



Faculty of Graduate Studies

M.Sc. Program in Water and Environmental Engineering

**Assessing the Impacts of Regional and Local Water Theft on Sustainability of
the Palestinian Water Sector**

تقييم أثار سرقة المياه اقليميا ومحليا على استدامة قطاع المياه الفلسطيني

A Master Thesis Prepared by:

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Student number (1175248)

Supervisor:

Dr. Maher Abu-Madi

January 2020



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Degree in Water and Environmental Engineering from the Faculty of Graduate
Studies, at Birzeit University, Palestine.*

2020

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The findings, interpretations and conclusions expressed in this study do not necessarily express the views of Birzeit University, the views of the individual members of the M.Sc. Committee or views of their respective employers.

Date of Defense: 29-10-2019

DEDICATION

To my beloved parents, brothers and sisters, for all the love, guidance, giving, support, prayers, and continuous encouragement.

To all dear friends who accompanied me during the Master study.

I dedicate this research study.

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First, thanks God for giving me the all the strength necessary throughout my study.

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ABSTRACT

This research deals with the issue of theft and illegal access to water, where the Palestinian water sector is exposed at the regional and local levels to water theft. At the regional level, the Palestinian side shares with the Israeli occupation four groundwater basins, three in the West Bank and one in the Gaza Strip, in addition to the transboundary surface waters of the Jordan River Basin. At the local level, the water sector is being used and illegally obtained by some citizens in the West Bank and Gaza Strip.

The research focused on Regional Water Theft and Local Water Theft. In order to determine the amount of water gap allocated between the two sides as well as the comparison between the volume of individual consumption to highlight the lack of fair use between the two sides, which violates the resolutions of the United Nations in addition to the principles of international water law.

For the section on the theft of local water was collected through the water balance of all municipalities in the West Bank and the Gaza Strip, where these data were obtained from the Water Sector Regulatory Council in the city of Ramallah and through this water balance, the amount of stolen water was calculated for each municipality and its percentage of the total water provided by the municipality.

The research also designed a special questionnaire addressed to water experts in Palestine and contains important questions divided into two sections. The first is questions about the Israeli-Palestinian conflict and the theft of territorial waters and are the international water law principles apply on the Palestinian-Israeli situation, and the second section contains questions on the issue of water theft locally to draw the views of water experts on this subject and derive their recommendations that can be relied on to reduce this phenomenon.

The importance of this study is to show the Israeli practices regarding water as a basic human right and its violation of the signed agreements as well as the principles of international water law, where this study showed a big difference in consumption between the two sides and the settlements that embezzle Palestinian water rights. In addition, this study highlights the importance of confronting local thefts which will increase the financial losses of the water sector and service providers and thus have a far-reaching impact on the Palestinian water sector.

ملخص :

يتحدث هذا البحث عن قضية سرقة المياه والحصول عليها بطريقة غير قانونية، حيث يتعرض قطاع المياه الفلسطيني على المستويين الاقليمي والمحلي من سرقة المياه. في المستوى الاقليمي يشترك الجانب الفلسطيني مع دولة الاحتلال الاسرائيلي في اربعة أحواض جوفية ثلاثة منها في الضفة الغربية وحوض واحد في قطاع غزة بالإضافة الى مياه سطحية عابرة للحدود وهي حوض نهر الاردن، وعلى الصعيد المحلي يتعرض قطاع المياه الى سرقة للمياه والحصول عليها بطرق غير شرعية من قبل المواطنين الفلسطينيين في الضفة الغربية وقطاع غزة.

تم العمل على أنجاز البحث خلال قسمين سرقة المياه الاقليمية، وكذلك سرقة المياه المحلية بالنسبة لسرقة المياه الاقليمية تم العمل على جمع كافة البيانات والمعلومات الخاصة بمصادر المياه المشتركة بين الجانبين حيث تشمل القدرة الانتاجية، والمياه المخصصة لكل جانب، وعدد السكان المستفيدين من هذه المصادر المائية المشتركة من اجل تحديد كمية الفجوة في المياه المخصصة بين الجانبين وكذلك المقارنة بين الجانبين في حجم الاستهلاك الفردي لابرار عدم الاستخدام العادل بين الجانبين والذي يخالف قرارات الامم المتحدة بالإضافة الى مبادئ قانون المياه الدولي.

بالنسبة للقسم الذي يتحدث عن سرقة المياه المحلية تم من خلال جمع الميزان المائي لكافة بلديات الوطن في الضفة والقطاع حيث تم الحصول على هذه البيانات من مجلس تنظيم قطاع المياه في مدينة رام الله ومن خلال هذا الميزان المائي تم حساب كميات المياه المسروقة لكل بلدية ونسبتها من المجموع الكلي للمياه المزود من قبل البلدية وتم أيضا حساب نسبة المياه الفاقدة باستثناء السرقة، حيث تم المقارنة بين نسبة جميع أنواع الفاقد مجتمعة مع نسبة المياه المسروقة والتي كانت متساوية في أغلب حالاتها وهذا يعني مدى خطورة سرقة المياه على استدامة القطاع الفلسطيني.

من خلال البحث أيضا تم تصميم أستبيان خاص موجه لخبراء المياه في فلسطين ويحتوي على أسئلة مهمة مقسمة الى قسمين الاول أسئلة تتحدث عن الصراع الفلسطيني الاسرائيلي وسرقة المياه الاقليمية وهل ينطبق قانون المياه الدولي على الحالة الفلسطينية الاسرائيلية وما هي النصائح التي يوجها خبراء المياه للقيادة الفلسطينية من اجل العمل على استعادة الحقوق المائية الفلسطينية، والقسم الثاني يحتوي على اسئلة عن موضوع سرقة المياه محليا لاستخلاص آراء خبراء المياه عن هذا الموضوع بالإضافة الى التوصيات التي يمكن الاعتماد عليها للحد من هذه الظاهرة.

تكمن أهمية هذه الدراسة في اظهار الممارسات الاسرائيلية فيما يتعلق بالمياه كونها حق من الحقوق الانسانية الاساسية ومخالفتها للاتفاقيات الموقعة، وكذلك لمبادئ قانون المياه الدولي حيث أظهرت هذه الدراسة الفرق الكبير في الاستهلاك بين الجانبين بالإضافة الى المستوطنات التي تختلس الحقوق المائية الفلسطينية، بالإضافة الى ذلك تبرز هذه الدراسة أهمية مواجهة السرقات المحلية التي بلغت نسبتها ما يعادل كمية أنواع الفاقد مجتمعة وهذا من شأنه زيادة الخسائر المالية لدى قطاع المياه ومزودي الخدمة وبالتالي تترك أثرها البعيد على قطاع المياه الفلسطيني.

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LIST OF ABBREVIATIONS:

ARIJ: Applied Research Institute-Jerusalem

B'TSELEM: Israeli Information Center for Human Rights.

BGR: Bundesanstalt für Geowissenschaften und Rohstoffe

CM: Cubic Meter.

GDP: Gross Domestic Product.

IWA: International Water Association.

JWC: Joint Water Committee.

L/c.d: liters per capita per day.

MCM: Million Cubic Meter.

Nis: Israeli Currency (Shekel).

NRW: Non- Revenue water.

NRW-T: Non-Revenue water resulted from water theft.

PCBS: Palestine Central Bureau of Statistics.

PWA: Palestinian Water Authority.

UN: United Nations.

UN-ESCWA: United Nations Economic and Social Commission for Western Asia

WB: World Bank.

WHO: World Health Organization.

WSRC: Water Sector Regularity Council.

CHAPTER ONE – INTRODUCTION

1.1. Background and Problem Definition

Water is one of the main sectors in the world to ensure development of communities in all aspects including agricultural, industrial, social, economic, and health. The sustainability of these important fields, forces each country exploits its water resources in the best way.

The global challenge is the utilization of transboundary water resources and avoiding conflict with other riparian countries where the shared water resources between two countries or more take a high interest from all countries all over the world. These basins are shared by 150 countries and disputed areas, cover 47.1% of the Earth's land surface and include 52% of the world's population (McCracken and Wolf, 2019). Transboundary water resources, sometimes exposed to unilateral action and exploited by some countries more than its neighbors. These policies called international community to put efforts to avoid conflict that could cause war for water and so this subject take a high priority in many international conferences.

The international conferences and united nation conventions called riparian countries to avoid conflict and unilateral actions and enhance cooperation to allocate shared water resources in an equitable water. Countries will join in agreement only if they obtain positive gains (or greater benefits than through unilateral action alone), and if they feel that they will receive a fair share of those gains (Qaddumi, 2008).

Privileges of some riparian countries form a power point to do as unilateral action like the upstream countries which have more controlling on the transboundary headwaters. So, the upstream countries take water more than downstream countries and some experts consider this unilateral action as a stealing water like in case of the Guadiana River between Spain and Portugal.

The conflict between riparian countries not only on the amount of allocating water between them. But, the strongest military country exploits weaknesses of other riparian countries to build and create its special projects like dams to elaborate electricity or supply farmer land near to the border and thus consider important economic point like in case Nestos-Mesta River between Greece and Portugal. However, there are other cases and other reasons of conflicts includes economic, social,

sovereignty and political issues. But, the principles of international water law could be implemented in all types of conflicts reasons.

Increasing of population in the world leads to increase productivity activities, social requirement welfare, and various economic development activities. However, in case of water shortage and water crisis put the leaders of communities in a big challenge to provide water for all users to ensure water security. Water scarcity, whatever its cause—natural catastrophes, pollution, poor water management, or theft—can have grave consequences (Brown, 2017).

To avoid water scarcity the managers of water sector should build a good plan to save water resource, either inside the border of a country or shared with other riparian countries. However, the controlling of water resources inside the country by extracting water from the sources and distribute the water to all users is the key point to avoid internal conflicts and prevent illegal actions from people if all people got the water inequitable manner.

The water supply systems are part of the urban infrastructure which must assure the continuity of the water distribution (Stancel et al., 2008). The water supplied for users across several stages started from the source point attached to the main pipeline that connected with secondary pipe lines, then internal distributed networks which linked directly with house connections. However, every water supply system exposed to many losses either by illegal actions or by technical reasons that decrease the amount of water extracted from the source across its path until reach the consumer point.

Technical losses sometimes resulted from Non-Humanity behavior like leakage from the tank or main pipe lines and these losses or other similar losses could be treated by continuous maintenance for the water distributed system. On the other hand, another type of losses occurs by unauthorized consumers whom got the water by illegal actions defined as water theft. The concept of water theft is valid—theft being the appropriation of water without the required payment, or in violation of existing rules (Brown, 2017).

Water theft is increasing problem in the world and form actual challenge to the leaders of water sector. Indeed, reasons of stealing water sometimes refer to the cultural background of the community. In addition, inequitable water distribution leads to create social problems and encourage some users to steal water. However, the price of water is one of the main reasons for

poor people to steal and smuggling water. Pricing policies may not only fail to encourage conservation, but they may even increase the incidence of theft itself (Mattoussi and Seabright, 2014).

Particularly in Palestine, the water sector suffers from a general weakness as a result of the Israeli occupation, which controls most of the shared water sources by up to 85% of the water resources.

Israel has controlled most of the transboundary groundwater sources shared with Palestine, controlling most of the water extracted from these basins and pumping large quantities into Israel while reducing water to the Palestinian side. And the only option for the Palestinian National Authority as the weakest side in terms of force in the face of water thefts by the Israeli occupation is to go to the donor countries to support the projects of the Palestinian National Authority and pressure on the Israeli side through support of international law to protect natural resources in order to respect and preserve the rights of Palestinians In accessing and controlling water sources and stopping thefts and looting by the Israeli occupation.

As a result of these policies, the Palestinians control about 15% of the shared water resources and these resources includes north-Eastern Aquifer, The Western Aquifer, and The Eastern Aquifer in West Bank and the coastal Aquifer in Gaza strip.

The quantity controlled by the Palestinian side is being subjected to theft and looting, as many cases of water shortages are recorded due to illegal connections and other reasons that leads to illegal access to water in various areas of the West Bank and Gaza Strip.

Working to reduce the loss of the quantity of water resulting from the theft of citizens, as well as forcing consumers to pay the water fees, resulting in a significant contribution to raise the economic level of water service providers and thus increase the amount of expenses for the maintenance and operation of networks as well as the sustainable development of the water sector.

This research studies the regional water theft in Palestine by estimating the amount of water that is stolen from shared water resources by the Israeli occupation and illegal consumption of local citizens in both West Bank and Gaza Strip, the percent of Non-Revenue water that will be resulted from unauthorized consumption and view the water experts opinions about both issues by using appropriate questionnaires.

1.2. Aim and Objectives

The major objective of this study is to assess the impacts of regional and local water theft on sustainability of the Palestinian water sector. This specific objectives are:

- To identify the shared water resources between both sides and to estimate the amounts of water stolen by Israeli occupation.
- To compare the water consumption between the Palestinians and Israelis, including the illegal settlers in the West Bank.
- To estimate the amount of water that is consumed illegally by the Palestinian citizens.
- To calculate and compare the percentages of Non-Revenue water resulted from water theft and other losses.
- To study the level of knowledge among the Palestinian water experts on the subject.

1.3. Research Approach and Methodology

Appropriate methodology to serve aims of this study started from collecting regional and local data, the regional data are about shared water resources and allocating of water for both sides. The regional data will collect from published literature or official report published by authorities in both sides. According to the local data that will be collecting from municipalities or councils and water sector regularity council to provide detailed data which is called water balance for each council to determine the amount of unauthorized consumption to deserve aims of this study.

The appropriate questionnaire prepared and contain critical questions that will discuss and illustrate main topics in both issues and derive the recommendations and observations from water experts.

1.4. Research Questions

- What are the shared water resources and what is the amount of water allocating for both sides?
- What are the differences in consumptions between citizens in both sides and quantities of water consumed by illegal settlers?
- What is the percent of Non-revenue water that resulted from water theft?
- What are the opinions of water experts about regional and local issues?

1.5. Thesis Outline

Chapter One identifies the problem definition and background of research issues, objectives of the study, research approach and research questions. Chapter Two illustrates the international cases of transboundary water conflict and how some cases reach to the logical solution by bilateral agreement, the international water law principles, Israeli cases with its neighbors, situation of the water sector in both Palestinian and Israeli sides, the local water theft and define water balance according to the international water association, Non-Revenue water and water sector sustainability. Chapter Three provides what is data required and how to collect regional and local data also how discuss these data and understanding the water balance to determine results of local water theft and then analyze and discuss results. Chapter Four presents the results of water theft quantities and discuss the results. Chapter Five summarizes the main conclusions and recommendations.

CHAPTER TWO - LITERATURES REVIEW

2.1. Basic Definitions

- Transboundary water conflict: Transboundary waters are the water resources which include groundwater and surface water that sharing geographically between two countries or more. Historically, the headwaters are the real impulse for immigration, conflict between people. In the past decade, water disputes have not produced large-scale global war, but regional fights and local wars often have used water as a part of a stratagem to advance political goals (Kreamer, 2012). However, the nature of conflict between riparian countries refers to the economic, political, and social aspects depending on the privileges of shared water resources. Transboundary water conflicts are frequently considered to be international issues resulting from human modifications in the way water moves across international boundaries (Matthews, 2005).
- Regional water theft: the extra withdraw water by one of the riparian countries shared with transboundary water without consultation other countries. However, the allocating water for each side is under the rules of special agreements between riparian countries or is under the conditions of international water law principles that ensure the equitable allocation of water, and enhancing cooperation in managing the mutual projects without cause significant harm for others. For example, in a basin shared by two riparian's, the downstream riparian may incur significant harm if the upstream riparian's population growth dictates the need for a substantially greater quantity of water, thus reducing the downstream party's existing allocation (Gander, 2014), the privileges of geographic location for upstream country form a strong impulse for appropriation water much more than downstream country and this consider a regional water theft since penetration the principles of international water law. In addition, in some cases the riparian countries which have stronger military power act unilateral action and neglecting the right of other countries in allocating water.

- Local water theft: withdraw water from the water network system by local citizens inside the country without the obligation of the required authorizing needs. However, the alternative definition of water theft is unauthorized consumption in the water balance model according to the international water association. Illegal water use is a problem that affects, above all, the environment and the legal users – suppliers, irrigators, industries and individuals abstracting water for domestic use –, who run out of water while others make a considerable profit by breaking the law (WWF, 2006). So, the real impulses for water theft by local citizens include high price of water, inequitable manner of water for all users leads to decrease social justice, weak of law to protect water resources or water networks from illegal actions, and the personal greed for some users to get water much more than other users.

- NRW (Non- Revenue Water): NRW form the big part of water supplied to the consumers without bringing money. However, Water losses (physical/real and apparent/commercial) represent the biggest part of the so-called non-revenue water (NRW), thus water not bringing in revenues to the water utility (Kanakoudis and Muhammetoglu, 2013). So, the higher the levels of NRW, the more inefficient the city's water management (González-Gómez, García-Rubio and Guardiola, 2011). In general, the NRW is the biggest challenge for the water management leaders to reduce the level of financial losses and to ensure sustainability of the water sector and its worth mentioning that the water theft form a noticeable percent in the total NRW.

2.2 Palestinian Water Sector

2.2.1 Groundwater resources

Groundwater is considered the most important water resource in Palestine and there are three aquifers (PWA, 2013): i) Western aquifer with sustainable yield 362-400 MCM/yr and Israel extract annually 340-430MCM/yr but Palestinian exploit 28 MCM/yr only, ii) the north- eastern aquifer with sustainability yield annually about 100-145 MCM and the Israeli side exploit 103 MCM/yr but the Palestinian side consumed about 23MCM/yr, and iii) the Eastern aquifer which has an annual sustainable yield 145-185 MCM/yr where Israel discharges about 150MCM/yr from wells and the Dead Sea but the Palestinians consumed 53 MCM/yr (PWA, 2013).

2.2.2 Surface water resources

Surface water resources include Jordan River which is exploited by only riparian countries Israel, Jordan, and Syria, while the Palestinians rights from this resource are denied (PWA, 2013). Water resources include rainfall with recorded quantities range 100-700 mm in all over West Bank while Gaza Strip rainfall recorded shows changeable annual rainfall. In addition, the wadis have average annual flow of approximately 179 MCM/year during season (2011/2012) (PWA, 2013).

2.2.3 Water uses and consumptions

The Palestinian Water Authority (PWA, 2013) shows the different uses of water from Palestinian wells in 2012 where is Palestinian citizens in West Bank exploit water for domestic uses about 12.3 MCM from western basin, 11.0 MCM from eastern basin and 10.0 MCM from north-eastern. However, for agricultural uses water consumed quantities were about 18.1 MCM from Western basin, 9.9 MCM from eastern basin, and 3.0 MCM from north-eastern basin. In Gaza Strip water quantities extract from coastal aquifer for domestic uses is 102.0 MCM and 31.0 MCM for agricultural uses.

The water consumed by Palestinian citizens in 2014 according to (FANAK WATER, 2016) Newsletter was 310 MCM divided into 125 MCM for West Bank and 185 MCM for Gaza Strip and to meet Palestinian needs for water, the Palestinian Water Authority purchased water from Mekorot about 55 MCM/year in period (2010-2015). However, the domestic water use in West Bank in 2011 was 62.4 MCM and the daily consumption by Palestinian in average was 60-90 l/c/d while the daily consumption in (2013/2014) by Gaza citizens was 90 l/c/d. For agricultural sector, the Palestinians used about 141 MCM/yr which was form 62% of water supplied where is divided into 55 MCM for Gaza Strip and 86 MCM for West Bank.

2.2.4 Water tariff

According to the Palestine Central Bureau of Statistics (PCBS, 2017) which is published the water tariff on average in the West Bank and Gaza Strip. The table indicates that the water tariff for first class which is consumed (0-5) CM/month equal 4.01 NIS/CM in West Bank and 1.03 NIS/CM in Gaza strip, while the tariff for second class (5.1-10)CM/month are 4.04 NIS/CM and 1.13 NIS/CM in West Bank and Gaza Strip respectively. The third class (10.1-20) CM/month have a tariff equal 4.62NIS/CM in West Bank and 2.5NIS/CM in Gaza Strip.

According to the report prepared by World Bank group (WB, 2018) which talks about water development in Palestine. The report indicates that the water tariff are low in both West Bank and Gaza strip, where tariff in the West Bank hardly cover operational cost and service providers collect only 76 cent on each dollar spent on cost. In addition, tariff in Gaza strip (2014) on average is 2.01 NIS (0.7\$) per each cubic meter. In general, on average 68% of customers pay their bills and the tariff hardly cover operation and maintenance costs.

2.2.5 Palestinian Water Law

The Palestinian water law 2002 was issued by a decision of the cabinet of the ministers on 8, Feb, 2002 then, after 12 years the law is modified upon the recommendation from the cabinet of the ministers meeting, which hold on 13, May, 2014. However, the basic objective of Law is to optimal utilization of water resources without harm their quality and increase their capacity, and to implement the integrated water resources approach for sustainable and to push up the level of water services (WSRC, 2014).

The water law (2014) is the law implemented now and it contains several articles that confirm the water resources are public facilities for authorities and also, the law ensures the right for everyone to get water with appropriate quality. The article (17) focusing on about establishing the water sector regulatory council for managing, monitoring operation activities and performance of water service providers. In addition, the section eleventh contains the articles (57-62) about the Penalties system for illegal access to water resources and unauthorized consumers (See Annex 1).

2.3 Israeli Water Sector

2.3.1 Overview of water resources

Israeli water resources includes surface water and groundwater resources (FANAK, 2016). There are many major surface water resources including Jordan, Yarmouk, Yarkon (Al-Auja), Kishon (el-Mokatta) Rivers and Lake Tiberias where the Jordan River is considered a shared water resource between Israel and its neighbors and provides about 580-640 MCM/yr for Israel. Also, there are groundwater resources that include Coastal Aquifer which is shared with Palestinian side (Gaza Strip) and while Gaza strip takes about 25% of its productivity. Furthermore, there is the Mountain Aquifer which is divided into (Eastern, Northern, and Western) where Israel extracts about 80% from these Aquifers. And there are other groundwater resources in Israel such as Negev (An-Naqab) and Arava (Araba).

2.3.2 Water use and consumption

According to FANAK (2016), the Israeli water consumption was estimated 2,187 MCM in 2013 which included all sectors (domestic, industry, agriculture) and the consumption is expected to be 2,672 MCM by 2020 and about 3,571 MCM by 2050. The largest consumption was in the agriculture sector, which consumes around 58% and the second sector is domestic use, which consumes about 35% and the rest about 7% goes to industrial uses.

Avgar (2018) wrote a report about water Israeli sector. One of the main topics is water consumption and uses in Israeli. The report indicates that the consumption in all sectors at 2016 is about 2,346 MCM where 34% of water uses is domestic and public, industry take about 5% of water consumed, and the agriculture sector is consumed more than half of water consumed which is about 55%. However, about 60% of water uses in agriculture is non-fresh water. He indicates to the changes in water consumption per capita for the last 15 years from 2000 to 2016 and the average consumption per capita including all sectors is 257 CM annually and for only domestic uses is about 96CM annually.

2.3.3 Israeli Settlements in Palestine

Nieuwhof (2013) wrote a report about the huge difference in water consumption between Palestinian and settlers in settlements. Also, she described the Israeli policies pillars that depend on apartheid approach and put restrictions on water resources to strangulation people where report is indicates that consumption of 500,000 settlers six times more than 2.6 million Palestinian in West Bank. Moreover, infrastructure and water networks parts destructive by Israeli force.

According to report published by the Israeli Information Center for Human Rights in the Occupied Territories (B'TSELEM, 2017) the Israeli policy and planning aim to establish and increase settlements. The number of settlements increased rapidly between 1967 and 2019 with more than 200 in the West Bank; about 131 settlements are authorized and supported by Israeli Ministry of the Interior and 110 settlements are not recognized but built by support from Israeli government. The number of Israeli citizens according the Central Bureau of Statistics is more than 620,000 where is 209,270 live annexed to Jerusalem and 413,400 distributes in the all parts of West Bank. The report explained the Israeli strategies to put control on the land and take over the natural sources of water which is consider the major factor to sustain live in these settlements.

2.4 International Water Conflict and Transboundary Water Issues

In this segment represents many different instances of water conflict on the transboundary water resources, some of the cases still under negotiations and international press to solve conflict and enhancing peace process in the world while other cases created the sound experience in sharing water courses through joint committees and sharing beneficial projects upon the international water law principles which support the national interests for all riparian states.

2.4.1 International water law principles

Wolf (1999) studied the main reason for international water conflict is the equitable allocation of shared watercourses and what are the criteria to appropriate allocation for transboundary water resource. These criteria are right-based: hydrography vs. chronology (extreme principles, moderate principles), economic criteria, social and political linkages. In addition he illustrate the criteria resulted from the previous experiences like the order priorities for using water in general aspects like domestic use, irrigation use, hydro-power produce and other beneficial uses.

Rahaman (2009) studied the international water law principles and how to create effective cooperation in management shared water resource. These principles are equitable and reasonable utilization, involvement not to cause significant harm, notification and consultations for each riparian parties, cooperation and information exchange, and peaceful settlement of disputes. All these principles of international water law built upon major theories which is absolute territorial sovereignty, absolute territorial integrity, and limited territorial sovereignty.

According to study prepared by Gander (2014) about how to simulate international water principles in a template for bilateral agreement. This template is meet the concept of international water law for equitable allocation and cooperation and do not harm other riparian parties. Also, development of the template is credence with the 1997 UN watercourses convention. He divided the rules for water management principles into substantive rules and procedural rules which is put mechanisms to implement the substantive rules.

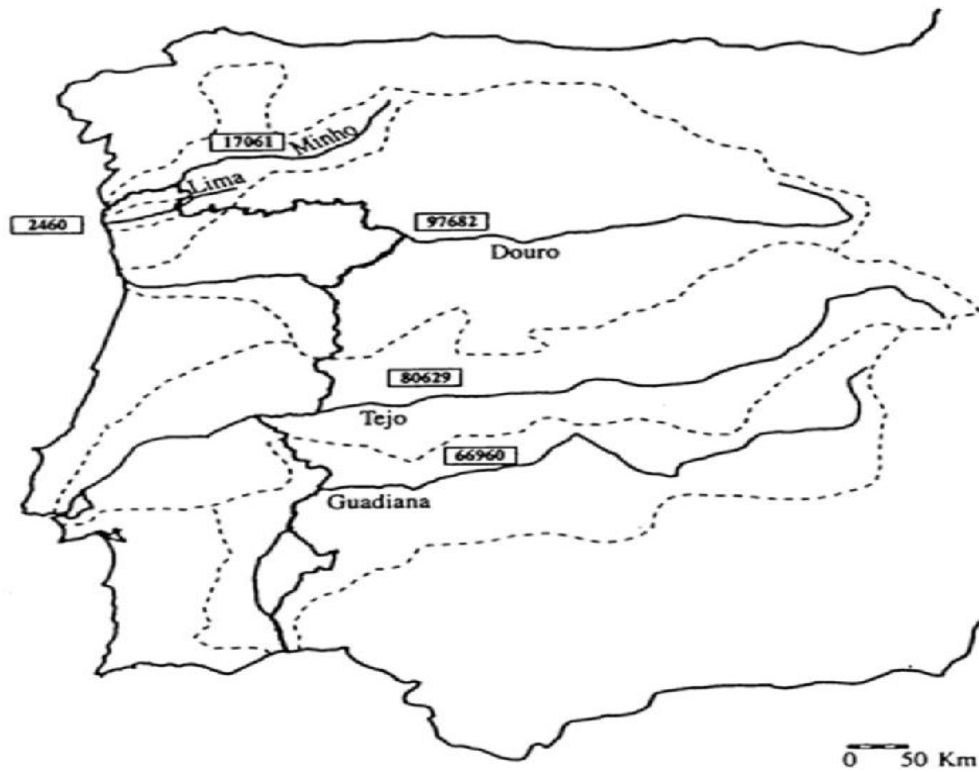
2.4.2 Portugal and Spain case

Thiel (2007) studied the case of river basin shared between Portugal and Spain that are shared on the border with five rivers: Lima, Minho, Douro, Tagus, and Guadiana. From the geographical location, viewpoint Spain is privileged because it is an upstream country. Portugal is a downstream country except for the Guadiana River, which forms the border with Spain after passing through Portugal. So, Portugal puts its efforts for conventions to save water rights in transboundary water with Spain.

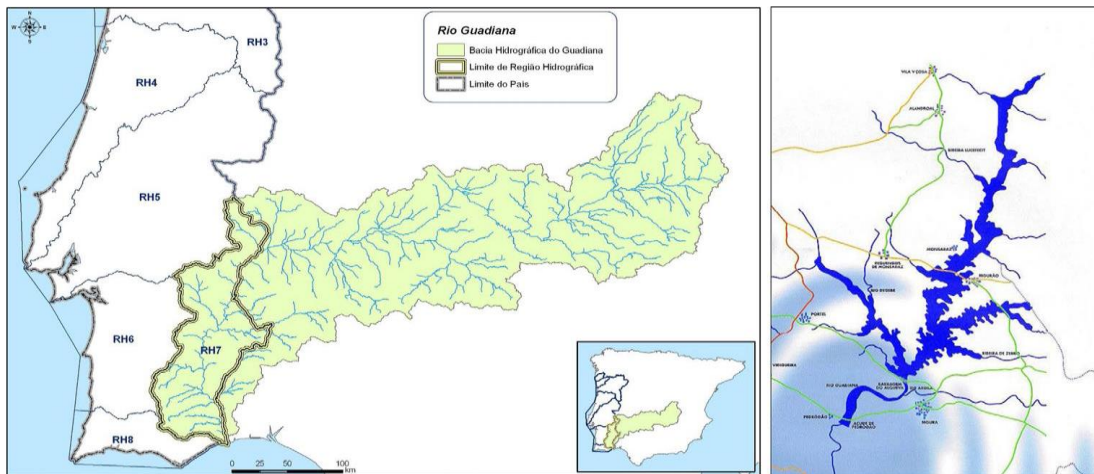
Negotiations arise because Portugal is obviously worried from Spain behavior significantly national experts when they published Spanish national water plan (Plan Hydrological Nacional, PHN) in 1993 which does not meet with the Portugal strategies, the approach of Spain to transfer transnational rivers to these lands without even consult the Portugal side. The press coverage this issue and addressed in a lot of distributed daily newspaper that formed a new strong idea about someone's country stealing a water from another.

The objective of a final convention, which is called convention on Co-operation for the protection and sustainable use of the waters of the Luso-Spanish River Basins were determined and signed in 1998 for take mechanisms for sustainable development, faces the droughts, floods and water scarcity by a joint commission to improve water status.

The Alqueva dam is one of the biggest project in the Iberian Peninsula, which established in Portugal side and have a capacity 4,000 million m³ and flooded area of 25,000 ha for several purposes include domestic, hydroelectricity, irrigation and recreation (Neto, 2019). The dam is falling at the level 152 m and creates an artificial lake with area 250 km² where 35 km² located in Spain.



Map 1. Transboundary Rivers on the Iberian Peninsula (Thiel, 2007)



Map 2. Alqueva dam location and reservoir (Neto, 2019)

2.4.3 Greece and Bulgaria (Nestos-Mesta River Case)

Kallioras et al., (2006) studied with partners the bilateral agreement between Greece and Bulgaria about transboundary water resources management. Both Greece and Bulgaria shared with Nestos-Mesta River, which is flowing from upstream Bulgaria and cross the border to the Thracian Sea in the Greece. The length of the river is about 243 km and the total area of the river basin is 5,479 km². The downstream country Greece exploits water from this basin to generate the electricity by

constructing hydroelectric dams and for irrigation uses. Greece and Bulgaria signatures many agreements and protocols and the first one was in 1964 for establishment joint committee to manage Nestos-Mesta River. Principles, strategy documents, technical guidelines on monitoring and assessment of transboundary and rivers prepared by the united nations economic commission for Europe, which derived these principles and rules from the united nations convention on the protection and use of transboundary watercourses and international lakes which was signed in Helsinki. Joint management of river basin and the experts from both sides advice to put fixed monitoring stations, mobile stations, chemical laboratories and exchanging information and data. But, the agreements still on paper and failed to implement the terms of agreements to protect this basin from qualitative and quantitative problems.



Map 3. Nestos - Mesta river basin (Kallioras et al., 2006)

Mylopoulos et al., (2007) worked on a paper that represents the combined IC methodology model through using engineering tools and public participation in enhancement transboundary water resource management in Nestos-Mesta River and sustainable utilization on this basin. The model developed five main steps includes situation analysis, stakeholder analysis, problem and objective

analysis, analysis of alternatives, and activity planning to state the activities are required for completion each objective.

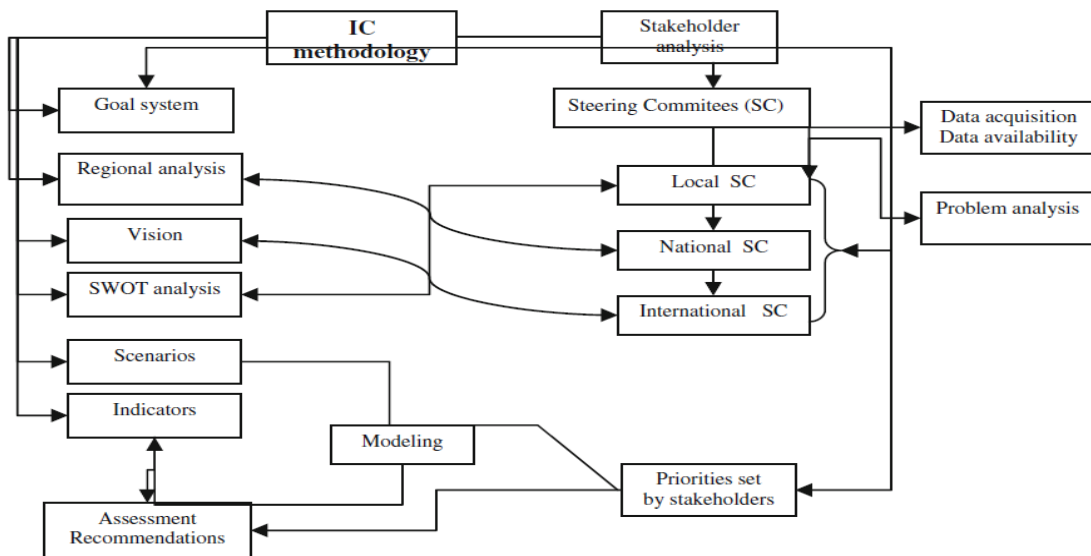


Figure 1. The combined IC methodology (Mylopoulos et al., 2007)

2.4.4 Transboundary water in the Mesopotamia region

Kucukmehmetoglu and Guldmann (2010) studied the status of transboundary water in the Mesopotamia region include turkey, Syria and Iraq. These states shared with the Euphrates and Tigris River, thus Euphrates flow from turkey, then passes through Syria and finally Iraq. Turkey and Syria sign agreement to build development projects and they ignored the presence of downstream Iraq. Turkey run scheme development on the Euphrates by building a series of dam projects called the Southeast Anatolia Development Project (GAP) to provide energy and supply water for irrigation. As a result, Syria and Iraq almost entered into war because of the lack of water at the Syrian border because filling Keban Dam in Turkey. Each country tries to allocate water much than other one because no agreement explains how to allocate transboundary water resource among them. Kucukmehmetoglu and Guldmann (2004) worked on developing models for best performance and allocating water on the Euphrates River for each country in a fair manner for all different scenarios called Euphrates River Basin Model (ETRBM).

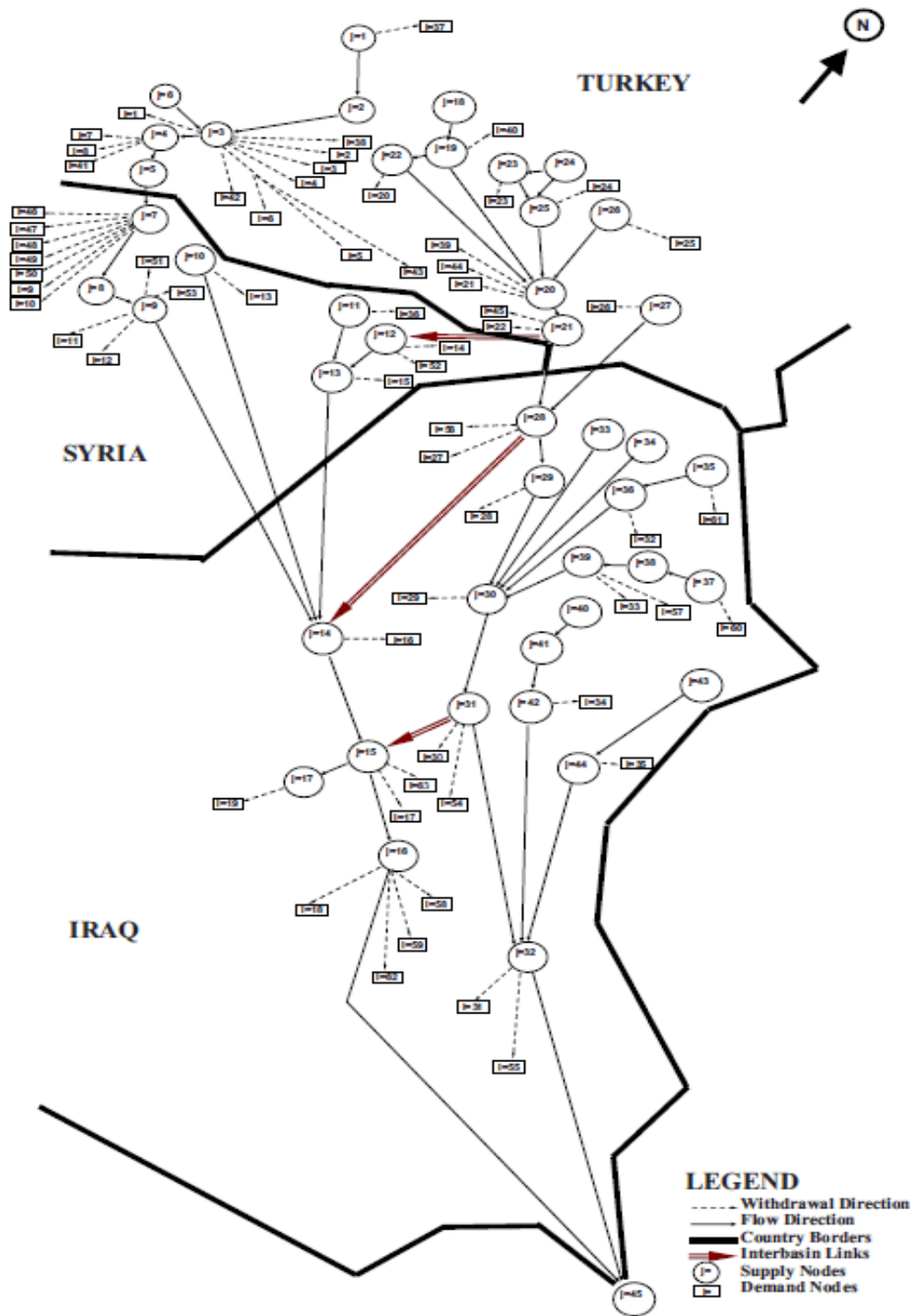


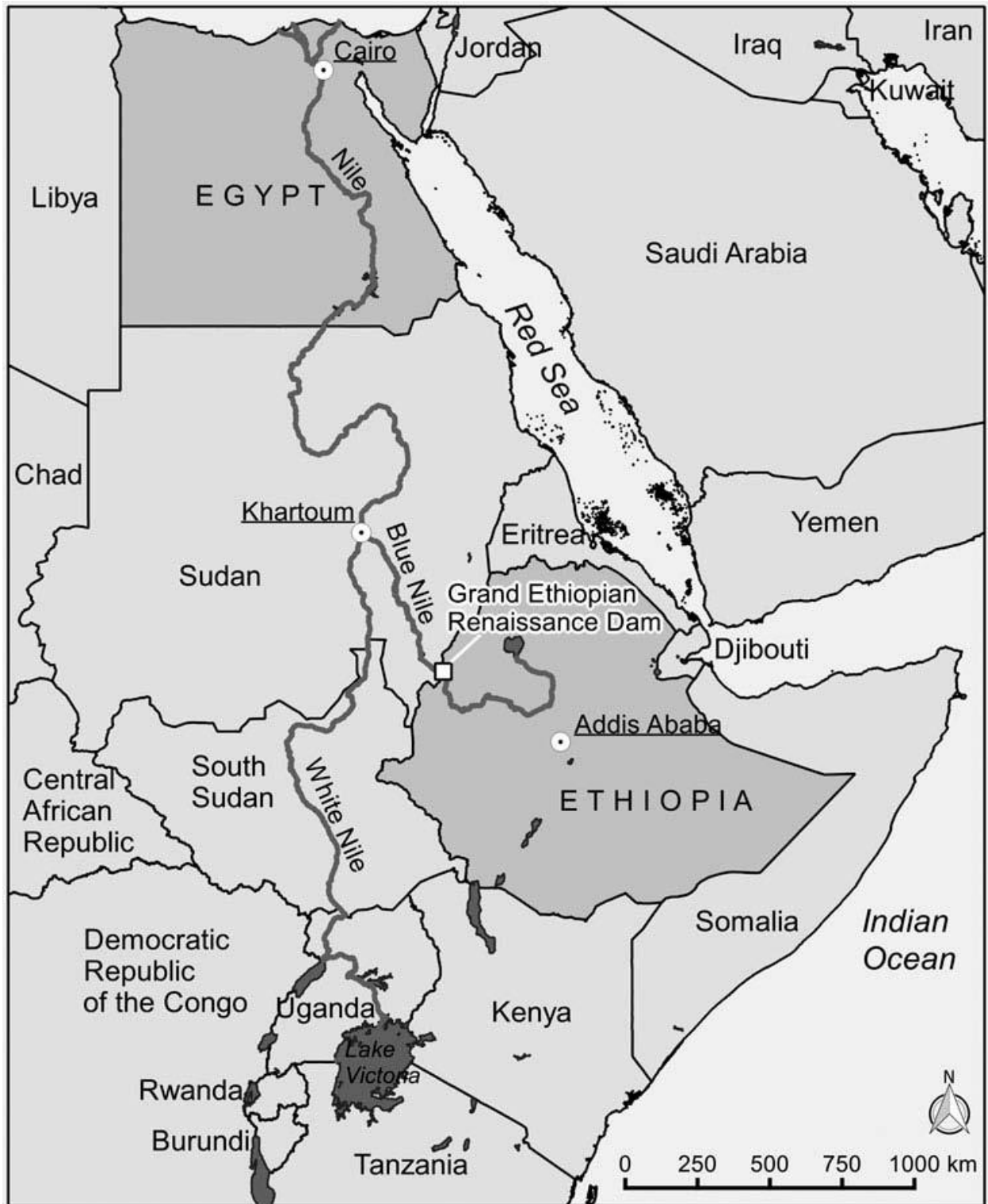
Figure 2. Network structure of the ETRBM (Kucukmehmetoglu and Guldmann, 2010)

2.4.5 The Nile Basin Issue

Teshome (2008) studied the transboundary water cooperation in the Nile Basin, which is shared between ten countries are Burundi, Democratic Republic of Congo (DRC), Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda. Egypt considers as a downstream country, but it takes water more other than countries specially Ethiopia, which is upstream country because 1929 treaty Anglo-Egyptian which is signed in caring of Britain will take a huge benefit from the Suez Canal. This treaty is stolen water rights from other countries which have ability to prevent water flowing in Egypt depend on its geographical location. Moreover, other boundary countries need to get permission from Egypt for any development project in the Nile river basin and this is a huge water rights theft. However, the rest of boundary countries struggle to get water rights by arguing to canceled the 1929 treaty and invite all shared countries to establish a committee that represent all countries. Thereby, the Nile basin initiative founded to allocate water resource and to share the benefits of the river basin between them.

Sudan and Egypt subsequently replaced the 1929 treaty in 1959 with the Agreement for the Full Utilization of the Nile Waters (K. Paisley and W. Henshaw, 2013) which converts the flow of water at Aswan Dam to the Sudan and Egypt and this scenario, create the concerns of other riparian countries which disagree this treaty depending on the international water law principles.

The Grand Ethiopian Renaissance Dam forms a new engagement and challenge along the Nile river basin special between Egypt, Sudan and Ethiopian sides. Yihdego et al., (2016) discussed the expected legal, political, economic and scientific dynamics changes on this basin for equitable, sustainable utilization for energy production and ensure filling the dam without side effects on Egypt and Sudan. However, the population benefits from this basin is at least 160 million people (Nasr and Neef, 2016) and this number increase yearly, which create the concerns for the national security issue for interest countries about the expected scenario after finishing GERD project.

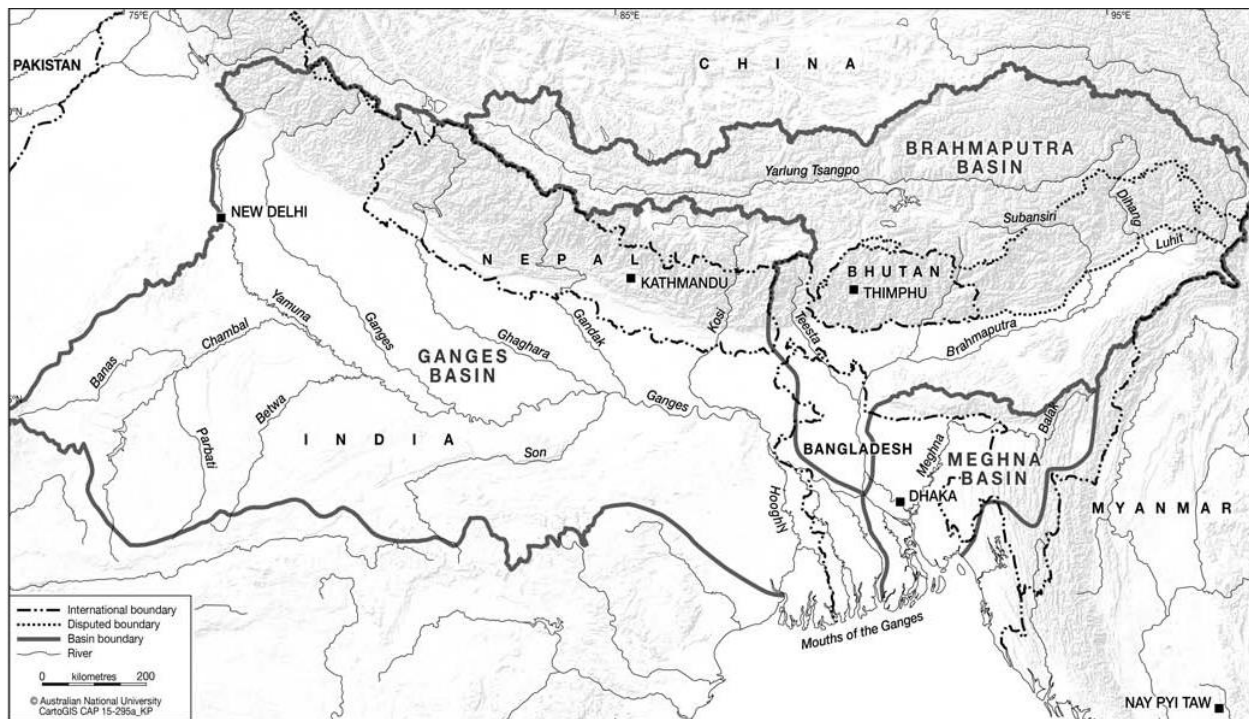


Map 4. Nile River Basin (Nasr and Neef, 2016)

2.4.6 The Ganges River Case between Bangladesh and India

According to a study by Bhuiyam (2008) about the conflict between Bangladesh and India, both are shared with transboundary river basins are the Ganges River, and the Brahmaputra-Jamuna River. India as an upstream country act unilateral behavior by building Farakka Barrage on the Ganges River to divert water direction into Bharirati-Hoogly River. The Bangladesh state argues that India takes water rights from the Ganges River which flow with the border between them and maybe form the starting point for conflict. Nevertheless, both countries call for negotiation to solve and manage this problem. After many series of treaties that leads to reach final agreement signed by both sides on December 1996 to control flow under varying conditions.

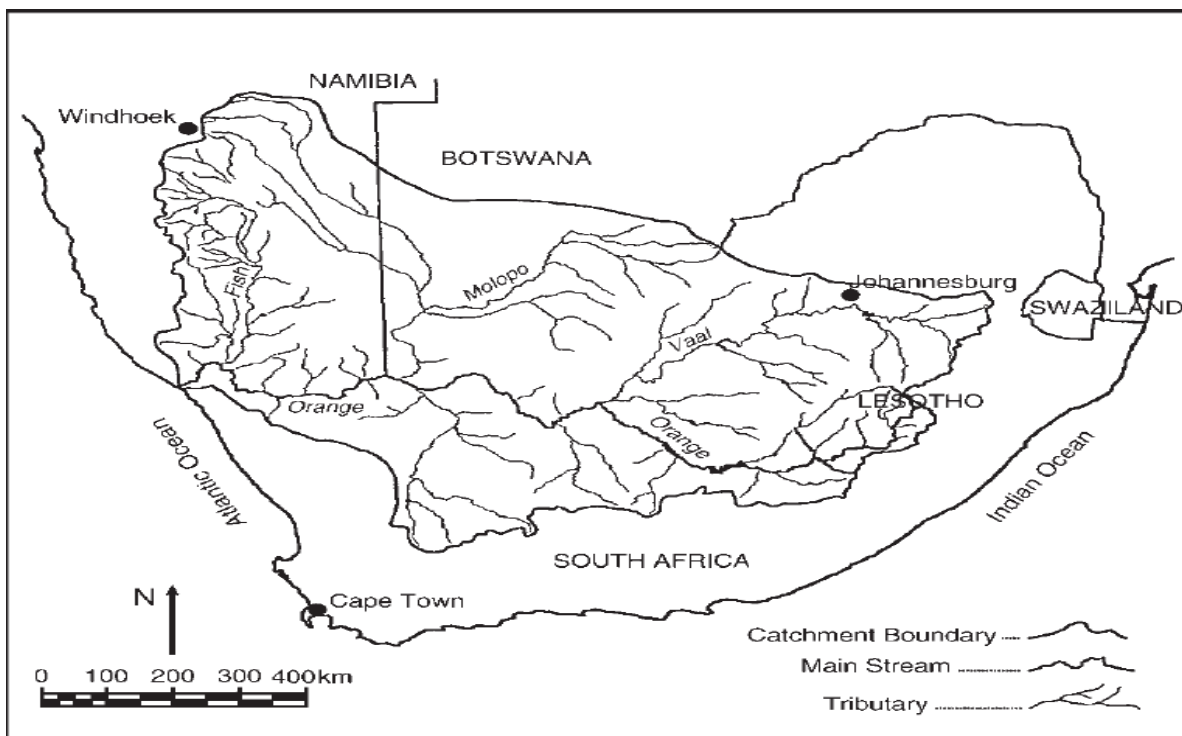
Kamruzzaman et al., (2011) designed a model called A Stackelberg leader–follower model for allocating water between Bangladesh and India with or without an extra quantity of water from Nepal. The market-based water transfer is the recommended option to transfer water from Nepal for both Bangladesh and India.



Map 5. The Ganges-Brahmaputra-Meghna River Basin (Australian National University CartoGIS CAP)

2.4.7 Orange River Case in Southern Africa

Heyns et al. (2008) studied the transboundary water resources management in southern Africa that take the Orange River as a special case to study and define the conflict and challenges for sharing water resources between riparian countries. Orange River is one of the most important river basins and shared with Botswana, Lesotho, Mozambique, Namibia, Swaziland and Zimbabwe. Also, the Orange River is flowing from the Lesotho Highlands, which is known as the Senqu River. One of the tributaries on the border between Lesotho and South Africa is the Caledon River, in addition the Vaal River in South Africa and the other tributaries lie in other riparian countries like the ephemeral Fish River in Namibia and the Molopo-Nossob River where are the Nossob River paths crossing the border between Botswana and Namibia. The international water law and Helsinki Rules were presented to mitigate the conflict. In addition the United States convention principles adopted as a framework for managing shared water resources. Many issues were discussed related to the Orange River mainly are how to allocate water between Bilateral countries and multi-lateral parties and the environmental management for this basin as one team by establishing a joint committee to manage all projects inequitable manner.



Map 6. Orange River Basin (Department of Water Affairs and Forestry, Ministry of Agriculture, Water and Forestry, Namibia)

2.4.8 Two different Cases in South Asia

Biswas (2011) studied two cases in south Asia about the successful and un-successful bilateral agreement between riparian countries on cooperation to manage transboundary water resource. The first case about how to get stability and benefit sharing between Bhutan and India. Both countries have different situations in many sides like population, terrain, and especially economic side. Both Bhutan and India agreed to construct the Chukha project for generates electricity where is this project increase the economic and social life level in specially Bhutan and this case, consider a good experience in improve regional relations. In contrast, on the relation between Nepal, India, and Bangladesh missed the confidence between them to establish a good approach for cooperation and development watercourse and this partially refers to the political leaders in this region.



Scale 1: 13 000 000 1 cm = 130 kms

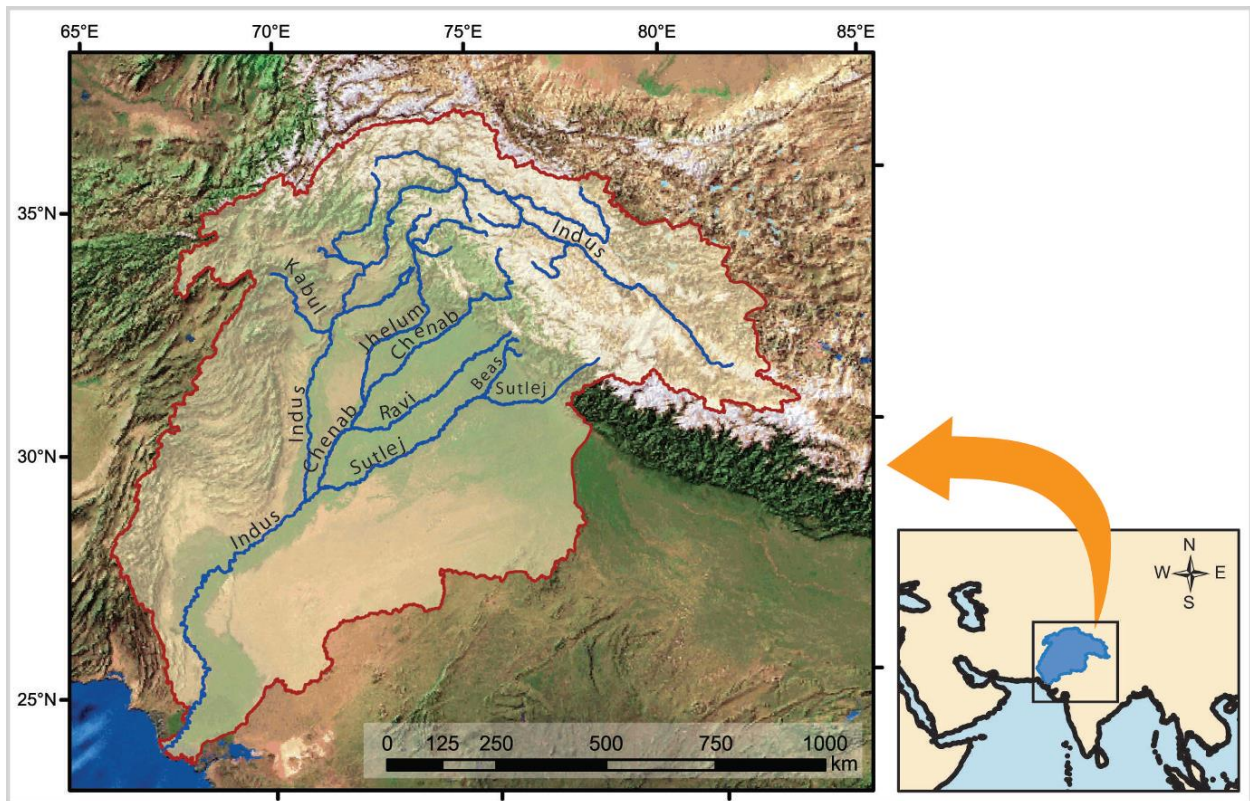
Map 7. Transboundary Rivers of Bhutan, India, Nepal and Bangladesh (Biswas et al., 2009)

2.4.9 Cooperation between India and Pakistan (Indus River Case)

Zawahri (2009) studied the cooperation between India and Pakistan on how to allocate quantity water flows through the Indus River that shared between them. The Indus Water Treaty (IWT) signed in 1960 between India and Pakistan, where is dividing the tributaries into two main groups include the three eastern tributaries are Ravi, Sutlej, and Beas directed to the India. The rest of tributaries are the western tributaries include Main Indus, Jhelum and Chenab allocated to the

Pakistan. Moreover, This Treaty gave India to exploit western tributaries for other uses like construct hydrology and infrastructure projects and this point formed problems on the quantity that allocated to Pakistan from western tributaries in addition the quality of water which is becoming less quality and unusable for human needs. Although Pakistan allowed for India to build, Dams to storage water and electricity generator, but with conditions related to design of Dams to ensure specific quantity of water from western tributaries which is originally considered rights for Pakistan. In general the author appointed the negotiations are the only path used by the two sides to solve issues about allocating of water for Indus River in contrast other parts of the world.

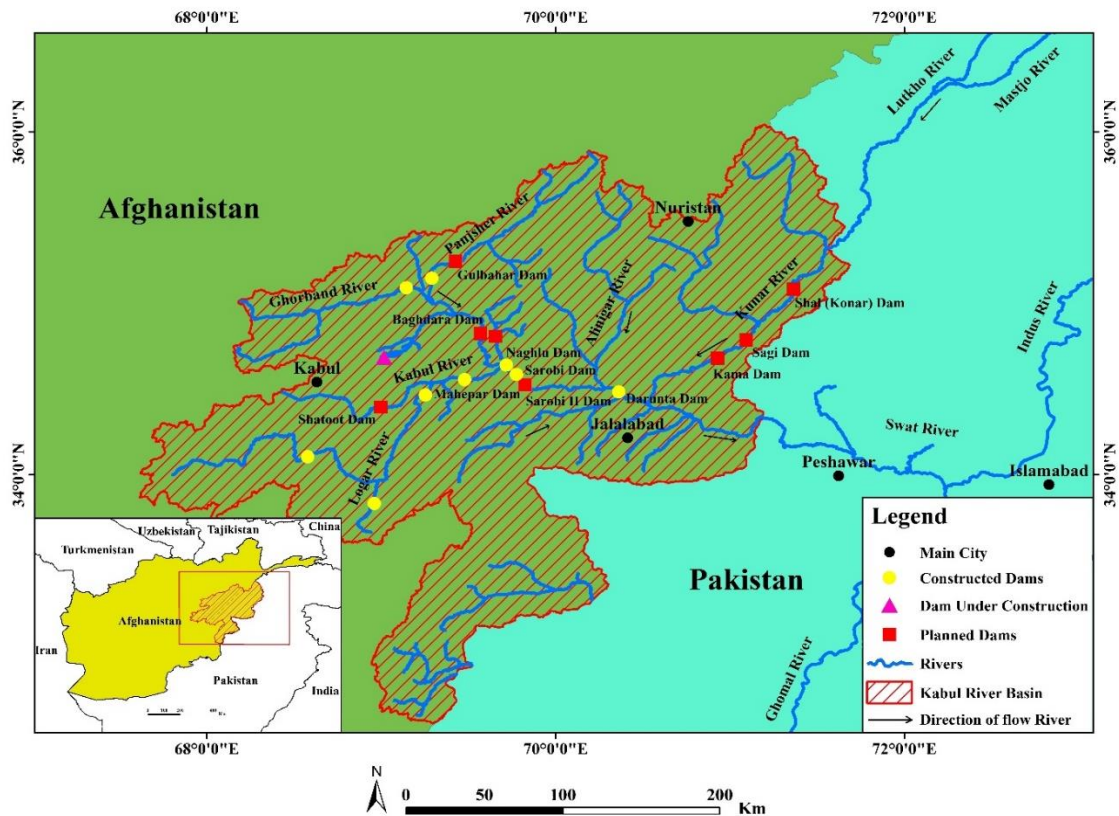
The basins of the Indus and Ganges rivers cover 2.20 million km² and are inhabited by more than a billion people (Sharma et al., 2010) where the Indus Basin covers an area of about 1.10 million km² distributed among Pakistan 63%, India 29% (Karki et al., 2011). So, this region required emergency actions, strategies for optimal utilization of ground water and improve the infrastructure to push up the level of economic and social life in the Indus River basin.



Map 8. Indus River Basin (Karki et al., 2011)

2.4.9 Kabul River Case between Afghanistan and Pakistan

The Kabul river basin lies between longitude 67_400 to 71_420 east, and latitude 33_330 to 36_020 north, and it is a shared river with Pakistan (Lashkaripour and Hussaini, 2007). According to Sedeqinazhad et al. (2018) study prepared with partners about the Kabul river basin, how to get the benefits and avoid conflict between Afghanistan and Pakistan on the availability and quality of water. According to the World Bank report published in 2016 the annual flow enters Pakistan from Kabul river basin about 4500 million cubic meters per year. They suggest a strategy to build a framework for cooperation and bilateral management for this basin where includes three stages start with a good understanding, significance of benefit sharing and determine the magnitude of benefits. This strategy saves both sides from stealing rights each other and more exploiting in an equitable manner for this basin. The agreement shall be presented to enhance both sides to start as a team for managing this basin by representative experts for each side. In the end the results expected from this strategy improvement many aspects like economic, environmental, political, security issues, and social for both countries.



Map 9. Kabul River Basin (Afghanistan Waters Portal)

2.5 Regional Water Theft including Israeli Practices

Basheer (1990) studied and illustrated the historical actions on the conflict between Israel and its neighbors which includes Syria, Jordan, Lebanon and Palestine. He proved the quest of the founders of the Zionist movement to ensure water resources as necessary required for establishing the state of Israel in the Middle East by defining the border of Palestine according to the headwaters in this region. Also the state of Israel puts its hand on groundwater in the West Bank and he thought the Israel does not leave these water resources even in case of political settlement.

Mimi and Sawalhi (2003) studied the shared water resources conflict between five countries. These five countries are Palestine, Jordan, Syria, Lebanon and Israel shared with Jordan valley basin. Syria as an upstream country have Yarmouk River, which is one of the major parts for supplying Jordan River. The upper part of Jordan River includes headwater streams are the Dan, Hasabani, Baniyas, Huleh valley and Lake Tiberias, and then the Rest of flowing water through the Rift valley to the Dead Sea. The water rights for Palestine, Syria, Lebanon were ignored especially after Israel built the national water carries to transfer water from Lake Tiberias to the south and central region of Israel. Moreover, Jordan constructed the East Ghor Canal off the Yarmouk River for irrigation sector. The major problem in this basin is how to allocate water between all riparian countries inequitable manner. They discuss how to use international water law principles to save water rights for all parties and explains the methodology for equitable allocation and discuss all factors that provide best allocating water rights.

Naji (2004) studied the obstacles for water management in Palestine include political, financial, and technical. Water is the most important issue between both sides, Palestinian and Israeli to recreation a peace process in this region. He talks about ground water aquifer where is controlled and exploiting by the Israeli side include North-Eastern Aquifer, The Western Aquifer, and The Eastern Aquifer, the coastal Aquifer in addition the main surface water resource is Jordan river which is Palestine take about 17% of the total amount produced by this basin. For all aspects political, financial and technical Israel responsible all these points that make improvement water sector in Palestine is weakness and complicated. Finally, he recommended many points to reach an effective water resource management in Palestine includes a call for cooperation in shared water

resources, and allocation of water resources in an equitable manner which is pushing the peace process in the Middle East.

Bridges (2016) according to the a brief study about water security in Palestine and concerns, obstacles puts to reduce the efforts of the Palestinian side to supply water and save its resources from exploiting by the Israeli side which is controlled about 85% of water resources aquifers that shared with the Palestinian side. Israeli policies and strategies prevent Palestinian side to improve the water sector in all aspects which is making the political solution is more complicated. In addition, when a comparison between the quantity water consumed by Palestinian and Israelis, noticeable and huge difference where the Palestinians get about 22MCM annually but the Israeli pumps about 320MCM. However, according to the some factors like climate change, increasing in growth of population for both sides leads to puts all efforts for cooperation in water shared management by establishing the Joint Water Commission (JWC) as a good step for enhancing the peace process in the region. But, actually this JWC failed to reach its goals because Israeli side acts as unilateral according to its national interests.

2.6 Water issue in bilateral agreement (Oslo Agreement)

Gray (2009) studied the water situation in Palestine after the Oslo agreement signed at 1995 which is allowed Palestinian side to control, developed, and manage water resource within the conditions of the Gaza-Jericho treaty in 1994. The Palestinian water authority (PWA) established and take its responsibilities to manage water sector in Palestine territories. However, the PWA develop water sector to ensure water for all Palestinian but the improvement is weak and the progress is slowly where is the PWA depend on the financial support from the donors countries and the second important reason is any project will be establish by the PWA should be approved by the Israeli side according to the Oslo agreement. The joint water committee (JWC) which is includes representative persons from both sides where is the projects for develop water sector and infrastructure like pipelines, reservoirs, treatment plant should be approved by the JWC but the problem in this committee is the Israel has the power of veto decisions which is mean Israel has absolute authority over water resource. In general Israel exploit the most quantities of water produced and the consumption is more than the Palestinian users. Finally, he claimed must re-arrange the water issue and push the Palestinian side to increase sovereignty on the water resource and re-allocating of the water between both sides in equitable manner according to the international water law.

Shamir studied and reviewed the bilateral agreements between Israel and its neighbors Jordan and Palestine which includes the peace treaty in 1994 and Oslo agreement in 1995. He discussed especially article 40 in Oslo agreement which is concern about water and sewage issues. His observations and comments about Oslo agreement indicate to consider this is interim agreement and comprehensive more than the peace treaty and this agreement consider a start point to reach the final situation in the final negotiations issues.

The following table shows the allocating water for each side according to the Oslo agreement from the shared aquifers in the West Bank.

Use	Oslo Agreement (MCM)			
	WAB	NEAB	EAB	Total
Israel	340	103	40	483
Palestine	22	42	54	118
Additional Quantity for Palestinian Development	--	--	78	78
Basin Total	362	145	172	

Table 1. Water allocation according to Oslo agreement (PWA, 2013)

2.7. Nonrevenue Water and Local Water Theft

2.7.1 Nonrevenue Water

The component of Non-Revenue water resulted from three parts include unbilled authorized consumption, apparent losses, and real losses. However, apparent losses contain two terms are unauthorized consumption (water Theft) and metering inaccuracies.

According to Lambert (2002), all parts of water balance include two types of inputs are authorized consumption and outputs divided in two types are revenue and non-revenue water and defined all terminology according to international water association. in addition, He shows many methods for calculation in national reports for assessment all losses and variety performance indicators for evaluate overall system.

Mutikanga et al., (2011) studied with partners the assessment of apparent losses for Kampala City. They selected water balance approach which is a certified by International Water Association to determine real losses and apparent losses where is they determined the apparent losses by excluded the real losses from total input volume. Then they went in details approaches to determine all components of apparent losses which is include metering inaccuracies, meter-reading errors, billing and data handling errors and unauthorized consumption. The recommended developed strategies were to reduction apparent losses by use Metering technology, Revenue protection unit (RPU), Replacement of meters, New customer connections timely updates, Further studies.

Patil et al., (2014) according to study prepared with his partners about how to calculate revenue and Non-revenue water for Chiplun municipal council in India. They used water audits to determine all components of water balance for water supply system and they advise Chiplun council to follow many procedures for reduce losses and establish computerized system to manage finance aspect for Chiplun municipal council which leads to read actual situation for water supply system in all aspects.

Petroulias et al. (2016) estimated the water losses and assessed the network management for water utility of Drama city which has a population about 60,000 in the northern of Greece. They selected an approach that includes collecting data about network system and follow basic steps using water balance diagram to evaluate each part and calculate infrastructure leakage index. The results show that effort in optimize the water balance may increase save amount of water.

Farok (2017) studied the NRW for Dhaka water supply system management (DWASA) which is covered 75% of city. He depend on basic calculating methodology by understanding water balance component from international water association which expressed by excluding the billed authorized consumption from total input system. Also, he collected data by surveying and select sample randomly to represent target area. He recommended to follow techno-managerial concept to reduce NRW which is effect seriously on water sector.

As shown below in water balance the system input volume will be divided into two main paths are authorized consumption and water losses then enter in many tracks and finally will be ends into two main components include Revenue water and Non- Revenue water (NRW).

Table 2. IWA Standard International Water Balance and Terminology (Lambert, 2002)

System Input Volume	Authorized Consumption	Billed Authorized Consumption	Billed Consumption	Metered Consumption	Revenue Water
			Billed Consumption	Unmetered Consumption	
		Unbilled Authorized Consumption	Unbilled Consumption	Metered Consumption	Non- Revenue Water (NRW)
			Unbilled Consumption	Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorized Consumption		
			Metering Inaccuracies		
		Real Losses	Leakage on Transmission and/or Distribution Mains		
			Leakage and Overflows at Utility's Storage Tanks		
Leakage on Service Connections up to point of Customer metering					

2.7.2 Local water theft

According to study by Meehan (2013) which is discuss how to disciplining the hydro social order using bio-political approach to debate the authorities that use illegal actions to discipline populations and other sectors. To check these policies she takes Tijuana in Mexica as a case study to explore how authorities' policies and law to treat with people stealing water. She suggest to follow impellent punishment on bodily level but she also indicates that this is only illegal way to save water for distressed and poor users because weakness in allocating water and inequality between all users. Finally, she suggest to understand needs all users and how to implement state power in equitable manner on all people.

Mattoussi and Seabright (2014) studied the determinants that can increase water theft in Tunisia in a specific period from 2001-2003 and how to build a sensible and acceptable cooperation against theft. They used a theoretical model and proved the increasing probability of theft when prices are high and punishments are weak. The results shows that proper design incentives leads to reduce water theft and the institutional design is influenced by constraints on monitoring costs.

Brown (2017) studied in special report about water theft and smuggling. She define water theft the appropriation of water without the required payment, or in violation of existing rules according to school that thought water is a value needs to be assigned to maintain its sustainability and efficient use. She submitted examples of water theft in many areas in Asia, Africa, Latin America and Western Europe and according to the World Bank about 48.6 MCM escaping daily from water supply system and this amount of water enough to provide 200 million people. However she indicates that this highly controversy issue and required huge efforts for puts appropriate legislations and policies to reduce this problem for sustain water sector and ensure water security for communities.

2.8 Water sustainability criteria

Gleick (1998) studied the water sustainability and facing water scarcity to sustain water services and he tried to put appropriate definition for water sustainability and discussed, analyzed seven important criteria which include human water requirement, environmental water requirement, standards of water quality, state the nature of resource are renewable or not, availability of data ,collection, institutions management, and conflict resolution. These criteria form a framework to put priorities and take appropriate decisions and answers for questions which define the obstacles and problems for sustainability.

Baily and Wook (2017) studied the local water sustainability practices and how to examine the change in these practices. They discussed the factors effect on the local government attempts to enhance water sustainability which include physical and political environmental condition, local political institutions, economic condition and how these factors form an important rule for water conservation. They finding from built a logistic regression model indicate leads to increase programs for water conservation and more sustain water sector.

Richter et al. (2018) studied with many students how to assessing the sustainability of urban water supply systems. They developed indicators to help in assessment the sustainability of water. These indicators are Water governance, Drought and other emergency Preparedness, Water monitoring, Water affordability and social justice, Water-use efficiency and conservation, Water quality, and Watershed protection. The indicators have subcomponents leads to evaluate main indicators and must track these evaluated results to improve water sector in general.

CHAPTER THREE - RESEARCH METHODOLOGY

This chapter presents the main components related to approach and methodology that were followed. These topics are the research questions, data required, how to collect and access the data. Finally what is specific approach to get the results and to answer of the research questions.

3.1 Research Questions

It is the most important topic will help to derive what is data required should be collected to answer the research questions. However, the research questions could be summarized on the water quantities stealing by Israeli side and the water theft by local citizens, and reviewing the opinions of water experts about regional and local issues that will be discussed through this research. In addition, the effects of regional and local water theft on water sector.

3.2 Data Collection

According to the research questions and objectives there are many numerical data required that will be helpful to reach objectives of this study. With respect to the regional issue the data are required include the productivity of shared water resources between both sides and the allocating water volume for each sides, the daily consumption for local citizens for both sides and the number of population, the settlements population and water consumptions per capita, and uses of water in different sectors. Also, information about the bilateral agreement conditions between both sides and joint committee for cooperation are required.

On the other hand, to serve aims of this study the local data is required. These data include mainly the unauthorized consumptions (water theft) quantities for all local municipalities in West Bank and Gaza Strip which will be derived from simple water balance according to the IWA definition, the total quantities of water supplied by each municipalities that defined as the total input volume in water balance for each councils. Important financially data like water tariff, operation and maintenance cost for network, the cost of construct water network.

With respect to the regional data it is difficult to reach exactly correct data especially from Israeli side. However, the statistical data about water sector in Israel were collected from websites, or published reports prepared by legal authorities in Israel and by reviewing the data about water sector in Israel published by statistical centers and official websites.

On the opposite side, the data about water sector in Palestine were collected and derived from the official annual reports issued by Palestinian water authority, and by the official statistical data prepared by legal institutions.

On the other hand, the modern data about local water sector situation will be collect by visit the water sector regulation council (WSRC) in Ramallah which supplied me water balance for each municipalities and councils to derive and calculate all necessary terms specifically the water theft (Unauthorized consumption) and the total input volume for each one.

3.3 Research Approach

Appropriate methodology to serve aims of this study started from collect data on two levels regional and local. Thereby, the path to exploit these data divided into two ways includes first the bilateral issue between both sides Palestine and Israel, the second is local sector in Palestine and how both issues contribute to create water crisis and then its effect on sustainability of water sector in Palestine.

3.3.1 Regional issue

For this part it is essential to understand the nature of conflict which should subject to the international water law principles or to the bilateral agreement between both sides. However, the comparison analysis will be take in consideration to compare between both water sector in Palestine and Israel and go in depth analysis to issue the Palestinian water rights.

Appropriate questionnaire will be prepare and should be directed to the water experts to illustrate the views about the Palestine- Israeli and if there a solution for this conflict or not. However, the questionnaire includes main questions related to unequitable consumptions in both sides, rule of negotiations and joint water committee, current situation of water sector, and discussing their recommendations for issued and restore Palestinian water rights.

3.3.2 Local sector

By understanding the water balance and describing all terms according to the IWA definitions to calculate the NRW from water theft and other losses.

According to the international water Association (IWA) there are many indicators to assess and evaluate performance of water sector in term of NRW. In this study will be determine NRW resulted from only water theft (unauthorized consumption) in function by volume.

In addition, to calculating the percent of NRW resulted from other listed losses by excluding water theft (unauthorized consumption) to analyze and discuss which is have more contribution in the total NRW either by NRW-T or by NRW resulted from other losses.

The Non-Revenue water resulted from water theft (NRW-T) in function by volume could be calculated simply from simple water balance as

$$\text{NRW-T by volume} = \frac{\text{Volume of water theft}}{\text{System Input volume}} \times 100$$

The NRW resulted from other losses (Without water theft) will be calculated from this simple equation:

$$\text{NRW- without water theft} = \frac{\text{Volume of other losses without unauthorised consumption}}{\text{System Input Volume}} \times 100$$

3.3.3 Data analysis

By determining these two percent leads to form observations and clearly indicates about what is the most important component that contribute in the total NRW and to directing the leaders of water sector to put efforts and appropriate policies for ensuring achieve the aims of national strategic.

Organize and classify the performance of municipalities according to the percentage of water theft and this option gives indications about situation of the water sector in all over Palestine and compare the results with aims of national strategic for water and wastewater at 2032.

In addition, results of the second part of questionnaire about local issue will discuss and illustrate the answers of water experts about unauthorized consumption activities in all aspects like legibility, reasons, responsibility, and expressing their recommendations and observations to reduce this social phenomenon.

CHAPTER FOUR - RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results, including the regional and local water theft. Regional results show all shared water resources and how they are exploited by each side in addition to a comparison of water consumption between both sides, as well as that from illegal settlers.

The section of local results shows the results of local water theft in both Gaza Strip and West Bank and derives noticeable observations, analyzes and discusses the performance and the obstacles of the local water sector.

In addition, evaluation of knowledge of experts about regional conflict with the Israeli occupation and about illegal water use by some Palestinian citizens.

4.2 Regional Water Theft

4.2.1 *Shared water Resources allocation*

The shared water resources between Palestinian and Israelis include three aquifers in the West Bank and one aquifer in the Gaza Strip. The aquifers in West Bank are the Western basin, Eastern basin, and the north eastern basin where these aquifers fed by water from rainfall and supply water jointly about 679 MCM per year (World Bank, 2009). The last aquifer called the coastal aquifer in the Gaza Strip.

The following map shows all shared groundwater resources with the cities that are covered by each basin. The Western Basin located in two governorates of the West Bank which are Tulkarm and Qalqiliya. The Eastern basin covers five governorates including Tubas, Nablus, Ramallah & Al-Bireh, Jericho & Al-Aghwar, Bethlehem and Hebron. The North-Eastern aquifer supplies Jenin, Tubas, and Nablus governorates of the West Bank.

The coastal aquifer provides all governorates of the Gaza Strip while the water quality is non-applicable for human consumption but this source is the only ground aquifer in Gaza and polluted by the wastewater contaminants.

Among the Palestinian – Israeli conflict these basins form the critical points in negotiations between both sides and were discussed the situation of each basin individually in the following sections.



Map 10. Shared groundwater resources (PWA, 2011).

4.2.1.1 Western Basin

This basin consider is one of the largest basin between both sides and it's extend from the eastern mountains of the West Bank to the coastal area in the west. The basin controlled mostly by Israeli occupation where is among 40 years (1967-2008) Israeli side exploit 368.7 MCM per year which is equivalent 94% from the total water extracted from this basin. Although this basin consider as a shared ground water resource but still under controlled by Israeli side. However, the negotiation between Palestinian and Israeli sides started by agreement Oslo-1 (1993) and Oslo-2(1995) which allowed to the Palestinian side to abstract 23.7 MCM per year among period between 1995 and 2011 which is equivalent to 6% of total abstraction from this basin. In 2012 the mounts of water exploited by Palestinian side is 30.4 MCM (PWA, 2013).

From the last Records the water theft by Israeli side is clear where the consumption of Israelis in one year is equivalent to amount of water consumption by Palestinian side in at least ten years.

The following bar chart shows the water pumped from this basin by Palestinian side in the last few years.

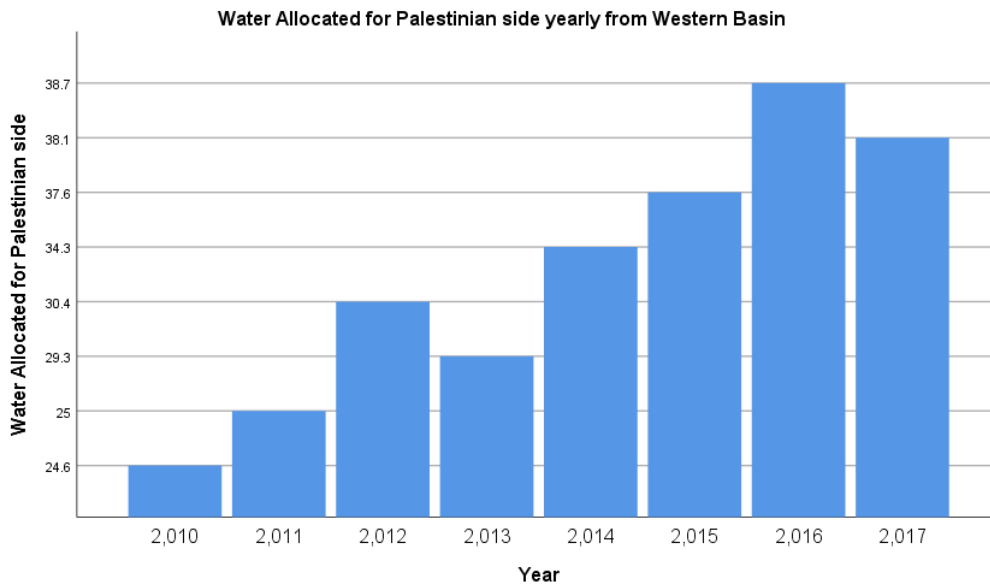


Figure 3. Water allocated for Palestinian side- Western Basin (PWA 2010-2016, PCBS- 2017)

Estimated population covered by this basin is about 4.6 million divided into 1 million Palestinian inside West Bank and the 3.4 million Israeli citizens in Israeli part (UN-ESCWA and BGR, 2013). Among the last few years from figure2 the maximum amount of water abstracted by Palestinian is 38.7 MCM and this mean the consumption each person in this part equal 106 l/c.d while the

minimum extracted water is 24.6MCM which given that the water consumption is 70 l/c.d and thereby the range of consumption by Palestinian citizens in the last 7 years is 70-106 l/c.d.

On the other side, the situation of water consumption and water uses are definitely difference by consider that the productive of this basin is 390 MCM/ year. This mean when Palestinian side abstract 38.7 MCM the Israeli side will exploit at least 351 MCM and this option mean that the Israeli water consumption is 283 l/c.d and this number will increase when assumed that the Palestinian side abstract only 24.6 MCM and the Israeli side will exploit about 365 MCM which lead to push up the water consumption to become 294 l/c.d.

In natural conditions the consumption of Palestinian side is 70-106 l/c.d while the Israeli consumption is 283-294 l/c.d which means the consumption percentage of Palestinian is 25-36% of the Israelis water consumption from this basin. However, the last percentages will be increase on the Israeli side when increase the amount of water extracted from this basin that sometimes reach to 500MCM/year since Israeli act as unilateral action ignored the Palestinian water rights in this basin.

Limited water allocated for Palestinian side among the last long years indicate that the Israeli side stolen large quantities of water and could be estimate these quantities at least 175 MCM/year from this basin.in addition, increase of population in Palestinian side without increase amount of water allocated for Palestinian side will cause water crisis in this part of West Bank and will lead the Palestinian water sector managers to buy water from the Israeli side to meet needs of Palestinian citizens from water and to ensure water security. But, these actions put the water sector in West Bank at stake if Israeli policies still the same on the future since the amount of water allocated doesn't meet the increasing in population in this part of West Bank.

In conclusion, the following table describe percentages of water consumption and target population in each side in this basin.

Table 3. Water Consumption per capita for each side - Western Basin

Target Side	Target population	Water Consumption (l/c.d)	Range of Consumption for capita in this part of Palestine is 25-36 % from the Israeli capita consumption
Palestinian side	over 1 million	70 - 106	
Israeli Side	over 3.4 million	283 - 294	

4.2.1.2 Eastern Basin:

Eastern basin consider as a shared water resources. But, actually this basin geographically lies totally inside in the eastern half of the West Bank. However, Israeli exploited water produced by this basin since war 1967. Productive sustainability of this basin is 145-185 MCM per year (PWA, 2013).

According to the Oslo-2(1995) the Palestinian side have a right to pump about 54MCM and in addition 78 MCM as extra source capable to increase. However, Israeli side exploit illegally about 40MCM/year to provide agricultural settlements activities in the Jordan valley since these amounts of water consider part of Palestinian right from this basin because this basin lies totally in the West Bank part. The following bar chart shows the water allocated for Palestinian side in the last years 2010-2017 (PWA, Water Information System).

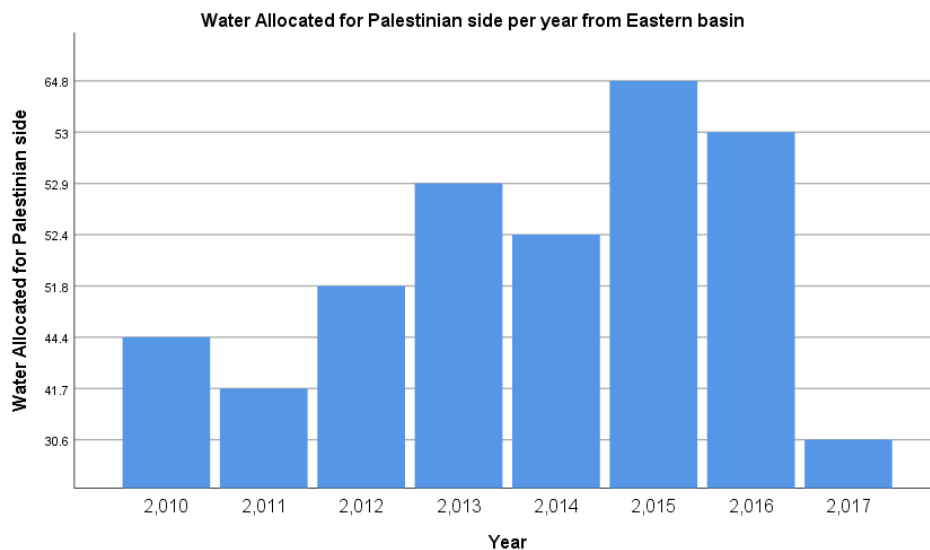


Figure 4. Water allocated for Palestinian side- Eastern basin (PWA 2010-2016, PCBS- 2017)

The average of water exploited by Palestinian from this basin the last few years is 45 MCM and the target population from this basin is at least 1.3 million and this number is increasing year after year that`s mean the consumption of citizens in this part of West Bank is not more than 90 l/c.d. By referring to the (PWA, Water Information System) the mainly target area is Hebron governance which suffered from water crisis which lead to create internal conflicts. But, if the Palestinian restore about 40MCM that stolen by Israeli occupation the consumption per capita will increase to at least 200 l/c.d and this ensure water security and improve social life.

4.2.1.3 North-Eastern Basin

This basin is located in the north of the West Bank and consider as one of the shared ground water aquifers between both sides. The North-eastern aquifer is 80 percent within the West Bank and the remainder shared with Israel. The Northeastern aquifer is the smallest with an annual safe yield of 145 MCM (ARIJ, 2012). The percentage of recharge area is 80% in the West Bank side but the storage area is 80% in the Israeli side (PWA, 2012). The Oslo agreement-2 (1995) is allow to the Palestinian side to pump 42MCM per year. However, the next bar chart shows amount of water exploited from this basin by Palestinian side and includes the unauthorized wells in this basin.

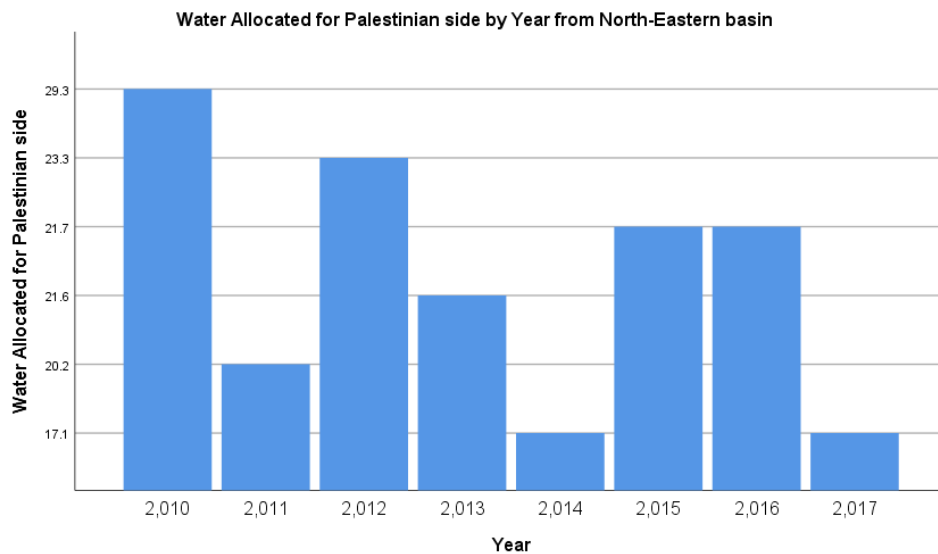


Figure 5. Water allocated for Palestinian side-Northeastern basin (PWA 2010-2016, PCBS- 2017)

The maximum amount abstracted from this basin is 29.3 MCM and this happened in 2010 after Oslo-2 and this amount form about 70% from the quantities that agreed between both sides in the Oslo-2. The breach of the agreement is clear from the Israeli side since in the following years the amount of water pumped to the Palestinian decreased and unstable until reached about 17.1 MCM in 2017 and this amount form only 40% form the agreed quantities in Oslo-2.

The target areas for this basin are Nablus, Jenin, and Tubas Governances which have at least 700,000 Capita and this mean the consumption of persons in these area from this basin is in range 60-105 l/c.d and this depend on the amount of water abstracted by Palestinian part.

About 75% of this basin’s water is used by Israel 101- 115 MCM (El-Fadel et al., 2001) and this mean the amount of water abstracted by Israeli occupation in one year is equivalent to amount of water exploited by Palestinian side in four years and thereby the amount of water stolen by Israeli occupation from this basin is at least 30MCM every year. In addition, the water extracted from this basin by Israeli occupation is almost supplied to the settlements in this area which have general uses of water includes domestic, industrial, agricultural activities while the Palestinian side hardly cover domestic uses.

4.2.1.4 Coastal Aquifer Basin

The coastal aquifer is located in the coastal area in Gaza strip and Israeli. This basin consider the only source for fresh water in Gaza strip. However, this basin exposed to increase the salinity since Israeli side drilling wells more than required and this causes to push down level of water table. In addition, this basin is becoming more polluted resulted from failure sewage system and fertilizers infiltrated to the ground water table.

Local resources from Gaza are obtained from 4,779 groundwater wells with depths mostly ranging between 25 and 30 meters (PWA, 2012). The coastal aquifers yearly sustainable yield is estimated at 450 MCM per year in Israel and 55 MCM per year in Gaza (ARIJ, 2012 According to the international reports the coastal aquifer is not usable for drinking water since over 90% of this basin is polluted that resulted from overuse pumping from this basin which is reached over than 100MCM per year.

In the following bar chart shows the amount of water pumping to the Gaza strip from this basin.

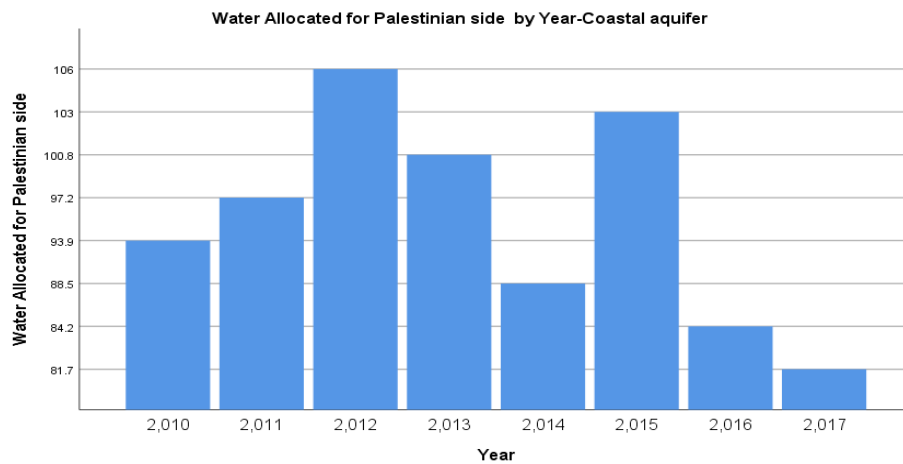


Figure 6. Water allocated for Palestinian side-Coastal Aquifer (PWA 2010-2016, PCBS- 2017)

In the last few years the average water pumped from this basin is 94 MCM. However, the water abstracted from this basin is fluctuated and unstable where does not meet the needs of community in Gaza strip because increasing of population. The range of consumption per capita from this basin is 115-170 l/c.d which does not meet the World health organization (WHO) standard.

Table 4. Water Purchased and Desalinated- Gaza Strip

Year	Water Purchased from Israeli Water Company – Mekorot (MCM)	Desalinated Water Provided by Private Sector (MCM)
2010	4.9	---
2011	4.2	---
2012	4.0	---
2013	4.0	---
2014	3.5	4.70
2015	6.4	3.90
2016	10.1	3.90
2017	10.6	4.00

Because the salinity, polluted ground water and most of coastal aquifer water unusable for drinking water the Palestinian side goes to buy water from the Israeli water company (Mekorot) to meet needs community of water. Also, private sector was established in the last four years to provide desalinated drinking water for citizens. The following table shows amount of water bought from Israeli side and provided by private sector.

Annual Israeli abstraction from this basin is 400-480 MCM and the Egyptian side exploit about 70-80 MCM and the both sides Israel and Egypt have other alternative water resources while the Gaza strip depend only on the Coastal aquifer basin. The total population in the Coastal Aquifer Basin estimated at about 5.6 million, with about 3.8 million inhabitants in the Israeli part of the basin and 1.6 million in the Gaza Strip (UN-ESCWA and BGR, 2013).

The consumption per capita in the Israeli side from this basin is 285-345 l/c.d which mean that the percentage of Palestinian consumption from this basin is 40-49% from Israeli consumer each day. Also, the amount of water abstracted by Israeli side in one year is equivalent to amount of water exploited by Palestinian side in five years. Although, there are privileges for Israeli side where the Geographic features like length, width, and area of this basin is the largest in the Israeli side and the smallest in Palestinian side. But, the population density is extremely high in Gaza strip when comparison with the Israeli side. The following table shows Geographic features that describe basin in the three repairing countries.

Table 5. Geographic features of the Coastal Aquifer Basin (UN-ESCWA and BGR, 2013)

	EGYPT	PALESTINE	ISRAEL	TOTAL
Length (Km)	200	40	150	390
Width (km)	40-130	7-12	12-45	7-130
Area (Km ²)	12,950	365(Gaza strip) 49 (West Bank)	5,006	18,365
Population	395,000	1,644,000	3,816,000	5,628,000
Population density (inhab./Km ²)	31	4504	762	307

Gaza strip face actual catastrophe while increasing in population in a small area and lack of water resources, unilateral actions by Israeli side change the quality water of coastal aquifer which the only source for Gaza citizens. Israeli occupation is not stealing water only. But, also theft the health of citizens, created water crisis, distribution water for users in inequitable manner, poor people does not have ability to buy desalinated water. All of these last issues form the appropriate environment to create internal conflicts and security problems where the water security is not available.

4.2.1.5 Jordan River basin

The most important surface water resource in this region where five riparian countries shared on this basin but not all of them derive water from this basin in equitable manner. The five countries are Lebanon, Syria, Israel, Jordan, and Palestine. The headwaters springs that recharge Jordan

River are two under occupied Israeli control includes the Baniyas in the Golan Heights, Dan, and the Hasabani in Lebanon.

Prior to the 1950s, the annual flow of the Jordan River was 1,300 MCM per year (ARIJ, 2012). But, as any the shared water resources Israeli occupation exploited most water productive from this basin and act as unilateral action by build special projects without take in consideration the opinion of riparian countries. The national water carrier was established to transport water from Jordan River to the coastal cities and Negev desert. According to the both Palestine and Syria haven't ability to access this water resource where parts of both two countries under Israeli occupation. But, the situation in Syria is better than from Palestine where Syria built the Yarmouk dams to collect water as possible as. The country uses about 450 MCM/yr of surface and groundwater resources in the basin (UN-ESCWA and BGR, 2013), and the main purpose for these amount of water is to meet agricultural uses in the near areas.

According to UN-ESCWA and BGR (2013), Lebanon exploits about 9-10 MCM from the Hasabani Sub-basin to meet only domestic uses and the Israeli side pumped annually 580-640 MCM while the Jordanian side uses about 290 MCM/year. It is worth mentioning that the Palestinian share of the legal waters of the Jordan River is about 257 million cubic meters annually, according to Johnson plan (PWA, 2011).however, Johnson plan suggested to build the West Ghor canal to supply irrigation uses in the Jordan valley area and the amount of water was estimated about 240MCM.

After 1967 war, the Israeli occupation declared a military order to convert the West Bank and Jordan River as military zone area and this mean the accessibility and control on this area only by Israeli settlers and soldiers. Among the last years the Palestinian water rights were neglected where the Israeli occupation exploited the Jordan River to supply and improve settlements in that area.

Although negotiation was started after the agreement declare principles in Oslo-1 (1993) and followed after two years by the agreement Oslo-2 (1995) the Israeli side recognized the Palestinian water rights but without define and estimate what is the amount of water that will be exploit by the Palestinian side. In the light of above, the Palestinian water rights was ignored in the Jordan River basin and the access to this basin is prevented. Although, all riparian countries have a specific

amount could be exploited from this basin either by the pumped from the headwaters for this river or by pumped directly from the river the Israeli side exploited the large percent of this basin ignoring the principles of international water laws and united nation decisions. So, the situation still the same until this present time regarding to the Palestinian water rights.

The following table shows the situation and privileges of all basins that shared between Palestinian and Israeli side.

Table 6. Privileges of all Basins for each side.

Term	Palestinian side					Israeli side				
	Western basin	Eastern basin	North-Eastern basin	Coastal aquifer	Jordan River basin	Western basin	Eastern basin	North-Eastern basin	Coastal aquifer	Jordan River basin
Allocated water (MCM/year)	24.6-38.7	30.6-64.8	17.1-29.3	81.7-106.0	Palestinian water rights are disabled from this basin and was discussed above	350-390	40	101-115	400-480	580-640
Mainly target areas	Tulkarm, Qalqiliya (little sharing in Bethlehem and Hebron)	Hebron Governance	Nablus, Jenin, Tubas	All Gaza Strip			settlements	settlements	areas inside Israel	Coastal cities and Negev desert and close settlements
Population	1 million	1.3 million	700,000	1.6 million		3.4 million	in the next section (settlements in West bank)	in the next section (settlements in West bank)	3.8 million	---
Consumption (l/c.d)	70-106	90 l/c.d	60-105	115-170		283-294			285-345	---

Although international water principles and united nation convention decisions to enhance cooperation and ensure water for all riparian countries the Israeli policies still the same and strategies prevent the Palestinian side to access the shared water resources and the occupied Israeli argues and thought that the Palestinian side as an authority not a state and thereby international water law principles not applicable on Palestinian – Israeli case.

The critical question is the international water law principles could be applicable on the Palestinian- Israeli case. However, the principles of international water law build on three main theories include absolute territorial sovereignty, absolute territorial integrity, and limited territorial sovereignty. But, all last theories are not applicable and no any privileges for the Palestinian side that faces many obstacles to access their water resources and establish development water projects while the Israeli side has full sovereignty on all water resources in the region.

Many factors should be considerable in allocating shared water resources like population, economic, equitable uses of water, prevent unilateral actions and other factors depend on the case. However, economically by referring to (El-Fadel et al., 2001) the agriculture sector in Palestine contributes about 23-29% of GDP, while contribute about 6% to GDP in Israeli. Although, the water allocated for the Palestinian side for agricultural uses is not enough where the al-Ghor region suffers from water shortage for agricultural uses.

Weak supplying water for Palestinian agriculture sector decrease opportunities of improvement methods on income, decrease number of employments in this sector. Agriculture inevitably plays a key economic, social and political role in all plans for rebuilding the Palestinian economy (WB, 2009).

4.2.2 Water theft by the settlements in West Bank

One of the main obstacles that stand on the Palestinian improvement life where distribution of settlements in all over West Bank. The settlers population increasing one of the main reasons that effect on Palestinian rights which include the confiscation of Palestinian lands, demolition of Palestinian houses, the freedom of Palestinian movements through West Bank areas, in addition the stealing water from shared water resources to meet needs of settlers in the settlements in all aspects that includes agricultural, industrial, and domestic uses.

The Jewish population in the West Bank has been too widely spread, in line with a past government policy of large distribution of settlements so as to capture as much land as possible (Efrat, 1994) and so the Israeli occupation to ensure and sustain life in these settlements provide all types of supplying to the settlers. Water is one of these things that settlements need to build their lives in these lands. Israeli ecological and infrastructure projects exploit extra Palestinian lands to transfer water from water resources to the water distribution network in the settlements and the estimated area of lands that was stealing to establish these projects at least hundreds of donums of lands.

By refer to the last statistics the number of settlements was established officially in West Bank excluded East Jerusalem is 132 settlement and the number of unauthorized outputs which are established without government approval since 1990 is 133 units. The number of settlers in West Bank settlements among the period (1999-2019) is shown in the table below.

Table 7. Population Settlements (Foundation for Middle East Peace, Israel Central Bureau of Statistics, B'Tselem)

Year	Population
1999	176856
2001	198095
2003	226051
2005	249954
2007	278875
2009	299340
2013	324562
2018	438359
2019	449697

The growth rate of settlers in the period 1999-2009 is 5.4%, while this percentage decreased in the last ten years to become 4.2%. However, the next chart shows the increasing annual in population among the last period.

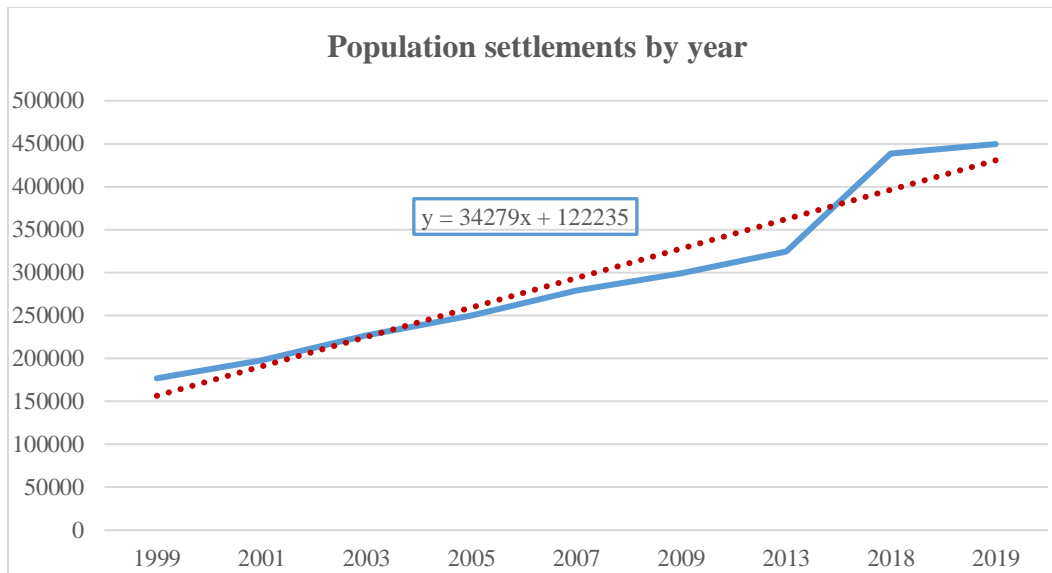


Figure 7. Linear Growth rate of Population Settlements

From the last chart the linear equation that describes growing in the number of population in settlements and by using this equation so the expected population after ten years in 2029 at least one million settlers.

The chart below shows the percentage of population in West Bank, where these settlements shared the Palestinian side in exploiting water resources.

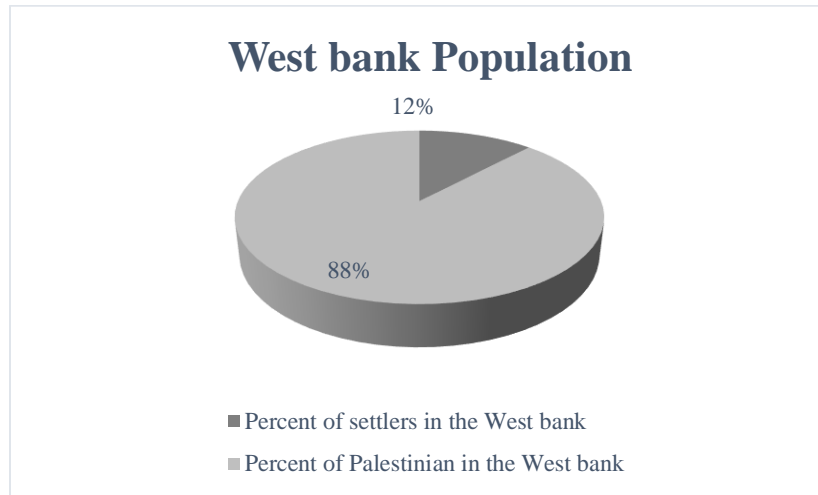


Figure 8. Percentage of Population in West bank

While this percentage is different when comparison the settler's population in the West Bank with the number of Israeli citizens inside Israel and the next chart illustrate the percentages of Israelis in two different regions.

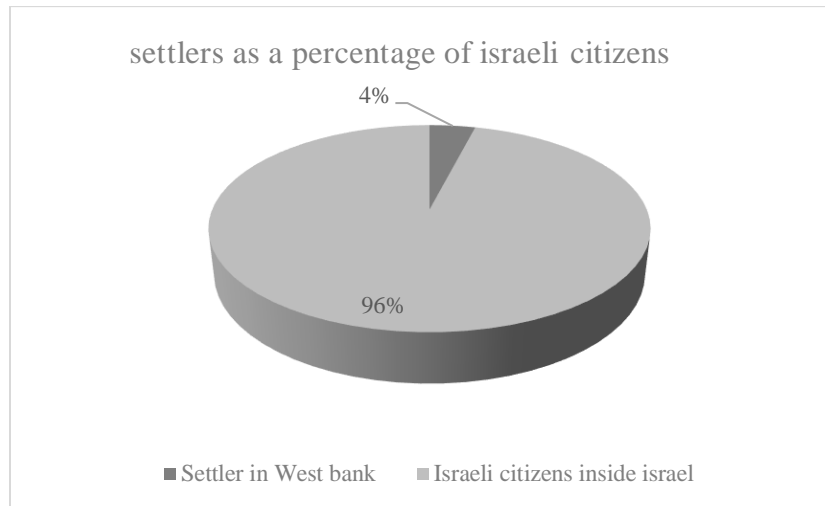


Figure 9. Settlers as a percentage of Israeli citizens

From the last percentages the clear indications that the settlers in West Bank have a significant impacts where the natural resources in West Bank will be exploited in high efficiency and the water resources is one of them.

The agricultural sector consumed about 58% of the total water supplied and this mean huge amounts of water pumped to the settlements for agricultural uses and secondly for domestic uses. However, more than 30,000 settlers live in the Jordan valley area and derive water from the Jordan river basin for specific agricultural uses while the Palestinian farmers in the same area do not have the ability to derive water from the same basin and this mean a clear stealing of water and so the Palestinian farmers have only one choice is to buy water from an Israeli water company (Mekorot).

By referring to (ARIJ, 2015) the consumption of settlers in the settlements is at least 365 l/c.d and the Israeli water company pumped water from the wells in the West bank to provide water for settlers while the original citizens in the West Bank (Palestinians) consume about 90 l/c.d.

By depend on the consumption of settlers the total water supplied from the West Bank of settlements at least 61 MCM per year and this quantity of water was stealing from the Palestinian water rights in West Bank aquifers where the Eastern-north basin supply about 115MCM/year for irrigation uses in Kibbutzim and Moshavim in the northern valley while the Eastern basin supply at least 40MCM/year for agricultural settlements in the Jordan valley.

The total Israeli water abstracted from water resources in the West Bank about a 495MCM / year and the percentage of the settlements from this quantity is 12%. However, the Palestinian side percentage of the shared water resources is about 15% and this percentage is too close to the settler's consumption percentage.

4.3 Local Water theft at West Bank

In case of West Bank, the last year 2017 was taken into consideration since all data required are available, however the data related for both years 2015, 2016 is not available all data where is some of the data are missing for most municipalities and this refer to miss management in these municipalities in this both years because this data is necessary to evaluate water sector and derive clear indications to take appropriate decisions in all aspects like financial and technical aspect.

4.3.1 Sample Calculation

The following table represents the water balance model for Ya'bad Municipality in the West Bank for year 2017.

Table 8. Water Balance Model - Ya'bad Municipality

System Input Volume	Authorized Consumption	Billed Metered Consumption (490,584CM)	Revenue Water 493584 CM
		Billed Unmetered Consumption (3,000 CM)	
		Unbilled Metered Consumption (6,000 CM)	Non- Revenue Water (NRW) 127416 CM
		Unbilled Unmetered Consumption (8,000 CM)	
	Water Losses	Unauthorized Consumption (5,416 CM)	
		Metering Inaccuracies (50,000 CM)	
		Leakage on Transmission and/or Distribution Mains and Leakage on Service Connections (30,000 CM)	
		Leakage and Overflows at Utility's Storage Tanks (28,000 CM)	

From the water balance model:

The System input volume = Revenue water + Non-Revenue water = 621,000 CM.

$$\text{NRW-T by volume} = \frac{\text{Volume of water theft (unauthorized consumption)}}{\text{System Input volume}} \times 100$$

$$\text{NRW-T by volume} = \frac{5416 \text{ CM}}{621000 \text{ CM}} \times 100 = 0.87\%$$

$$\text{NRW- without water theft} = \frac{\text{Volume of other losses without unauthorised consumption}}{\text{System Input Volume}} \times 100$$

$$\text{NRW- without water theft} = \frac{122,000 \text{ CM}}{621000 \text{ CM}} \times 100 = 19.6\%$$

By make the same calculation for all councils and municipalities the following model is the water balance for all West Bank supply systems in single model.

Table 9. Water Balance Model - West Bank

System Input Volume (90,167,385 CM)	Authorized Consumption	Billed Metered Consumption (63,374,052 CM) - 70%	Revenue Water (63,858,896 CM) 70.5 %
		Billed Unmetered Consumption (484,844CM) - 0.5%	
		Unbilled Metered Consumption (453,958CM) - 0.5%	Non- Revenue Water (NRW) (26, 308,489 CM) 29.5%
		Unbilled Unmetered Consumption (1,425,258 CM) - 1.6%	
	Water Losses	Unauthorized Consumption (5,549,620 CM) - 6.2%	
		Metering Inaccuracies (6,329,927 CM) - 7.0%	
		Leakage on Transmission and/or Distribution Mains and Leakage on Service Connections (11,852,406 CM) - 13.1%	
		Leakage and Overflows at Utility’s Storage Tanks (697,320 CM) - 0.8%	

The following chart shows the percent of Both NRW that resulted from collecting data in year of 2017.

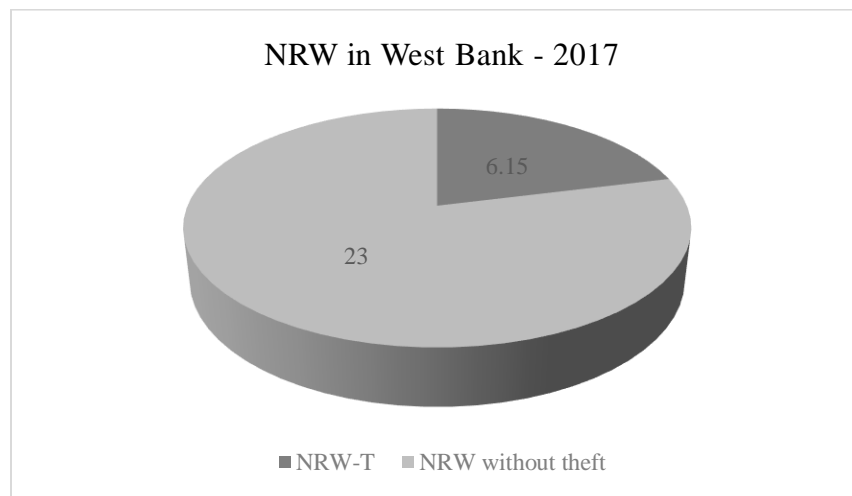


Figure 10. Percentages of Non-revenue water in West bank

From this chart the total NRW is about 29% from the total water supplied and the NRW-T that resulted from unauthorized consumption is about 6% and form about 26% from all NRW.

4.3.2 Water theft per capita

According to the total water supplied for consumers in 2017 the water amount allocated to one person is 34CM/ capita and the water theft in cubic meter per capita is 2 in the same year where is the number of population in West Bank is 2.6 million and this number will increasingly year after year and in case the situation still like this surly the water theft per capita will increase in the next years.

4.3.3 Classification performance

The following two charts illustrate the percent of water theft for each council in West Bank. However, some of municipalities excluded since the amount of unauthorized consumption not available and these municipalities include Al Bireh, Al-Ram, Annzeh, Beituniya, Bir Nabala, JSC For WW Management in Taybeh and Ramoun, Ramallah.

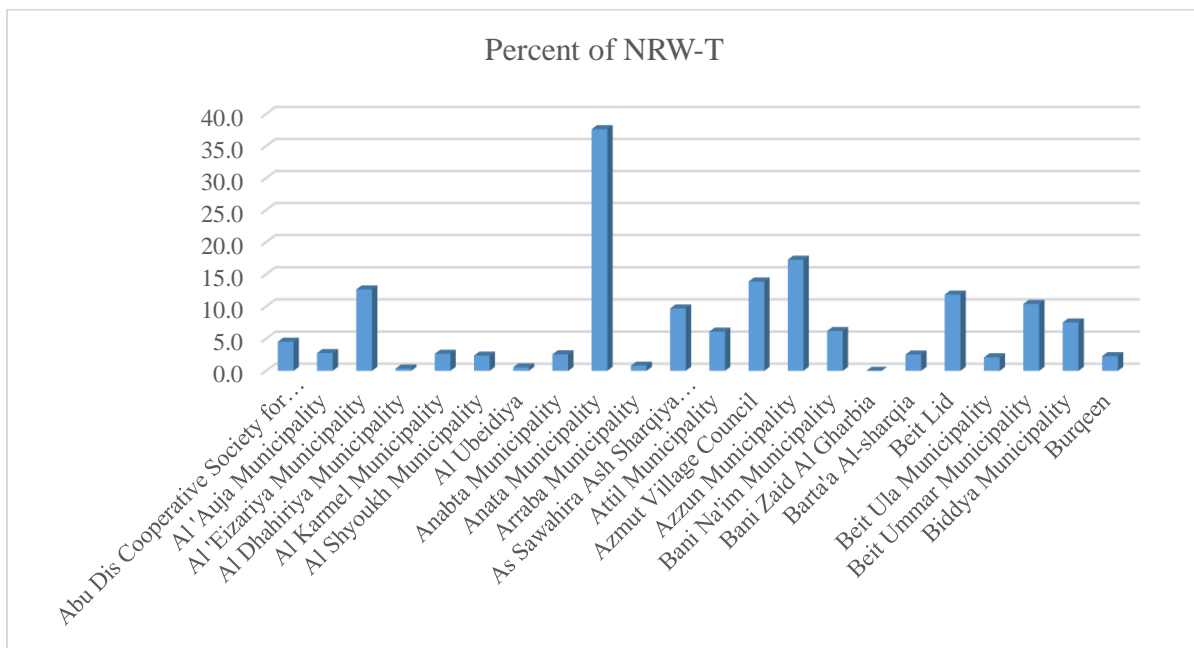


Figure 11. NRW-T for all West bank councils- 1

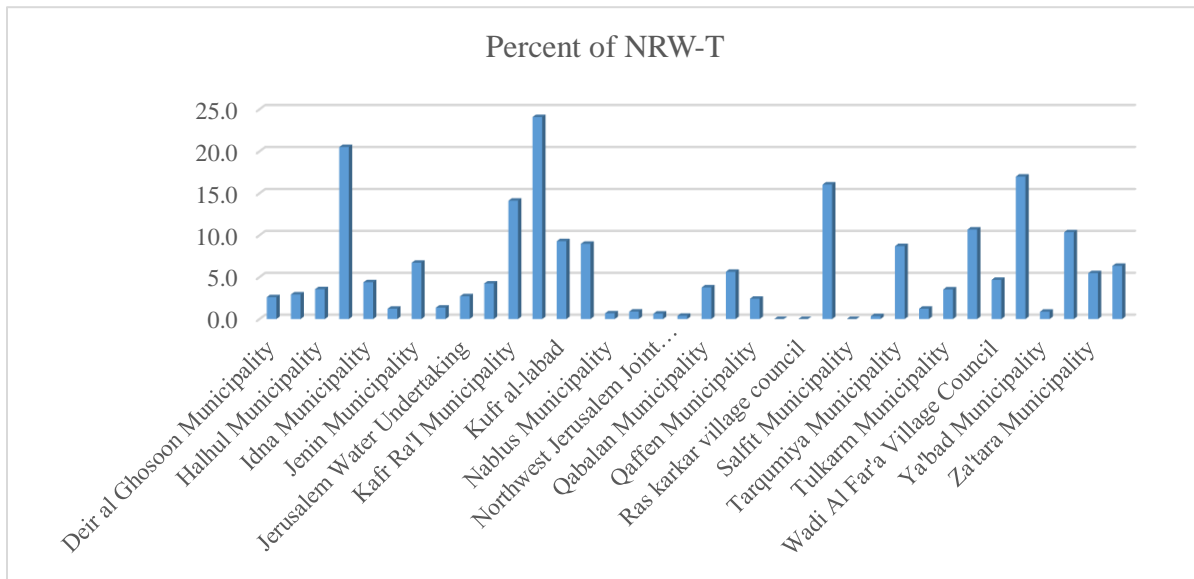


Figure 12. NRW-T for all West bank councils- 2

From these results there are bad performance in some councils which have percent of NRW-T more than 25% and this percent founded only in Anata municipality, the second group have a moderate percent of NRW-T of 10-25% like Al 'Eizariya, Azmut Village Council, Hebron, Kafr Ra'I, Kharas, Sa'ir, Tuqu', WSSA of Bethlehem Beit Jala and Beit Sahour, Yatta, and the rest municipality consider have bet performance in comparison with other councils performance where have a percent less than 10% of NRW-T.

4.4 Local water theft in Gaza Strip

4.4.1 Sample Calculation

The water balance model below is for Beit Hanun municipality in Gaza Strip in 2017.

Table 10. Water Balance Model- Beit Hanun municipality

System Input Volume	Authorized Consumption	Billed Metered Consumption (2,131,968CM)	Revenue Water (2,311,968 CM)
		Billed Unmetered Consumption (180,000 CM)	
		Unbilled Metered Consumption (900 CM)	Non- Revenue Water (NRW) (1,894,654 CM)
		Unbilled Unmetered Consumption (15,000 CM)	
	Water Losses	Unauthorized Consumption (1,306,730 CM)	
		Metering Inaccuracies (360,024 CM)	
		Leakage on Transmission and/or Distribution Mains and Leakage on Service Connections (200,000 CM)	
		Leakage and Overflows at Utility's Storage Tanks (12,000 CM)	

The System input volume = Revenue water + Non-Revenue water = 4,206,622 CM.

$$\text{NRW-T by volume} = \frac{(\text{unauthorized consumption})(1,306,730 \text{ CM})}{\text{System Input volume} (4,206,622 \text{ CM})} \times 100 = 31.1\%.$$

$$\text{NRW- without water theft} = \frac{\text{Volume of other losses without water theft} (587,924 \text{ CM})}{\text{System Input Volume} (4,206,622 \text{ CM})} \times 100 = 14\%.$$

In the following water balance model, All Gaza strip municipalities collected in single water balance.

Table 11. Water Balance - Gaza Strip

System Input Volume (90,659,241 CM)	Authorized Consumption	Billed Metered Consumption (57,854,879 CM) - 63.8%	Revenue Water (58,304,284 CM) 64.3 %
		Billed Unmetered Consumption (449,405 CM) - 0.5%	
		Unbilled Metered Consumption (1,587,885 CM) - 1.75%	Non- Revenue Water (NRW) (32,354,957 CM) 35.7%
		Unbilled Unmetered Consumption (1,607,749 CM) - 1.8%	
	Water Losses	Unauthorized Consumption (17,841,895 CM) - 19.7%	
		Metering Inaccuracies (7,179,544 CM) - 7.9%	
		Leakage on Transmission and/or Distribution Mains and Leakage on Service Connections (3,961,442 CM) - 4.4%	
		Leakage and Overflows at Utility's Storage Tanks (176,442 CM) - 0.2%	

The contribution of local water theft in all NRW in Gaza Strip at 2015, 2016, 2017 is shown in the following pie charts.

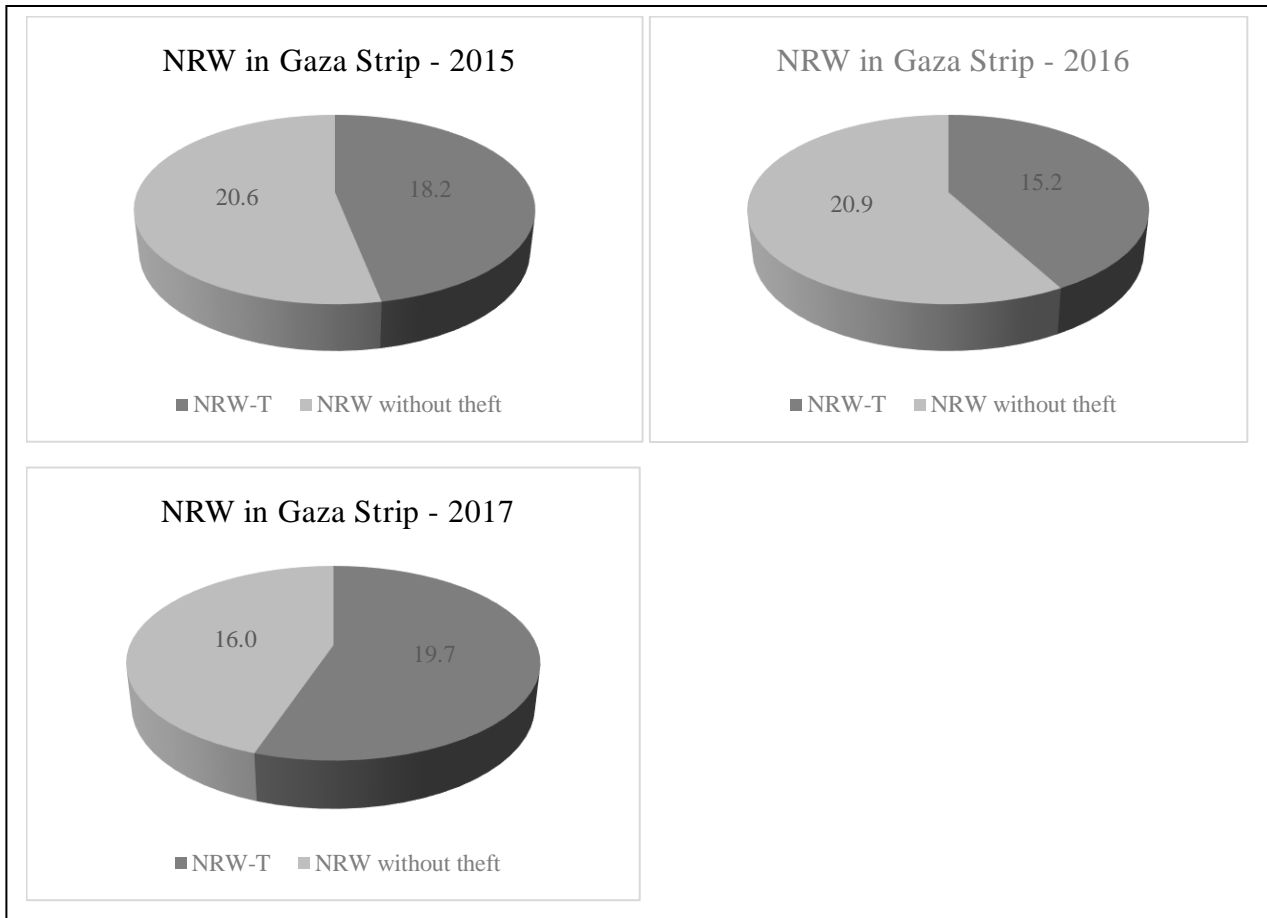


Figure 13. Percentages of Non- Revenue water in Gaza Strip.

As shown above the NRW-T at 2015 is 18.2% of the total water supplied and this percent is very closed to the percent of NRW resulted from other losses which equal 20.6%.so, the total NRW percent in volume at this year is 38.8% from the total water supplied.

In the next year, the percent of NRW-T is decreased about 3% to become 15.2%. In addition, other losses without theft sharing in 20.9% from the total NRW and thereby the total sharing of losses NRW is 36.1%.

There are no noticeable changes in performance of water sector in the next year at 2017.however, the NRW-T percent is 19.7% which is more than value of percent of contribution other losses in NRW which is equal 16.0% and so the total NRW percent is 35.7%.

In general, the important notes that derived from the past results in the last three years are the water theft percentage contribute approximately in half of total NRW and this percent gives a noticeable indications that the water theft has a strongly sharing in failure of finance performance of water sector.

Other point, the range of water theft is between 15.2- 19.7 % among last three years and these percentage are very closed so there are no any improvement in procedures, policies, measures from municipalities and councils and no cooperation from consumers in preventing and struggling of water theft and this form a big catastrophe in case of scarcity of drinking water in Gaza Strip.

4.4.2 Water theft per capita

According to the data collected the average water theft per capita in 2015 is 8.8m³/capita and in the next year although increasing in number of population the water theft decrease to become 7.5m³/capita. However, this percent is coming back to increase in the next year in 2017 to 9.2m³/capita.so, the average of water theft per capita in the last three years is 8.5 m³. This unstable fluctuation in percent of unauthorized consumption refers to miss management, no clear policies, and the regulations and laws are not implemented to reduce unauthorized consumption.

4.4.3 Classification performance

In the next chart that illustrate the percent of NRW-T for each councils in Gaza Strip by Average for the last three years 2015,2016,2017 where there are municipalities have a percent exceeds 25% includes Al Mughraqa, Wadi as Salqa, Wadi Gaza and these councils considerer have a bad performance in comparison with the rest municipalities in Gaza Strip.

However, the little of municipalities have recorded the smallest percent and have a good performance where is the percent of NRW-T less than 10% and these include Al Naser, Al Zahra, Bani Suheila, Khuza'a municipalities.

While the rest municipalities form the largest number which is lie in the middle area and it has percent of NRW-T is 10-25%.

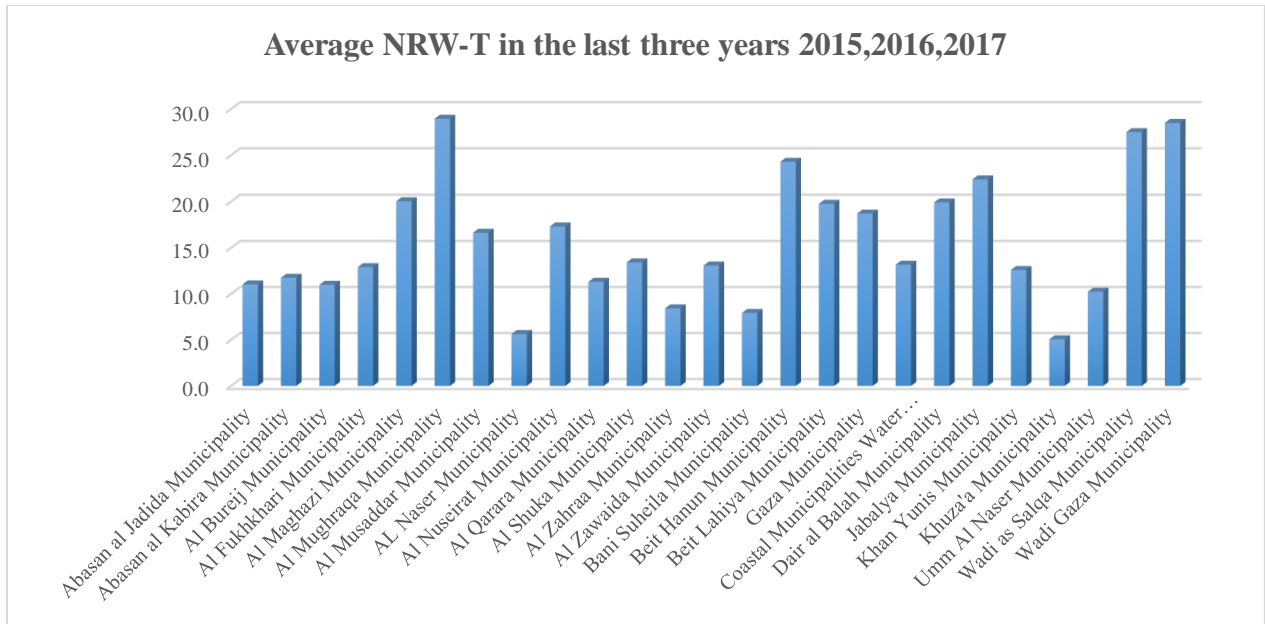


Figure 14. Average Non-Revenue water resulted from unauthorized consumption in Gaza Strip

4.5 Sustainability of Water sector in West Bank and Gaza Strip

The shared water resources as explained above exploited mostly by Israeli occupation and by increasing population on both sides, Palestinian and Israelis this mean increase demand of water, but in case of water shortage in the West Bank because Israel policies leads to increase water crisis which means inability of water sector to meet the needs of people for different uses.

In present time and in the light of deal century will allow the Israeli occupation to expand their lands and settlements in West Bank leads to increase restriction policies on Palestinian water rights and decrease efficiency of developing water projects and thereby decrease agricultural and industrial activities will effect on the income of Palestinian families where water sector hardly cover the domestic uses.

Water shortage put service providers in difficult conditions since inability to distribute water in equitable manner for all users and this form strong reason to theft, water by local Palestinian citizens in West Bank where the amount of water stolen in the last year at least 5.5MCM and the financial losses not less than 20 million Nis and these number capable to increase if the water rights still the same and there are no positive indications so the no clear future for Palestinian water sector.

According to the last results which include the average amount of water theft in the last three years is 16MCM/year, the average water tariff is 2.01NIS/CM and then the financial losses will be at least 32 million NIS/year, average water theft is 8.5 CM/capita, average NRW-T is 17.7%. However, the national strategic goals in 2032 is to reduce NRW to become 20%, but there are no actual policies, and an actual desire to achieve this goal.

The sustainability of the water sector in the Gaza Strip is at stake while increasing in population and scarcity of drinking water because ground water resources are almost polluted. High percentage of water theft and weak policies and less cooperation from citizens surly will share in increase water scarcity and miss water security and decreasing development economic and social life in the Gaza Strip.

If the situation in management of unauthorized consumption will still like the past years the expected scenario in the future is increasing the number of unauthorized consumption as well as increasing population and thereby raise up the percentage of average water theft per capita in the Gaza Strip and deeply decrease in NRW will be lead to huge financial losses and weak in operational and maintenance cost and this decrease maintenance and development works on water networks. In addition, the new projects of water network will be disappeared where the Revenue Water is hardly covering the operational and maintenance cost.

4.6 Water Theft cycle

The starting point is from the Israeli policies, strategies in allocating water for riparian countries, and specifically for the Palestinian side. The results above in section regional water theft proved that a huge difference in exploiting water between both sides. Thereby, the limited access, control of water resources which allowed for the Palestinian side to pump about 15% of the total production from the shared water resources and so, this limited water quantities created the water shortage, and an actual water crisis in West Bank and Gaza Strip, where these quantities are not enough to meet Palestinian citizens uses in all aspects which include domestic, agricultural, industrial uses.

The expected reaction by local citizens in light of the circumstances of the water crisis that led to the failure to provide water for all citizens is to obtain water illegally. The internal conditions in the water sector management are also factors in increasing the rate of water theft in the West Bank and Gaza Strip.

Disrupting the role of the Water Sector Regulatory Council and the inability to implement the Palestinian water law, high water tariffs, population growth, and administrative imbalance are essential points in the inability to cope with water theft and the growth of this phenomenon.

The high percent of water theft this mean increase in the NRW and financial losses which create a poor performance in water sector. The following model shows the water theft cycle from the originate (Regional water theft) to the final point.

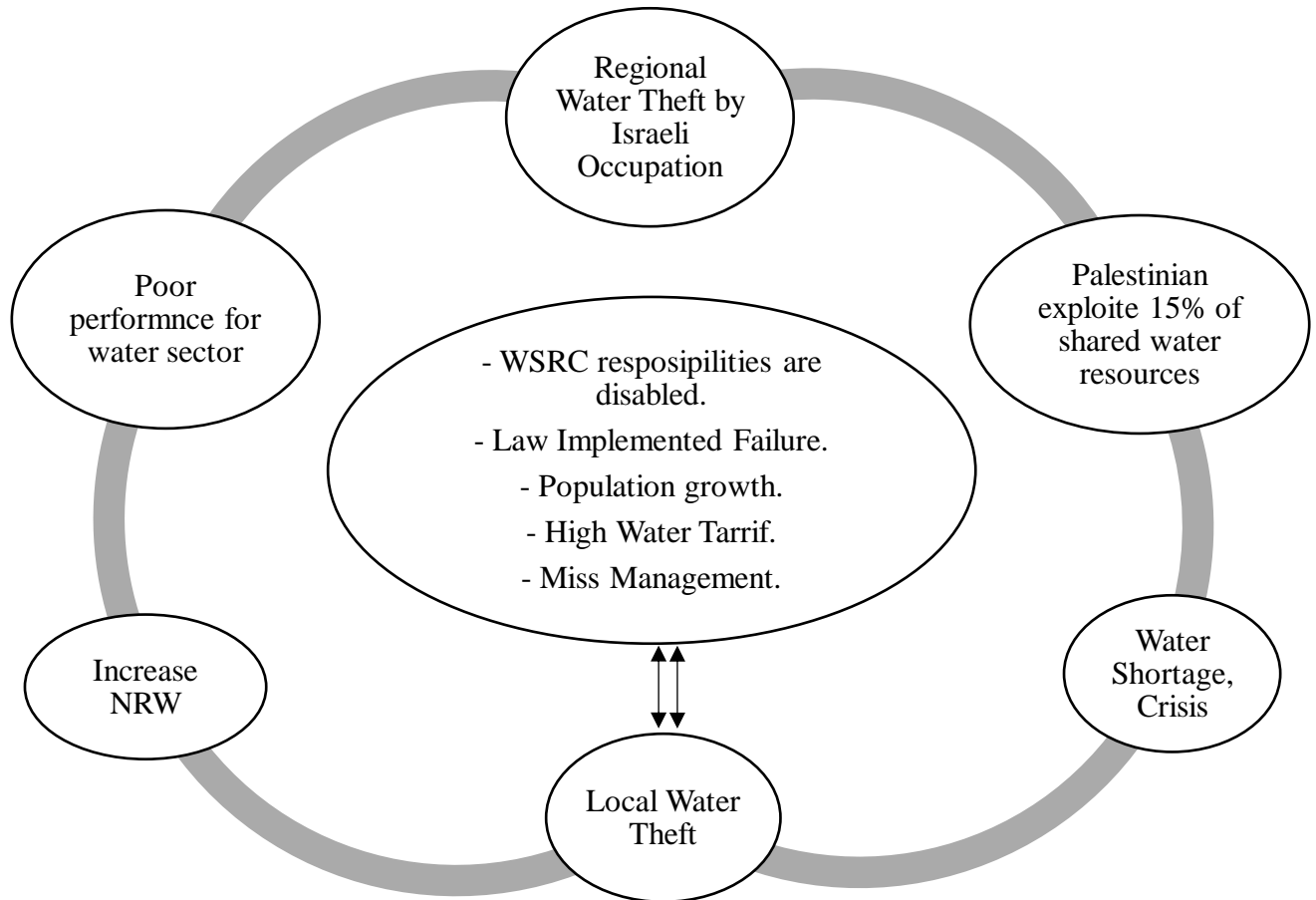


Figure 15. Water Theft Cycle

4.7 Knowledge of Palestinian water experts about Regional and Local Issue

4.7.1 Regional Issue

The questionnaire was directed to the water experts only and just 31 experts answers to this questionnaire. In addition, the water experts have different scientific background and various experiences and to cover all experts the questionnaire were directed to water experts whose work in different places include governmental, NGOs, private sector, academics, and so in this section illustrating the opinions of water experts about a regional issue.

All experts thought that the water consumption by Palestinians and Israelis is Not-equal where a clear gap between both sides in water consumption. According to the Oslo Agreement specifically in article 40 all experts disagree with this agreement since was not fair for the Palestinian side. But, Dr. Shaddad Al-Attali, former President of the Palestinian Water Authority explained his opinion about this agreement that Israel recognized Palestinian water rights in the West Bank but postponed the issue to permanent status negotiation. Also, Israel uses the JWC established in article 40 in the Oslo Agreement to veto and control Palestinian projects as well as used it as a mechanism to legalize settlements water projects. Moreover, Israel has managed to undermine the development of the water sector as reported by 2009 World Bank report as well as 2009 Amnesty International Report as well as other international reports like the French National Assembly report that described the water situation as water apartheid.

Various opinions appeared when asked them about the international water law principles if could be applicable on the Palestinian Israeli conflict and this chart shows the opinions of them.

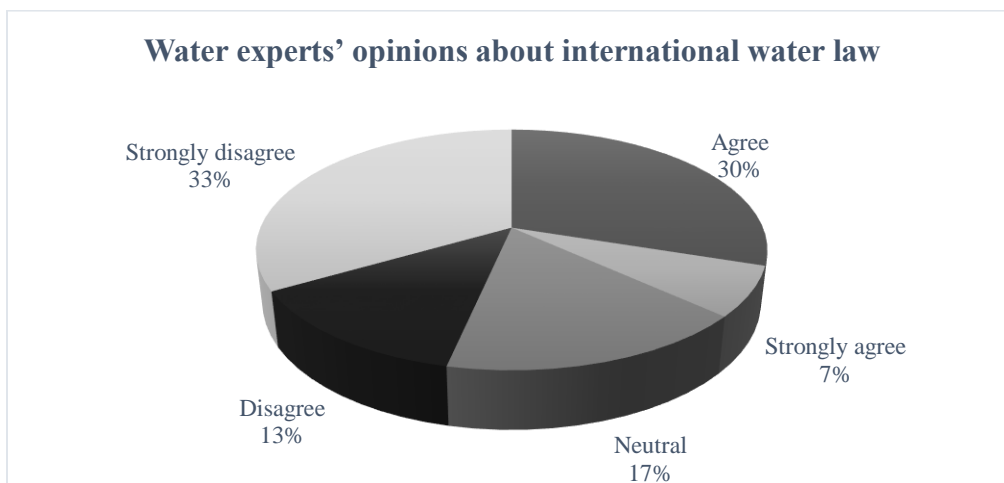


Figure 16. Water experts' opinions about international water law

The negotiations between both sides, about water issues was delayed to the final solution negotiations. However, most of water experts seems that the negotiations will not lead to the satisfactory solution for Palestinian side and this refer to many reasons including the Israeli side consider the Palestinian as beneficiary (consumers) not as state, no balance power between the two sides, and because the Israeli side deny the Palestinian water rights.

The JWC was established in cooperation between both sides after signing the Oslo agreement but the question now is does the joint water committee have a positive role for the Palestinian side. Most of water experts express their opinion about this subject that the JWC has a negative and destructive role in undermining the development water sector and limited within the Palestinian boundaries in the West Bank.

Israeli Water Company pumped water from the West Bank to the settlers, but the quantities do not identified exactly. However, fifty percent of water experts didn't have an idea about water quantities that pumped to the settlers. Other experts said the water quantities that were pumped at least more than 60MCM/year, which is too close to the estimated results. Jane Hilal the Head of Water and Environment Research Department- at Applied Research Institute- Jerusalem says the number of settlers about 628,000 Jewish settlers consume on average 369 l/c.d which also close to the estimated water consumption in the section that talked about settlements.

In addition, one third of water experts haven't an idea about lands stolen by Israeli side which exploit these lands for establishing trunk lines and to link between settlements. Other experts indicate that the land confiscation by Israeli side could be estimated a hundred of thousands donums of lands were stolen to construct trunk lines.

With respect to the entitled compensation for water stolen among the last years all experts have apposite answers except two experts and this step, according to many experts need a lot of arrangement and someone says the political leaders should be working hardly on ending occupation and then request for any kind of compensations. However, Attili indicates that the Palestinians have already prepared a file for damage resulted in occupation requesting reparation and compensation for damage.

Among the last 20 years the Palestinian water rights still the same situation and there no any improvements in restoring water rights and this is the opinion of all water experts. There are many reasons for retreat water rights indicated by water experts include Israeli occupation and non-resolution of water rights has led to have Gaza with no water that fits for human consumption and restriction of access to Palestinian to their water resources like the Jordan River basin and the water in groundwater aquifers. However, someone experts indicate that improvement was marginal where in the first 5 years, many wells were drilled but unfortunately without success due to water depletion and lower water levels due to nearby Israeli wells. After that, only rehabilitation works were invented to restore the already available water quantities. So, may be occurs improvement in water distribution, but not in increasing of water quantities since the Palestinian water rights was ignored by the Israeli occupation.

4.7.2 Local Issue

The first specific question directed to the water experts if can describe stealing water as illegal action and deserve punishment and the chart below shows the answers.

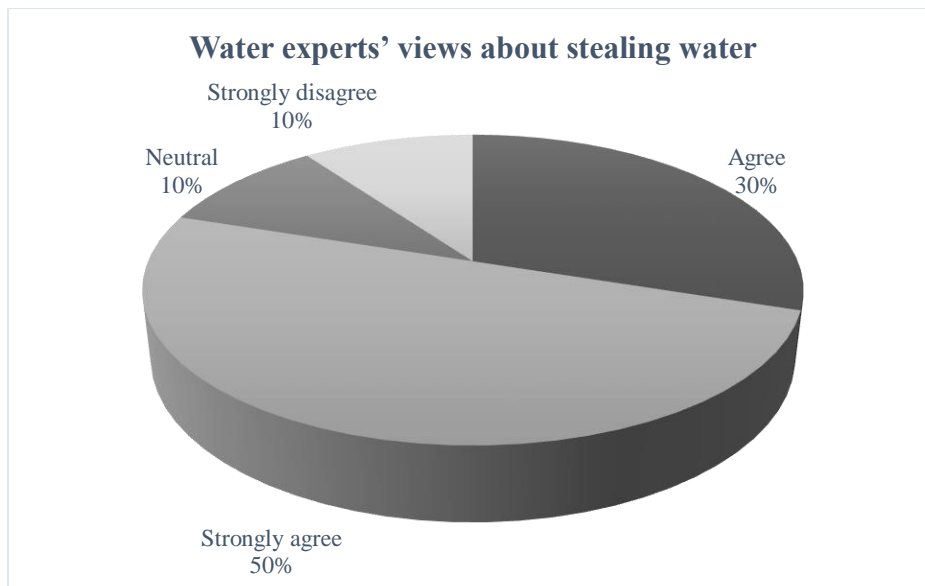


Figure 17. Water experts' views about stealing water

Eighty percent of water experts believe that the cause of the escalating problem of water theft is the service provider and consumer while few experts believe that the cause of this problem is consumer and 10% of the experts indicates that cause of increasing water theft is water service providers.

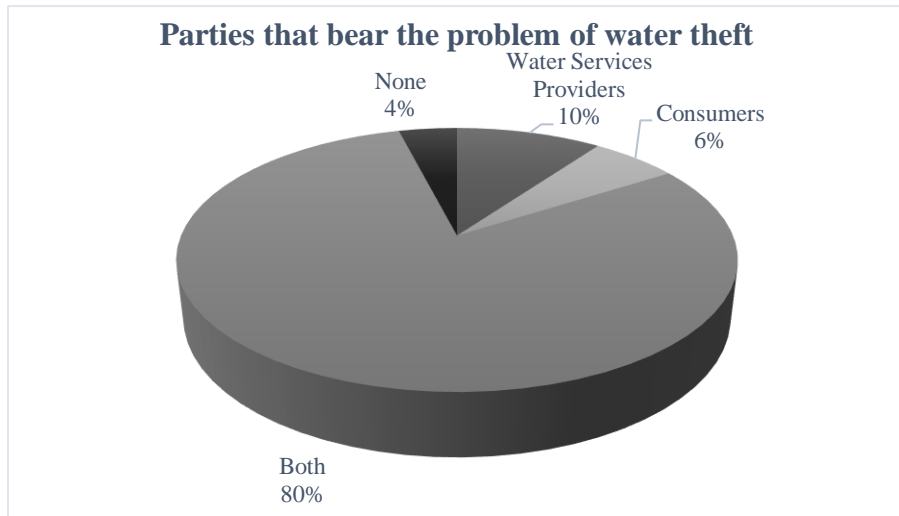


Figure 18. Parties that bear the problem of water theft

Water theft occurs in several various regions include cities, villages, and camps. The following chart illustrates the views of water experts about what is region that sharing in water theft more than another.

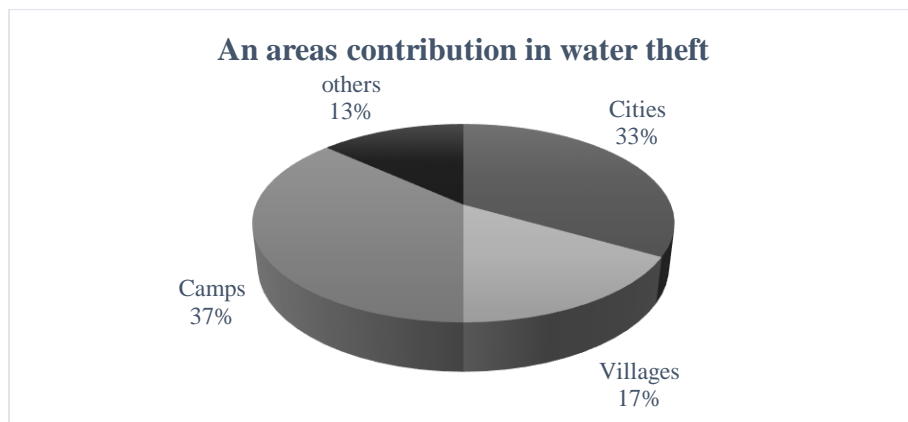


Figure 19. An areas contribution in water theft

Regarding to the question about real impulses that push people to stealing water the experts indicates too many reasons divided into two main parts include reasons related to the water service providers and the second part the impulses related to the consumers. However, the reasons related

to water users include greediness, lack of satisfaction and social responsibility, difficult economic conditions, the personal interests of some citizens, unwillingness people to pay for the high price of service, and inequitable distribution of water with affordable price so these reasons lead to form a bad prevailing culture. On the other hand, the reasons for which water service providers are responsible includes weak control by service providers, miss management at the service provider level, weak of legislations and limited law enforcement.

Two-third of water experts seins that the failure in implementing law leads to increasing water theft while other experts thought that it's difficult to implementing the law if the water non-available in an equitable manner for all users and this lead to a lack of social justice. To implement the law the real desire is mainly required from the political leaders. Although, fifty percent of experts thought the political leaders have a real desire to implement law and reduce water theft while other experts seins that the desire is not enough and also, creating tools and clear mechanisms to implement policies and regulations is more efficient to reduce water theft.

Few experts give a specific answer about the percentage of water theft could be overlooked and the most of the answers were about 5%, while other experts say there are other considerable losses due to leakages and pipe damages that have to deal with but this is an opinion is not sensible where have a high percentage of water theft which equivalent to the all other losses and this opinion reflect to what extent an experts have an idea and knowledge about water theft. In addition, most of experts do not have an idea about percentage of water theft and little of them have non-clear various answers.

Water theft mitigation still the same and there is no improvement in reducing percentage of water theft and this due to many points as water experts thought that include limited political will, occupation which causes water shortage, less transparency by the water providers, insufficient enforcement and punishment, leak of fund, lack of proper control over water resources, and the political interferences that form a gap between water sector managers and political leaders so as mentioned most of experts thought that the real desire to reduce this phenomenon is not available by political leaders.

In the light of above, most of water experts have a disadvantage vision about water sector and no clear future on the long term and this mean the sustainability of the water sector is at stake if the situation still the same without a clear mechanism on the ground.

CHAPTER FIVE – CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This research aims to study water issue in both regional and local levels. Regional level to study the shared water resources between Palestinian and Israeli side and estimate the allocated water for each side and average water consumption in both sides. Also, the illegal water uses and consumption in the settlements in the West Bank.

Local level to study and estimate local water theft by local Palestinian citizens in the West bank and Gaza strip and classification performance of municipalities according to the percent of water theft. In addition, to evaluate knowledge of water experts about both issues, regional and local water theft.

To achieve aims of this study, collecting regional data will derive from the official reports from both sides, official statistical data, and researches published about a regional issue. Local water theft by collecting all water balance data from WSRC in Ramallah to find and calculate percentage of water theft. Appropriate questionnaire will directing to the water experts and through critical questions about both issues.

The shared water resources include Western basin, Eastern basin, North-Eastern basin, Coastal aquifer and the Jordan River basin. Abstracted water from the Western basin for the Palestinian side is 6% and the consumption Palestinian per capita is 70-106l/d while the Israeli side reaches to 94% of total water extracted from this basin and the consumption per capita is 283-294l/d. Israeli occupation exploited 40 MCM /year from the eastern basin to the settlements in the West Bank and the water abstracted for Palestinian is 44.4-64.8 MCM/ year and the average water consumption per capita is 90l/d.

Water pumped from the north-eastern basin to the Palestinian is 17.1-29.3MCM/year and the water consumption per capita is 60-105 l/d while the Israeli occupation exploited 101-115 MCM/year and the amount of water stolen by Israeli occupation is at least 30MCM/year. The coastal aquifer basin is 90% polluted and the amount of water exploited by Palestinian in Gaza strip is in average is 94 MCM/year and the water consumption per capita is 115-170 l/d while Israeli occupation pumped about 400-480 MCM/year and so the water consumption per capita is 285-345l/d inside

Israeli. Jordan River basin never exploited by the Palestinian side and no access to this basin and this basin exploited other four riparian countries and the largest amount of water exploited by the Israeli occupation.

Local water theft in the West bank by Palestinian citizens is 6.2 % of the total water supplied and the water theft per capita is 2 cubic meter and the amount of water stolen in the West bank in the last year is at least 5.5 MCM and so the financial losses were estimated not less than 25 million Nis in the same year.

While the water theft percentage in the Gaza strip in the last three years is 15.2-19.7% and so the average water theft per capita during the same period is 8.5 cubic meter and the average amount of water in the last three years is 16 MCM and the average financial losses in the same period is at least 32 million Nis/year.

Most of water experts give negative answers about situation of the water sector in both levels regional and local, and their opinions mean that no there are any indications about improvement water sector on the long term so the sustainability of the water sector is at stake.

5.2 Recommendations

The recommended messages that will improve the water sector in both regional and local levels derived from water experts' recommendations.

Regional recommendations include preparing and update the negotiation file and be ready whenever negotiations started. Also, political leadership should work on presenting the Palestinian water rights to the international community as per the international water laws principles and guidelines and the technical and legal members shall be the negotiators.

Building facts on the ground where the water is the problem for all, stop water purchase from the Israeli side and management of shared water resources should be integrated and involve the protection and sustainable utilization of these resources with mutual recognition of each other water rights and refusing or stopping to deal with the Oslo Accords and the ensuing unfair division of water quotas. Unfortunately, this is very difficult because it linked to the legitimacy of the authority and the absence of a serious political decision to examine this issue.

Show comprehensive and integrated management of available sources and ensure the equitable distribution of water to the population centers in the different regions and identifying and focus on the Jordan valley based in international law a Jonson agreement on 1955.

Regarding to the internal issue the recommendations law enforcement, increased water supply, water distribution inequitable manner, easy procedures for water house connections, and reasonable connection fees monitor and control, raising awareness by educating people about the bad consequences associated with this misconduct.

Improve water delivery systems meet the people water needs to assuring social justice, special treatment for the poor and needy and tightening control of thieves. Encourage wastewater treatment and reuse for agricultural and industrial purposes will provide alternative sources of water as partial solutions, go ahead with establishing the proposed institutional entities according to the water law and allow the WSRC to resume its responsibilities to water crisis management.

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Annex 1

The Water Law – 2014.

Chapter Eleven – Penalties Article (57) Application of Penalties Stipulated Under This Law

Without derogating from more severe penalties stipulated under other laws, the penalties stipulated hereunder shall be applied.

Article (58) The Penalty for infringement on a Water Resource

A prison sentence of minimum six months and maximum one year, and a fine of minimum one thousand dinars and maximum five thousand dinars, or the equivalent thereof in other circulated currency, shall be imposed on a person who commits any of the following offences:

1. Polluting any water resource or supply system, or causing such pollution through his actions without remedying it within the period set for him by the Authority.
2. Drilling groundwater wells or substitute wells, or extracting water without obtaining a license.
3. Infringement on any water resource or water and wastewater system, resulting in damage thereto or breakdown thereof.
4. The supply of water, or permitting the supply of water, to oneself or to others without a permit to do so.
5. Disposal of waste water without obtaining a license.

Article (59) Penalty for Unlawful Conduct in Water Resources

A prison sentence of minimum one month and maximum six months, and a fine of minimum one hundred dinars and maximum one thousand dinars, or the equivalent thereof in other circulated currency, shall be imposed on any person that:

1. Carries out any activities or works which are only permitted for the Authority under this law, without the prior written approval of the Authority.
2. Engages in conduct with respect to water resources, water, water related projects, or waste water, which violates the provisions of this Law.

Article (60) Fine for Violation of License Terms

The following acts are punishable by a fine of minimum ten thousand Jordanian dinars, or the equivalent in circulated currency, or by an amount equivalent to the value of the damage caused as a result of the act, whichever is the higher, :

1. Violation of the Tariff Regulation issued pursuant to this law or any of the directives and instructions issued pursuant to the regulation.;
2. The conduct, without a license, any of the works that require obtaining a license under the provisions of this law.
3. A violation of any of the terms or conditions of the license or permit issued by the Council.

Article (61) Repetition of Offences

In case of repetition of the offences mentioned above in Articles 60, 61, or 62, the stipulated penalties shall be doubled.

Article (62) Restitution and Compensation

Any person convicted of committing any of the offenses set forth in this chapter, shall be obliged to compensate the value of damages resulting from the offence, and shall remedy its causes and effects and restore the status quo ante that existed prior to the offence within the period set by the court. In case of failure to do so, the competent authorities shall order the implementation of the required works and shall charge all costs to the offender.

Annex 2

Table 12. Percent of NRW in Gaza Strip

Name of Council	Percent of NRW-T by volume %				Percent of NRW without NRW-T by volume %			Total NRW per year by volume %		
	2015	2016	2017	Average	2015	2016	2017	2015	2016	2017
Abasan al Jadida Municipality	11.5	12.3	9.3	11.0	14.0	15.0	10.4	25.5	27.3	19.7
Abasan al Kabira Municipality	4.9	14.2	16.2	11.8	22.7	11.3	12.3	27.6	25.5	28.5
Al Bureij Municipality	9.9	10.0	13.1	11.0	23.7	25.5	17.5	33.6	35.5	30.6
Al Fukhkhari Municipality	14.5	12.1	12.1	12.9	5.9	16.1	16.4	20.5	28.2	28.5
Al Maghazi Municipality	17.6	22.6	20.0	20.0	22.7	24.2	20.8	40.3	46.8	40.8
Al Mughraqa Municipality	37.4	7.0	42.5	29.0	20.3	12.4	22.6	57.7	19.4	65.0
Al Musaddar Municipality	12.6	17.2	20.1	16.6	20.8	16.4	21.0	33.5	33.6	41.1
AL Naser Municipality	6.0	7.6	3.4	5.6	12.2	18.0	16.4	18.2	25.5	19.8
Al Nuseirat Municipality	20.3	14.0	17.7	17.3	23.1	28.3	18.0	43.4	42.2	35.7
Al Qarara Municipality	12.4	9.3	12.3	11.3	15.1	18.2	22.3	27.4	27.5	34.7
Al Shuka Municipality	12.0	9.6	18.8	13.4	24.6	13.4	12.0	36.6	23.0	30.7
Al Zahraa Municipality	9.0	10.0	6.4	8.4	36.2	30.8	20.6	45.2	40.8	26.9
Al Zawaida Municipality	13.9	8.4	16.9	13.1	8.4	9.7	7.9	22.3	18.1	24.8
Bani Suheila Municipality	6.3	6.8	10.7	7.9	19.0	22.3	22.7	25.3	29.1	33.4
Beit Hanun Municipality	23.7	18.2	31.1	24.3	32.2	16.5	14.0	55.8	34.7	45.0
Beit Lahiya Municipality	40.0	10.0	9.3	19.8	3.5	31.7	29.5	43.5	41.7	38.9
Gaza Municipality	17.9	13.8	24.4	18.7	19.2	22.0	11.0	37.1	35.8	35.4
Coastal Municipalities Water Utility - Rafah	7.9	11.1	20.5	13.2	26.4	19.9	11.7	34.3	31.0	32.2
Dair al Balah Municipality	18.7	16.0	25.1	19.9	22.9	30.7	14.9	41.6	46.7	40.0
Jabalya Municipality	19.6	27.6	20.0	22.4	23.0	16.4	22.5	42.6	44.0	42.5
Khan Yunis Municipality	20.0	11.2	6.6	12.6	20.1	15.0	19.9	40.1	26.2	26.5
Khuza'a Municipality	0.0	10.1	5.1	5.1	28.9	20.5	10.7	28.9	30.6	15.8
Umm Al Naser Municipality	13.7	8.9	8.2	10.2	16.3	16.5	14.4	29.9	25.4	22.6
Wadi as Salqa Municipality	26.3	31.7	24.5	27.5	15.4	19.3	13.0	41.7	51.0	37.5
Wadi Gaza Municipality	41.3	19.2	25.0	28.5	17.0	22.1	7.2	58.3	41.4	32.1

Table 13. Percent of NRW in West Bank in 2017

Name of Council	Percent of NRW-T by volume %	Percent of NRW without NRW-T by volume %	Total NRW per year by volume %
Abu Dis Cooperative Society for Water	4.5	10.4	14.9
Al 'Auja Municipality	2.8	12.3	15.0
Al 'Eizariya Municipality	12.7	17.5	30.2
Al Bireh Municipality	----	16.4	----
Al Dhahiriya Municipality	0.4	20.8	21.2
Al Karmel Municipality	2.6	22.6	25.2
Al Shyoukh Municipality	2.4	21.0	23.4
Al Ubeidiya	0.5	16.4	16.9
Al-Ram Municipality	----	18.0	----
Anabta Municipality	2.6	22.3	24.9
Anata Municipality	37.6	12.0	49.6
Annzeh	----	20.6	----
Arraba Municipality	0.8	7.9	8.7
As Sawahira Ash Sharqiya Municipality	9.7	22.7	32.4
Attil Municipality	6.1	14.0	20.1
Azmut Village Council	13.9	29.5	43.4
Azzun Municipality	17.3	11.0	28.3
Bani Na'im Municipality	6.2	11.7	17.9
Bani Zaid Al Gharbia	0.0	14.9	14.9
Barta'a Al-sharqia	2.5	22.5	25.1
Beit Lid	11.9	19.9	31.8
Beit Ula Municipality	2.1	10.7	12.8
Beit Ummar Municipality	10.4	14.4	24.8
Beituniya Municipality	----	13.0	----
Biddya Municipality	7.5	7.2	14.7
Bir Nabala	----	16.0	----
Burqeen	2.3	16.4	23.6

Table 14. : (cont'd)

Name of Council	Percent of NRW-T by volume %	Percent of NRW without NRW-T by volume %	Total NRW per year by volume %
Deir al Ghosoon Municipality	2.6	10.4	13.0
Dura Municipality	2.9	12.3	15.2
Halhul Municipality	3.6	17.5	21.1
Hebron Municipality	20.5	16.4	36.9
Idna Municipality	4.4	20.8	25.2
Illar Municipality	1.2	22.6	23.8
Jenin Municipality	6.7	21.0	27.7
Jericho Municipality	1.4	16.4	17.7
Jerusalem Water Undertaking	2.7	18.0	20.7
Joint Service Council for Planning & Development - South East Nablus District	4.2	22.3	26.6
JSC For WW Management in Taybeh and R	----	12.0	----
Kafr Ra'I Municipality	14.1	20.6	34.7
Kharas Municipality	24.1	7.9	32.0
Kufr al-labad	9.3	22.7	32.0
Mythaloun Joint Service Council	9.0	14.0	23.0
Nablus Municipality	0.7	29.5	30.2
Northwest Jenin Joint Service Council	0.9	11.0	11.9
Northwest Jerusalem Joint Service Council	0.6	11.7	12.3
Nuba Municipality	0.4	14.9	15.3
Qabalan Municipality	3.8	22.5	26.3
Qabatiya Municipality	5.6	19.9	25.6
Qaffen Municipality	2.4	10.7	13.1
Qalqiliya Municipality	0.0	14.4	14.4
Ramallah Municipality	----	13.0	----
Ras karkar village council	0.0	7.2	7.2
Sa'ir Municipality	16.0	16.0	32.0
Salfit Municipality	0.0	16.4	16.4
Taffouh Municipality	0.4	1.8	2.1
Tarqumiya Municipality	8.7	3.0	11.7
Tubas Joint Service Council	1.2	26.5	27.8
Tulkarm Municipality	3.5	46.9	50.5
Tuqu' Municipality	10.7	23.8	34.5
Wadi Al Far'a Village Council	4.7	22.0	26.7
WSSA of Bethlehem Beit Jala and Beit Sahour	17.0	16.6	33.6
Ya'bad Municipality	0.9	19.6	20.5
Yatta Municipality	10.4	12.2	22.6
Za'tara Municipality	5.5	19.2	24.7
Zababdeh Municipality	6.4	14.7	21.0