor of the municipality	Khan Younis municipality
3	Eng. Hammad AL-Raggab	Mayor of the municipality	Bani Sohaella municipality
4	Eng. Abed-Raheem Abadla	Mayor of the municipality	Al-Qarara municipality
5	Eng. Moustafa AL-Shawaf	Mayor of the municipality	Abassan Kabera municipality
6	Eng. Abed-Raouf Assfour	Mayor of the municipality	Abassan Saghera municipality
7	Dr. Ahmad AL-Farra	Mayor of the municipality	AL-Foukhariy municipality
8	Eng. Kammal Najjar	Mayor of the municipality	Khozaa municipality
9	Eng. Tammer Tabash	Head of soil and irrigation KYG department	Ministry of Agriculture (MoA)/ Khan Younis department
10	Eng. Ahmad AL-Queek	Head of Design department & former area manager - Rafah	Ministry of Agriculture (MoA)
11	Eng. Mounther Shoblak	Vice-chairman of CMWU – Gaza	Coastal Municipalities Water Utility (CMWU)
12	Eng. Nehaad Al-Khateeb	Head of Design & water department manager – Gaza	Coastal Municipalities Water Utility (CMWU)
13	Eng. Saadi Ali	Site engineer in water department – Gaza	Coastal Municipalities Water Utility (CMWU)