CONAWAT Baseline Report

Providing background information on water management in Palestine as of 2019

Project deliverable of “Multi-Level Contextual Factors of Local Water Management in the West Bank and the Gaza Strip” (CONAWAT)

Funded within the Palestinian-Dutch Academic Cooperation Programme on Water (PADUCO)

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List of Abbreviations

ACF	Action Against Hunger (Action Contre la Faim)
CAMP	Coastal Aquifer Management Plan
CIA	Central Intelligence Agency
CMWU	Coastal Municipalities Water Utility
CONAWAT	Multi-Level Contextual Factors of Local Water Management in the West Bank and the Gaza Strip
CSO-G	Comparative Study of Options for an Additional Supply of Water for the Gaza Strip
EQA	Environmental Quality Authority
GDP	Gross domestic product
GETAP	Gaza Emergency Technical Assistance Program
GPCU	Gaza Program Coordination Unit
GRM	Gaza Reconstruction Mechanism
ICRC	International Committee of the Red Cross
IDF	Israel Defence Forces
JSC	Joint Service Council
Mm^3	Million cubic meter
NGEST	Northern Gaza Emergency Sewage Treatment
NGO	Non-governmental organization
NIS	New Israeli Shekel (₪)
NO_3	Nitrate
NRW	Non-revenue water
OPT	Occupied Palestinian Territories
PA	Palestinian Authority
PADUCO	Palestinian-Dutch Academic Cooperation Programme on Water
PCBS	Palestinian Central Bureau of Statistics
PLC	Palestinian Legislative Council
PLO	Palestine Liberation Organization
PSR	Palestinian Center for Policy and Survey Research
PWA	Palestinian Water Authority
RO	Reverse osmosis
STLV	Short term low volume
UNRAW	United Nations Relief and Works Agency for Palestine Refugees in the Near East
UNSCO	Office of the United Nations Special Coordinator for the Middle East Peace Process
USD	US Dollar ($)
WHO	World Health Organization

WWTP	Wastewater treatment plant

1. Introduction

This report outlines the results of a comprehensive review of background documents on water management in Palestine. It is part of the research project “Multi-Level Contextual Factors of Local Water Management in the West Bank and the Gaza Strip” (CONAWAT) that is funded within the Palestinian-Dutch Academic Cooperation on Water (PADUCO). Within this project, it provides a baseline for the subsequent analysis of the effect of contextual political factors on the implementation of small-scale, local-level water management projects, and the identification of coping mechanisms that reflect on the realities of the local context in Palestine.

The following types of documents were reviewed, focusing on material published since 2010:

- policy documents
- professional reports
- scientific studies

2. Geopolitical and socio-economic background of Palestine

2.1 Human geography

2.1.1 West Bank

The West Bank comprises an area of approximately 5,860 km², located in between Israel to the north, west and south and Jordan to the east. It is landlocked, but borders to the Jordan River to the east and includes the northwestern portion of the Dead Sea to the southeast. The West Bank is subdivided into eleven governorates that are shown in Figure 1. The terrain is mostly rugged and mountainous in the western part of the territory, and flattens towards the Jordan River Valley to the east (CIA, 2019b).

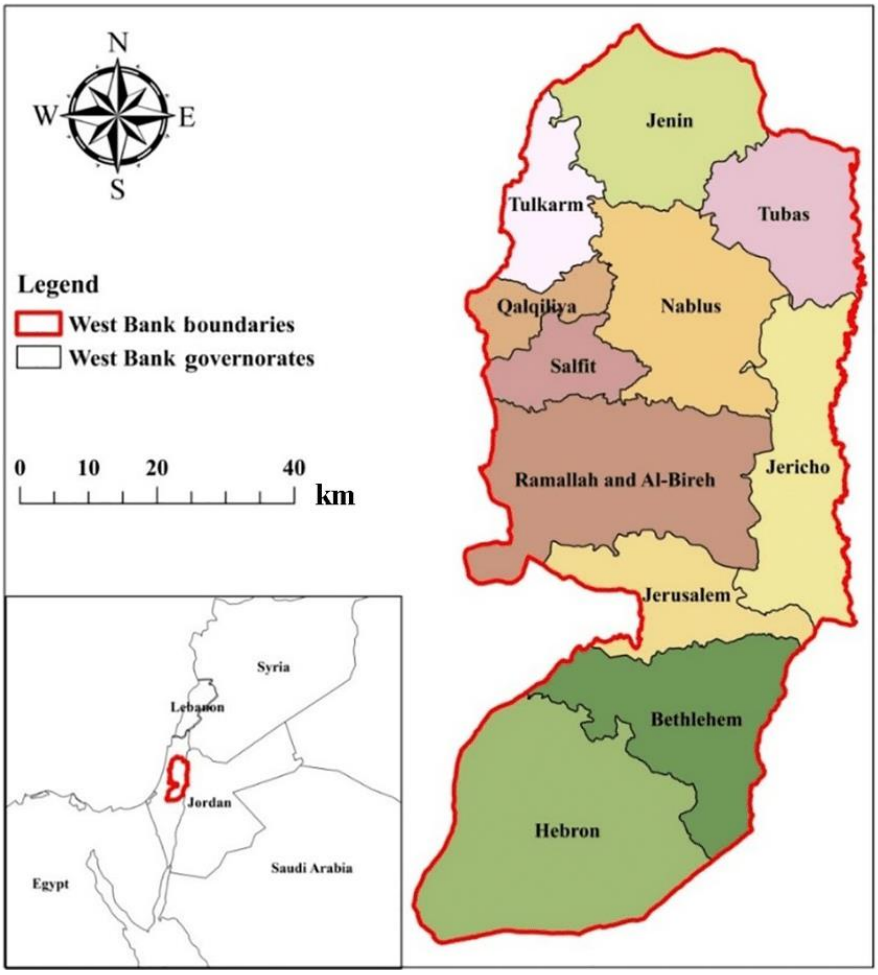

Figure 1. Location of the West Bank and its different governorates. Source: Shadeed et al. (2019).

The West Bank is inhabited by approximately 3.3 million people, of which 2.75 million are Palestinians, 391,000 are Israelis living in settlements across the West Bank and 201,000 are Israelis living in East Jerusalem (CIA, 2019b). Table 1 below shows the distribution of Palestinians over the eleven governorates of the West Bank in 2016 as estimated by the Palestinian Central Bureau of Statistics (PCBS). The PCBS distinguishes three forms of communities: 1) urban communities or cities, 2) rural communities or semi-urbanized areas, 3) refugee camps.

Table 1. Population estimates for the West Bank by governorate in 2016, not including Israeli settlements. Data source: PCBS (2016b).

Governorate	Total population	Urban population	Rural population	Population in refugee camps
Jenin	318,958	187,905	118,162	12,890
Tubas	66,854	44,555	14,701	7,598
Tulkarm	185,314	124,551	40,682	20,081
Nablus	389,328	214,903	137,009	37,416
Qalqilya	113,574	69,198	44,377	0
Salfit	72,279	26,225	46,054	0
Ramallah & Al Bireh	357,968	185,701	151,471	20,796
Jericho & Al Aghwar	53,562	28,434	12,046	13,082

Jerusalem (incl. East Jerusalem)	426,533	368,631	47,579	10,324
Bethlehem	221,802	155,607	49,965	16,230
Hebron	729,193	622,220	87,844	19,129

Table 2 shows the age structure of the population in the West Bank. More than half of the population (ca. 57%) is below 25 years old, while people aged 55 and older account for less than 10%. The gender ratio between male and female remains relatively constant around 50:50 for all age groups apart from the elderly population which is predominantly female (CIA, 2019b).

Table 2. Age structure of population in the West Bank. Data source: CIA (2019b).

Age	**Percentage of total population**	**Within age group…**	
		Percentage female	**Percentage male**
0-14 years	36.09%	48.7%	51.3%
15-24 years	21.17%	48.9%	51.1%
25-54 years	34.48%	49.3%	50.7%
55-64 years	4.74%	48.5%	51.5%
65 years and over	3.52%	54.7%	45.3%

2.1.2 Gaza

The Gaza Strip is a coastal zone that lies at the eastern extreme of the Mediterranean Sea between 31.27° N and 31.75° N latitude and 34.01° E and 34.42° E longitudes, with an area of 365 km^2. It borders Israel to the east and north along a 51 km long border, Egypt to the southwest along an 11 km long border and the Mediterranean to the west along about 40 km long coastline (CIA, 2019a). It is composed of five governorates: North Gaza, Gaza, Deir al Balah (The Middle Area), Khanyounis, and Rafah (Figure 2).

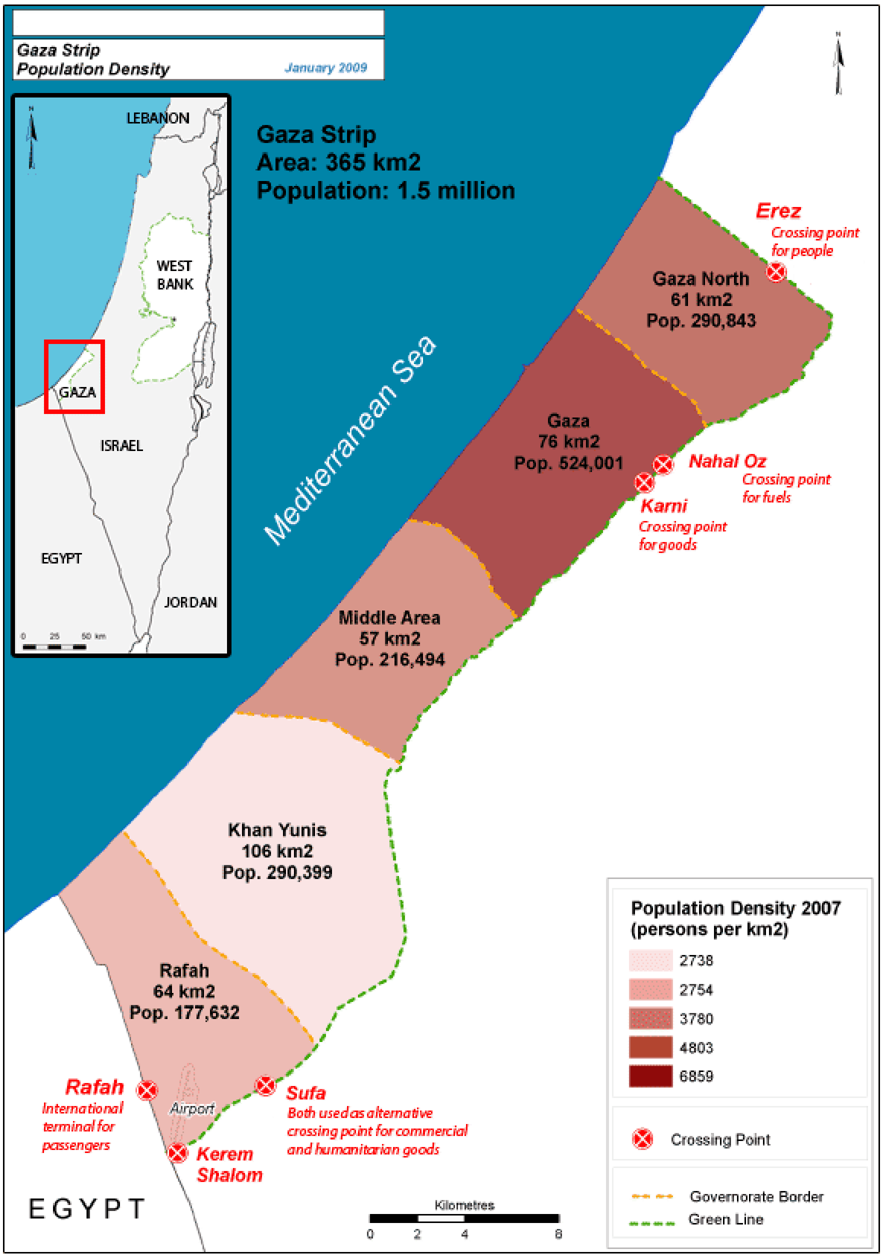

Figure 2. Location and population density (2007) of the five governorates in the Gaza Strip. Source: Alaeddinne (2012).

With a population density of 5,204 capita/km^2 (PCBS, 2018a), the Gaza Strip is considered one of the most densely populated areas in the world. The total population in the Gaza Strip reached 2,015,644 inhabitants by the end of 2016, among which 50.66% men/boys and 49.34% women/girls. The highest population is found in the Gaza Governorate (Ministry of Interior, 2016).

Table 3 shows the population per type of community in the different governorates for the year of 2016 as estimated by the PCBS. Gaza City has the highest population among all urban communities, while the Khanyounis Governorate has the highest amount of people living in rural communities and the Middle Area Governorate is characterized by the highest population in refugee camps. All types of communities in the Gaza Strip are highly populated.

Table 3. Population estimates for the Gaza Strip by governorate in 2016. Data source: PCBS (2016b).

Governorate	Total population	Urban population	Rural population	Population in refugee camps
North	377,126	314,686	3,923	58,517
Gaza	645,204	583,870	16,301	45,033
Middle Area	273,381	171,649	2,491	99,241
Khanyounis	351,934	283,207	19,758	48,969
Rafah	233,489	178,453	8,495	46,541

According to PCBS (2018a), the average annual population growth was 3.3% in mid-2016. The growth rate is expected to slow down slightly as a result of changes in education and family structure, as has been observed in other Mediterranean countries.

The age structure of the population in the Gaza Strip is summarized in Table 4. Individuals aged 0-14 have the highest percentage among all age groups, accounting for almost half of the total population in the Gaza Strip. The elderly population aged 65 years and over only constitutes 2.54% of the total population. Similarly to the West Bank, the gender ratio between male and female remains relatively constant around 50:50 for all age groups apart from the elderly population (CIA, 2019a).

Table 4. Age structure of population in the Gaza Strip. Data source: CIA (2019a).

Age	Percentage of total population	Within age group…	
		Percentage female	Percentage male
0-14 years	44.78%	47.5%	52.5%
15-24 years	21.25%	49.5%	50.5%
25-54 years	28.02%	52.0%	48.0%
55-64 years	3.4%	45.0%	55.0%
65 years and over	2.54%	64.5%	35.5%

2.2 Socio-economic background

2.2.1 Economy

The gross domestic product (GDP) of the whole of Palestine lied at ca. 13.4 billion USD in 2016, out of which 10.0 billion USD originated from the West Bank and 3.4 billion USD from the Gaza Strip. This translates to a GDP per capita of USD 2957.2 for the whole of Palestine, USD 3727.2 for the West Bank and USD 1851.4 for the Gaza Strip. As shown in Figure 3, GDP has remained relatively stagnant across Palestine from 1994 (the first year of recordkeeping by the PCBS) until around 2005, after which a slow increase in GDP is visible. GDP has historically been higher in the West Bank than in the Gaza Strip. The same trend is visible for GDP per capita (Figure 4), which remained relatively homogeneous across both Palestinian territories until 2005, when GDP per capita in the West Bank started to increase while GDP per capita in the Gaza Strip remained mostly stagnant.

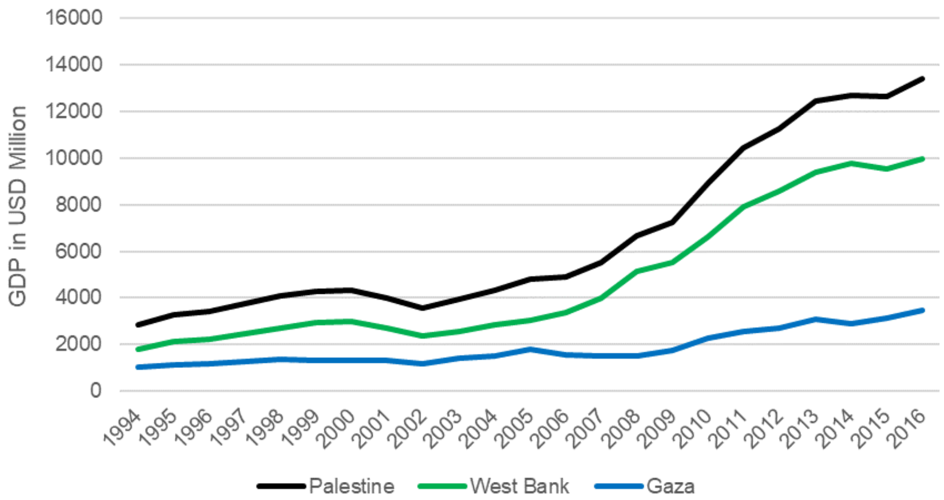

Figure 3. GDP in USD Million, for the whole of Palestine (black), the West Bank (green) and the Gaza Strip (blue). Data source: PCBS (2019).

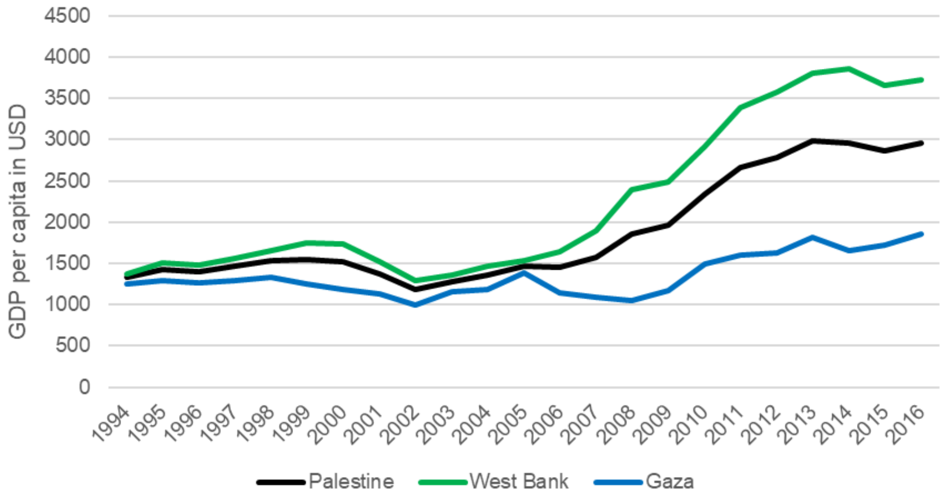

Figure 4. GDP per capita in USD, for the whole of Palestine (black), the West Bank (green) and the Gaza Strip (blue). Data source: PCBS (2019).

Compared to other countries in the region, Palestine has a low GDP. Its GDP per capita is comparable to other economically weak (e.g. Jordan) or very populous countries (e.g. Egypt; Figure 5).

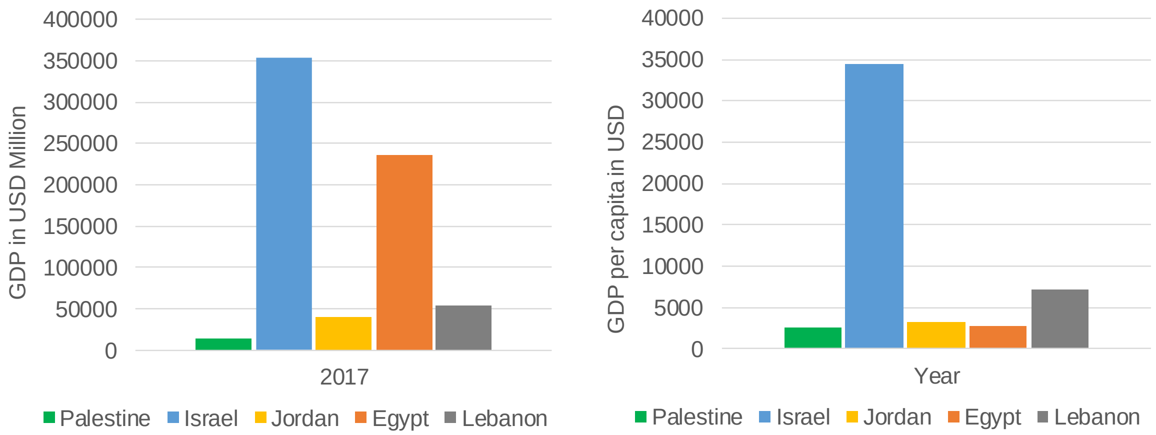

Figure 5. Palestine's GDP (left) and GDP per capita (right) in 2017 compared to Israel, Jordan, Egypt and Lebanon. Data source: World Bank (2019).

Figure 6 shows an overview of the contribution of different economic activities to the Palestinian GDP, based on the classification of economic activities by the PCBS.

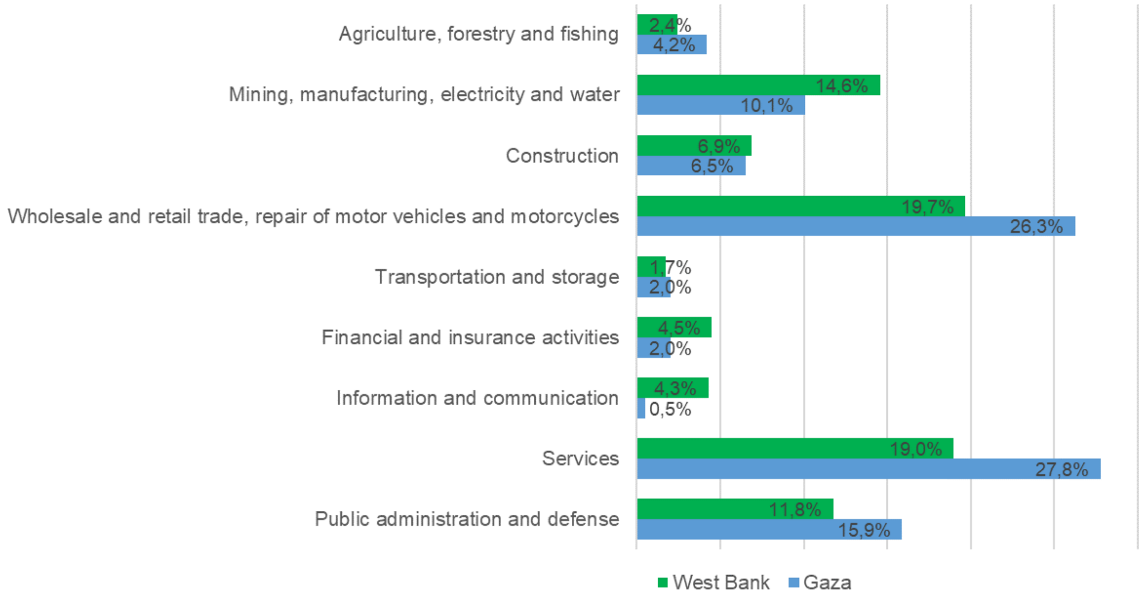

Figure 6. Contribution of different economic activities to the GDP of West bank (green) and Gaza (blue) in the fall quarter 2018. Source: UNSCO (2018).

International assistance has historically played an important role for the Palestinian economy. While the contribution of international assistance to Palestine's GDP has dropped below 20% over the past few years, it had reached close to 40% in 2009 (Figure 7).

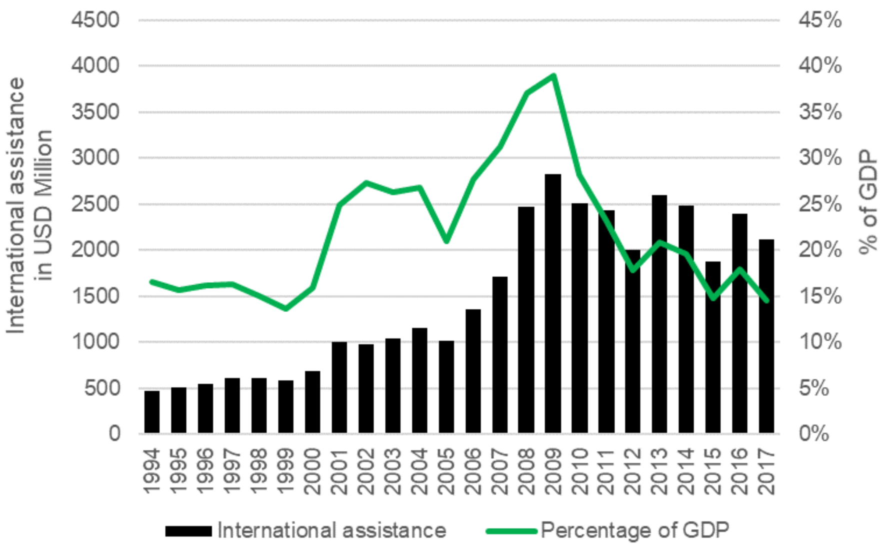

Figure 7. International assistance received by the Palestinian Authority expressed as total amount in USD million (black bars) and as percentage of GDP (green line). Source: World Bank (2019).

2.2.2 Employment

A summary of the PCBS's labour survey of 2017 regarding the labour force participation rate among adults aged 15 years and older and the unemployment rate among the labour force is presented in Table 5.

Table 5. Labour force participation rate and unemployment rate by gender group across the Palestinian territories. Data source: PCBS (2018b).

	Palestine		West Bank		Gaza	
	Labour force[1]	Unemploy-ment[2]	Labour force[1]	Unemploy-ment[2]	Labour force[1]	Unemploy-ment[2]
Both sexes	45.7%	28.4%	45.8%	18.7%	45.5%	44.4%
Men	71.6%	23.2%	73.2%	15.6%	68.9%	36.6%
Women	19.2%	48.2%	17.5%	32.1%	21.9%	69.1%

[1] Labour force participation rate in % of total population aged 15 or over
[2] Unemployment rate in % of labour force

Labour force participation rates are fairly similar in West Bank and Gaza Strip, although UNSCO (2018) highlights a "significantly higher labour force participation of women in Gaza" (25.8% in the Gaza Strip vs 17.6% in the West Bank for Q3/2018).

Unemployment is significantly higher in the Gaza Strip. In both territories, unemployment is generally highest among young people, especially young women.

2.3 Israeli-Palestinian conflict

2.3.1 Overview of the conflict

Control over both West Bank and Gaza Strip has been transferred numerous times over the past century. With the collapse of the Ottoman Empire after the First World War, both territories became part of the British mandate over Palestine. When the British withdrew from the region after the Second World War in 1948, Jordan took control over the West Bank, Egypt over the Gaza Strip (Wolf and Ross, 1992). Less than 20 years later, however, Israel captured both the West Bank and the Gaza Strip, as well as the Egyptian Sinai Peninsula and the Golan Heights previously held by Syria, during the Six-Day War in 1967, in which it established itself as a hegemonic power in the region and took control of most of the water resources in the Jordan basin (Feitelson, 2000).

Following the Six-Day War, the occupied West Bank and Gaza Strip were put under the authority of the Israeli Military Government and the construction of Israeli settlements in both territories begun (Weinthal and Marei, 2002). Growing discontent within the Palestinian society, as a result of increasing unemployment and anger at the Israeli expansion politics and humiliating treatment of local communities, eventually led to the first extensive uprising, i.e. *intifada*, of the Palestinian civil society in the late 1980s. The First Intifada was mostly characterised by protests and strikes throughout Palestine as well as mass riots that included throwing stones and Molotov cocktails, and aimed for the Israeli retreat from the Palestinian territories and the reinstatement of the borders from 1967. Although several years of violence from both sides prevailed in the Occupied Palestinian Territories (OPT), they eventually gave way to the belief that a political, not a military solution had to be found (Grinberg, 2013).

The year 1992 saw the onset of the Oslo peace process with negotiations between the Israeli government and the Palestine Liberation Organization (PLO), at this point based in Tunisia, as the representative of the Palestinian people. The Declaration of Principles on Interim Self-Government (also known as 'Oslo I'), signed in 1993, focused on economic and technological development cooperation between the parties (Aggestam and Sundell-Eklund, 2014). It also transferred the governmental authority over most of the Gaza Strip to the Palestinians, and the new Palestinian Authority was first established in Gaza City. Oslo I additionally granted the Palestinian authorities the establishment of a Palestinian Water Authority (PWA), but did not include details on its function or authority (Weinthal and Marei, 2002).

The Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip ('Oslo II'), signed by the Israeli government and the PLO in September 1995, marked a key point in the Israeli-Palestinian conflict. The Oslo II Accords addressed such central issues as borders and Palestinian self-administration, however, they were intended to cover a period of five years only, during which further negotiations were intended to take place. The agreement thus included many interim solutions and deferred the final decisions on many important issues, including the allocation and joint management of the water resources, to the permanent agreement that was supposed to follow up (Shamir et al., 2009; Weinthal and Marei, 2002).

However, when the interim period of five years ended, no successful permanent status negotiations had taken place. Shortly after the unsuccessful Camp David summit in 2000, one of the most prominent attempts to revive the peace process, the violent suppression of

Palestinian demonstrations during a visit of leading Israeli politician Ariel Sharon in September 2000 sparked an uprising that ultimately led to the Second Intifada which brought violent conflict to both the OPT and Israel for the next years (Hammami and Tamari, 2001). The onset of the Second Intifada is also considered the final collapse of the Oslo process (Selby, 2007).

Israel withdrew from the Gaza Strip in 2005; however, the international community largely considers the occupation as ongoing as Israel retains control of airspace and sea space and over the entry and exit of people and goods along the Gaza-Israel border (Human Rights Watch, 2006). There have been several episodes of violence between Palestinians and Israeli military since the Israeli withdrawal, particularly along the border fence. These are detailed in 2.3.3. Clashes between Palestinians and Israeli military and settlers in the West Bank have persisted as well, with a regular escalation in intensity in reaction to political incidents such as the move of the US embassy to Jerusalem in May 2018 (Holmes and Balousha, 2018).

2.3.2 Impacts on the West Bank

The Oslo II Accords in 1995 included the division of the West Bank into three administrative areas that are, in the absence of final status negotiations, still effective: *Area A* (ca. 18 % of the total West Bank area) covers all Palestinian cities in the West Bank and is mainly governed by the Palestinian Authority (PA) that had been established. *Area B* (ca. 22 %) contains mainly rural areas and is jointly administrated by Israelis and Palestinians. While the former are in control of all security matters, the PA is in charge of the civil administration. *Area C* (ca. 60 %) is completely controlled by Israeli authorities and used for the construction of Israeli settlements, with the PA only in charge of providing basic services to the Palestinian communities in Area C (B'Tselem, 2017a).

In 2002, during the Second Intifada, Israel began the construction of a physical barrier between Israel and the West Bank with the aim to protect Israel from Palestinian terrorists. This West Bank Barrier follows the border as agreed on in 1949 in some parts, but also deviates significantly in many areas (B'Tselem, 2017c). The area between border and barrier, also called ‘Seam Zone’, contains a large share of the Palestinian agriculture and water infrastructure. Palestinians living within the Seam Zone were largely required to move east of the barrier by the Israeli administration (Arsenault and Green, 2007). Large parts of this barrier take the form of a concrete wall, while other segments remain wire fences for the time being. Next to the barrier along the border between West Bank and Israel, additional segments have been constructed near some Israeli settlements, with plans for further expansion.

Figure 8 shows the area division according to Oslo II as well as the location of different parts of the West Bank barrier constructed by Israel.

Figure 8. Division of the West Bank into Areas A, B and C, and location of the West Bank barrier. Source: Donnison (2012).

Although all major Palestinian cities are located in Area A and Area B, a large part of Palestinians lives in Area C under Israeli control, as shown in Figure 9. Palestinian infrastructure development in Area C is severely obstructed. Approximately 60% of Area C are designated by the Israeli Civil Administration[1] as Israeli state land, closed military areas or natural reserves, blocking Palestinian development completely. In the remaining 40%, all Palestinian infrastructure projects require a permit by the Civil Administration, for which they generally need to adhere to the Israeli development plan for the respective area. The demolition of Palestinian structures constructed without an Israeli permit by the Israeli military is a common occurence (B'Tselem, 2017a).

[1] The Israeli Civil Administration is part of the Israeli military. It is concerned with civil matters in Area C, but is not in itself a civilian organization.

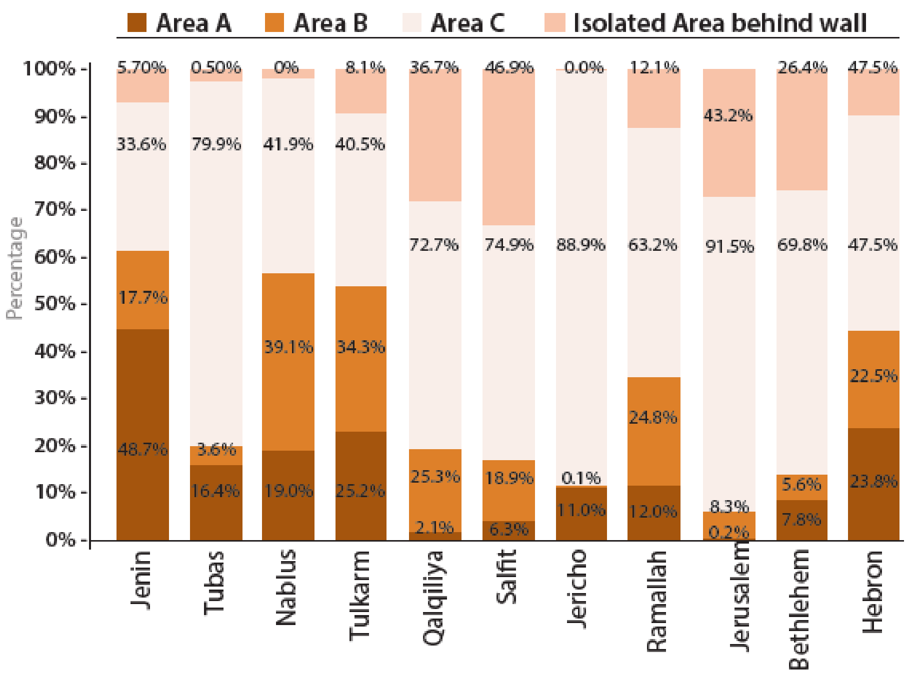

Figure 9. Population distribution over Areas A, B and C in 2013. Source: Ministry of Public Works and Housing (2014).

2.3.3 Impacts on the Gaza Strip

Since the Israeli withdrawal from the Gaza Strip in 2005, the territory has been the site of three major military campaigns by the Israel Defence Forces (IDF; Table 6) and continuous clashes between Hamas and Israeli troops. Palestinian protests along the border fence between Gaza Strip and Israel have repeatedly been met with force by the IDF over the past years (Holmes and Holder, 2019; OCHA-OPT, 2018).

Table 6. Major Israeli military campaigns in the Gaza Strip. Data source: B'Tselem (2017b).

Operation	**Duration**	**Palestinian casualties***	**Israeli casualties***
Cast Lead	27 Dec 2008 – 18 Jan 2009	1,391 (759)	13 (3)
Pillar of Defense	14 Nov 2012 – 22 Nov 2012	167 (87)	6 (4)
Protective Edge	8 Jul 2014 – 26 Aug 2014	2,202 (1,391)	73 (6)

* Total number of casualties. Estimate of civilian casualties is provided in brackets

The border between Gaza Strip and Israel, as well as between Gaza Strip and Egypt, has been fortified since 1994, with a limited number of border crossings, of which the main ones are Erez crossing at the northern border between Gaza Strip and Israel and Rafah Crossing at the southern border between Gaza Strip and Egypt. The movement of people and goods through these border crossings is heavily restricted. In 2008, the Israeli government introduced a list of ‘dual use’ items[2] that could be used for both civilian and military uses, with heavy restrictions applied to their import to Gaza and, for some, to the West Bank. The list has been extended several times since then.

After the Gaza war in 2014 (Operation Protective Edge), the Gaza Reconstruction Mechanism (GRM) was established in collaboration with the United Nations to facilitate the import of ‘dual use’ construction materials for international humanitarian projects. While the GRM made materials available for a number of projects, Oxfam (2017, p. 12) also critized that the GRM was “falling short” of providing an effective solution to the import restrictions and reflected the overall power dynamics between Israel and Gaza Strip.

2.4 Political instability within Palestine

2.4.1 Political divide between West Bank and Gaza

Palestinian politics are highly affected by the conflict between the two dominant parties Fatah and Hamas and their “irreconcilable ideological and policy differences” (Cavatorta and Elgie, 2010, p. 24) dating back to the First Intifada in the 1980s. Differences between the parties relate especially to possible solutions to the conflict with Israel where Fatah takes a more moderate position, recognising Israel’s right of existence and striving for a solution in negotiations. More militant Hamas campaigns instead aim both politically and militarily for the withdrawal of Israel from Palestinian territories at the least, and the destruction of the Israeli state at the most (Sirriyeh, 2011). Subsequently, while the Fatah-led PLO was involved in the Oslo peace process and provided the staff for institutions such as the Palestinian Authority (PA), Hamas boycotted the negotiations with Israel (Cavatorta and Elgie, 2010).

After the Oslo Agreement, Fatah kept its members in all political offices, including President Mahmoud Abbas, who has been in power since 2005. At the same time, however, Hamas gained popularity amongst the Palestinians thanks to its open resistance against the Israeli occupation and the support of social welfare and education projects within the oPt, leading to a landslide victory for Hamas in the Palestinian Legislative Council (PLC) elections in 2006. Although Abbas stayed in office as his presidential term was not over yet, Hamas now had the majority in the legislative (Sirriyeh, 2011). Due to Hamas’ designation as a terrorist organisation by numerous countries, international pressure on Fatah not to cooperate with the party was high. In the wake of the parliamentary elections, many western countries withdrew their financial support to the Palestinian Authority, fearing the money would end up in the hands of Hamas (Weisman and Smith, 2006).

This international boycott, combined with failed attempts to form an effective unity government of Hamas and Fatah representatives, presented Hamas with numerous obstacles to governing, including the inability to pay salaries to civil servants. After Hamas forcibly took control of the Gaza strip in June 2007, Abbas dismissed Hamas prime minister Ismail Haniyeh and the unity government that had been in office since March 2007 (Cavatorta and Elgie, 2010; Milton-Edwards, 2007). In a controversial move, Abbas then appointed per presidential decree a new government comprised of Fatah officials, thereby

[2] The full list is available at http://www.cogat.mod.gov.il/en/services/Documents/List%20of%20Dual%20Use%20Items%20Requiring%20a%20Transfer%20License.pdf

circumvented the authority of the PLC to elect a government (Entous, 2007). This further deepened the split between both parties as well as between West Bank and Gaza Strip and left the PLC dysfunctional as Hamas members did not attend the parliamentary sessions and instead convened in Gaza in boycott.

Over the past decade, there have been several attempts to reconcile Fatah and Hamas, mediated by Egypt and other third parties, and to form a new unity government. None of them proved successful.

2.4.2 Public trust and government legitimacy

A public opinion poll[3] by the Palestinian Center for Policy and Survey Research (PSR) in September 2018 found that 62% of Palestinians want President Abbas to resign (52% in the West Bank, 78% in Gaza) and that 61% are dissatisfied with his performance as president. Half of the surveyed people view the PA as a burden on the Palestinian people, 44% view it as an asset (PSR, 2018). Dissatisfaction and frustration with the Fatah government stems from factors such as the weak economy and related high unemployment, especially amongst the youth, an increasingly authoritarian rule with lacking accountability mechanisms, and concerns about corruption within the PA. The lack of process in the negotiations with Israel, and thus the persisting occupation, further adds to the anger and leaves many Palestinians without a perspective for their personal or national future (Elgindy, 2016).

Next to the lack of public trust, the legitimacy of the Palestinian government is restricted by the lack of parliamentary elections since 2006. With the split between West Bank and Gaza leaving the Palestinian parliament dysfunctional, there is currently no legislative power, making it impossible to pass new laws. Instead, Abbas can issue presidential decrees, thereby effectively introducing new laws, without being accountable to an elected parliament (Elgindy, 2016).

3. Water resources in Palestine

There are three types of water resources that are relevant in the region:

- Surface water, including the Jordan River and runoff from wadis
- Groundwater, including the different aquifers underlying the West Bank and Gaza (Figure 10)
- Non-conventional water resources, including water won through desalination and wastewater treatment, rainwater harvesting and water purchases

[3] Survey included 1270 adults from 127 randomly selected Palestinian communities; margin of error +/- 3%

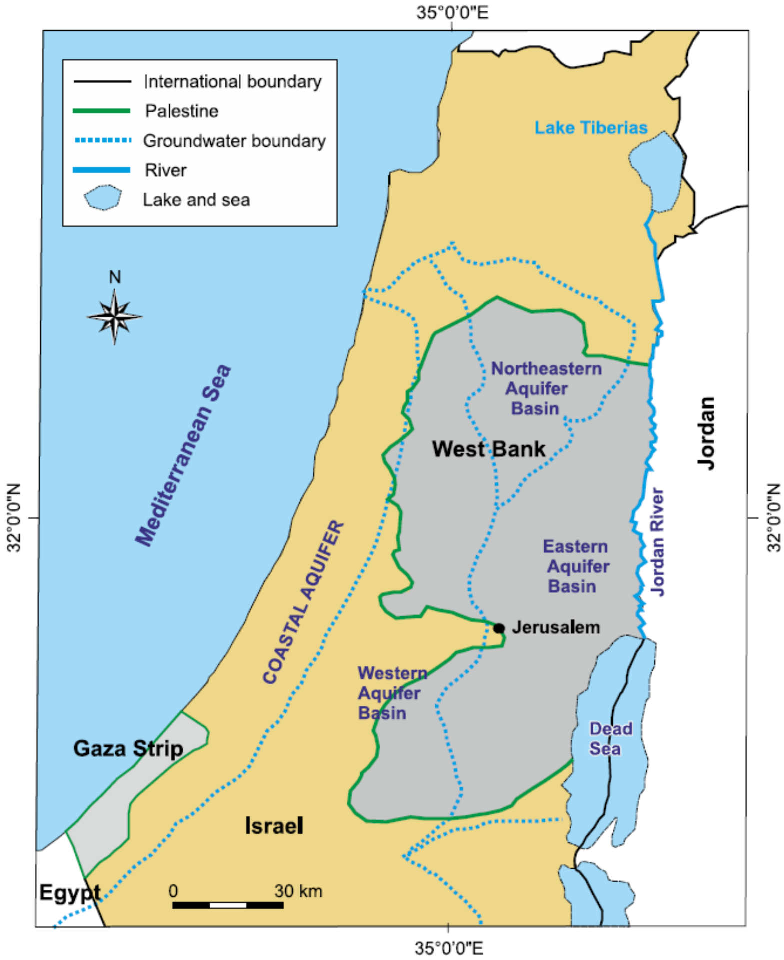

Figure 10. Mountain and Coastal Aquifer. Source: Jebreen et al. (2018).

3.1 Water resources of the West Bank

3.1.1 Geology

The region's distinct geology predominantly consists of limestone, intersected by layers of less permeable and soluble material (Hughes et al., 2008). These limestone layers are conducive to extensive karst systems across the West Bank (Jebreen et al., 2018; Figure 11).

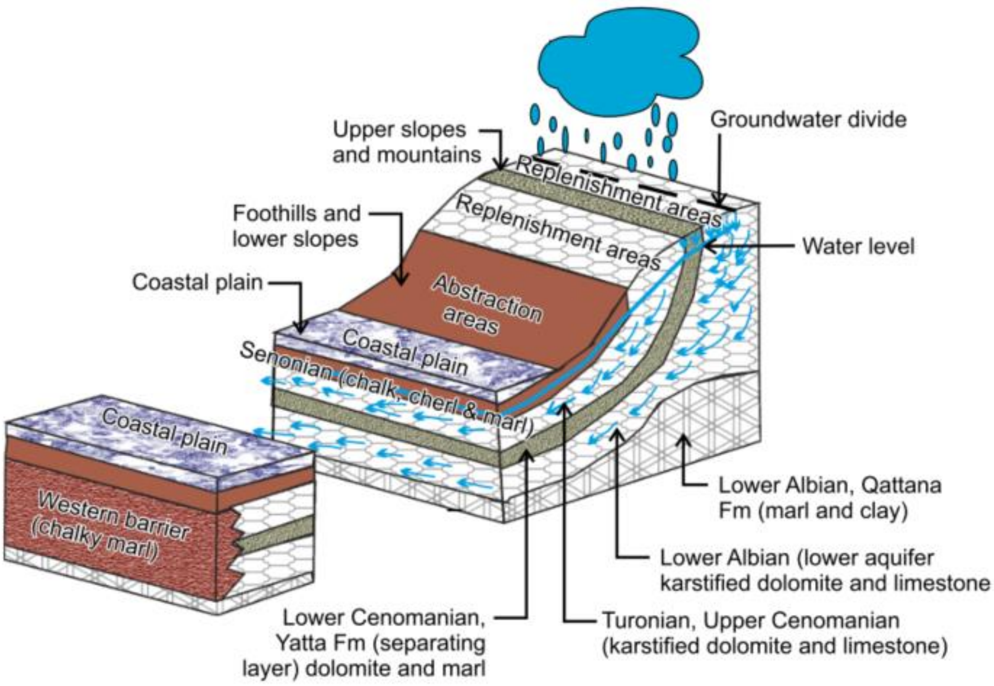

Figure 11. Hydrogeological setting of the groundwater aquifers in the West Bank. Source: Jebreen et al. (2018).

3.1.2 Surface water resources

The West Bank borders the southernmost section of the Jordan River, covering approximately two thirds of what is often referred to as the Lower Jordan River[4]. With four other riparians to the Jordan River[5] located upstream of the West Bank, the quantity and quality of the river runoff that reaches the West Bank is limited. Historically, almost 1,300 Mm^3 of water were discharged from the Jordan River into the Dead Sea, of which around 600 Mm^3 originated from Lake Tiberias and the upstream branches of the Jordan River and 465 Mm^3 from the Yarmouk River, the main tributary of the Jordan River that marks the border between Syria and Jordan (Venot et al., 2008, Courcier et al., 2005). These quantities have significantly decreased with the construction of extensive water diversion schemes constructed by Israel, Syria and Jordan, lowering Jordan River flow into the Dead See to 275 Mm^3 in the early 2000s (Courcier et al., 2005).

The decrease in flow volume, alongside the discharge of insufficiently treated wastewater and other polluted water, have led to a deterioration of the Jordan River's water quality over the past decades (Hillel et al., 2015).

In addition to the Jordan River, there are 33 wadi catchments in the West Bank. Wadis are ephemeral riverbeds that are dry most of the year and only carry water after heavy precipitation. The West Bank wadis total at an annual runoff of around 165 Mm^3, most of which is discharged through the western wadis into Israel in the direction of the Mediterranean Sea (PWA, 2013).

[4] The section of the Jordan River between Lake Tiberias and the Dead Sea.
[5] Syria, Lebanon, Jordan and Israel

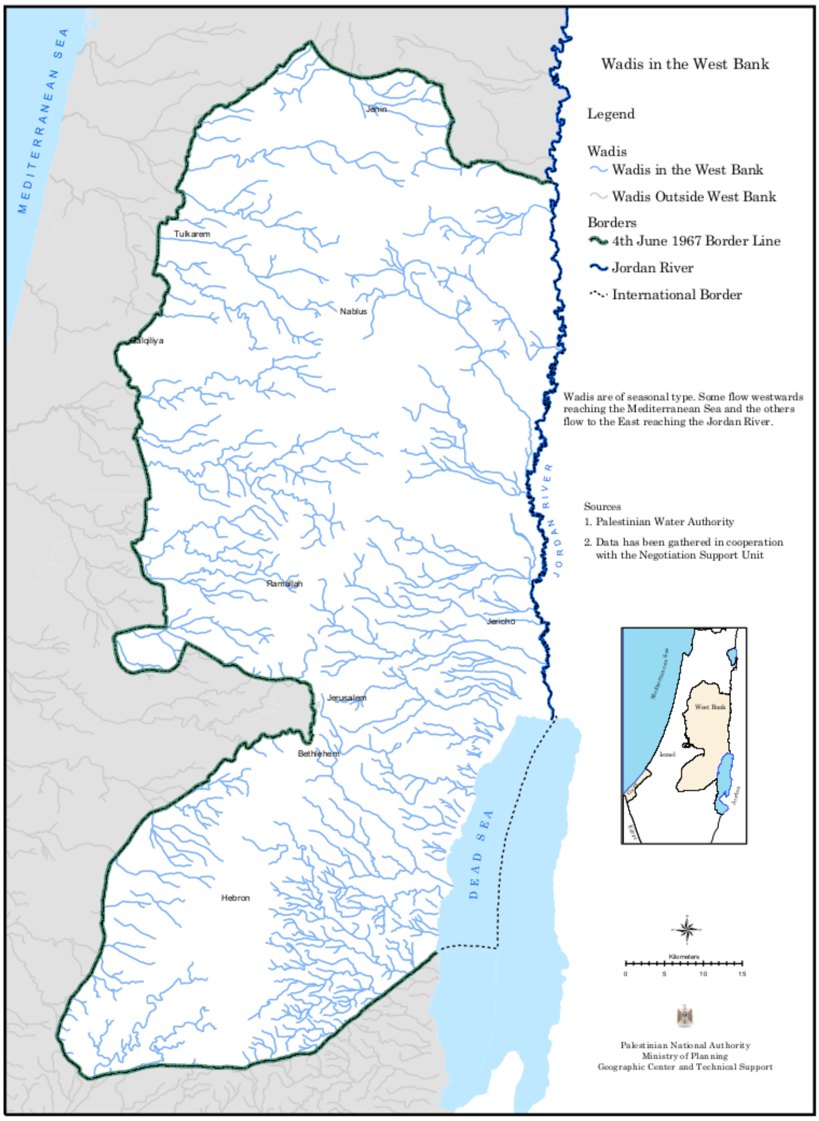

Figure 12. Wadis in the West Bank. Source: Ministry of Planning (n.d.).

3.1.3 Groundwater resources

The Mountain Aquifer, the groundwater reservoir that underlies the West Bank and part of Israel, is the main water resource in the West Bank (Mizyed, 2009). It is comprised of three smaller basins that are often addressed separately: the Eastern basin located almost entirely underneath the West Bank, and the Northern and the Wester basin that cross the border between West Bank and Israel. As all three basins have their main recharge area in the mountainous areas of the West Bank, the sustainable yield of the Mountain Aquifer highly depends on the annual rainfall received in the West Bank. Recharge rates for all three basins are given in Table 7 (Froukh, 2003). Recharge is usually concentrated on the winter months December, January and February when precipitation is highest and thus exceeds evapotranspiration losses from ground and vegetation (Mizyed, 2009).

Table 7. Annual recharge of the Mountain Aquifer's basins. Source: Froukh (2003).

Basin	**Recharge inside West Bank Mm³/yr**	**Recharge outside West Bank Mm³/yr**

Eastern	172	0
Northeastern	123	35
Western	329	37
Total	624	72

The distinct geology of the region, comprising mostly of limestone, but intersected by less permeable and soluble material, leads to an additional distinction into two separated layers or zones, the Upper Aquifer and the Lower Aquifer, schematised for the western side of the West Bank in Figure 13 (Hughes et al., 2008). With regards to the Western basin, MacDonald et al. (2009) note that Upper Aquifer is more prone to contamination due to its location close to the surface in areas that are more densely inhabited than the mountainous recharge area. They also calculate that the potential to develop new water resources is greater and economically more viable for the Lower Aquifer.

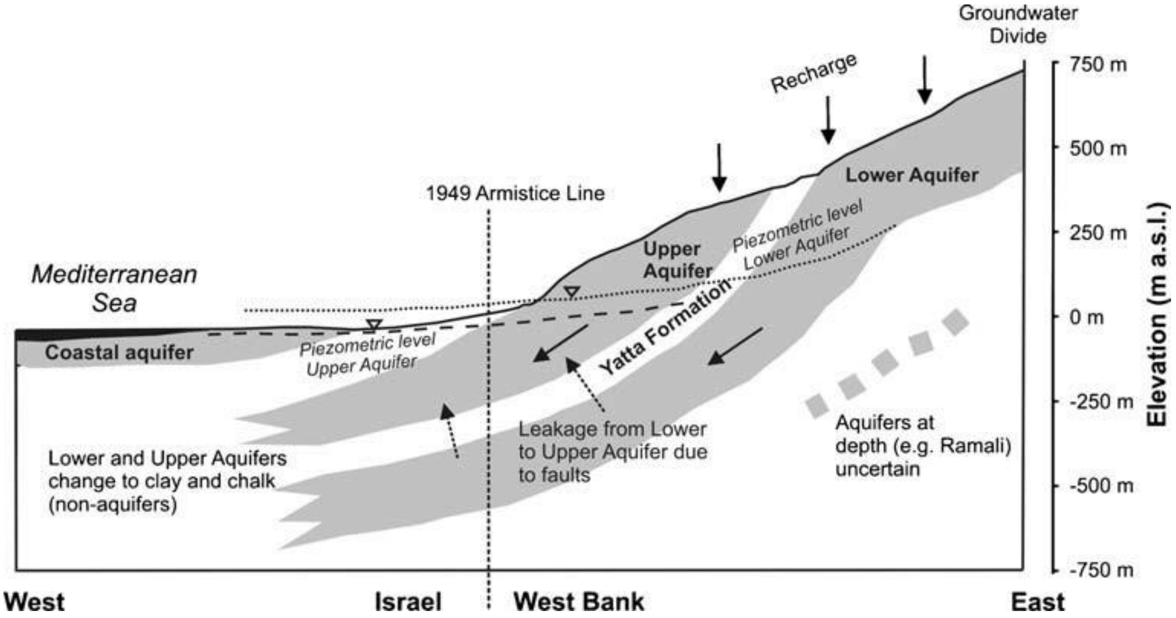

Figure 13. Schematic cross section of the Western Aquifer. Source: MacDonald et al. (2009).

3.2 Water resources in Gaza

The following sections provide information on water resources in Gaza in terms of location and size, geology, climate, population and demography, surface water, and groundwater.

3.2.1 Geography

3.2.1.1 Geology

The geology of the Gaza Strip is composed primarily of calcareous sandstone from the Pliocene Pleistocene age, unconsolidated sands, and layers of clay. Areas of chalk from the Eocene period, and Kurkar limestone and the Saqiye Group from the Miocene-Pliocene period are found about 15-20 km inland. This formation consists of shallow marine clays, shales and marls, reaching a depth of about 120 m, from the ground surface, at the shoreline and fanning out at the eastern boundary of the strip (Greitzer and Dan, 1967). A typical geological section of the Gaza Strip is shown in Figure 14.

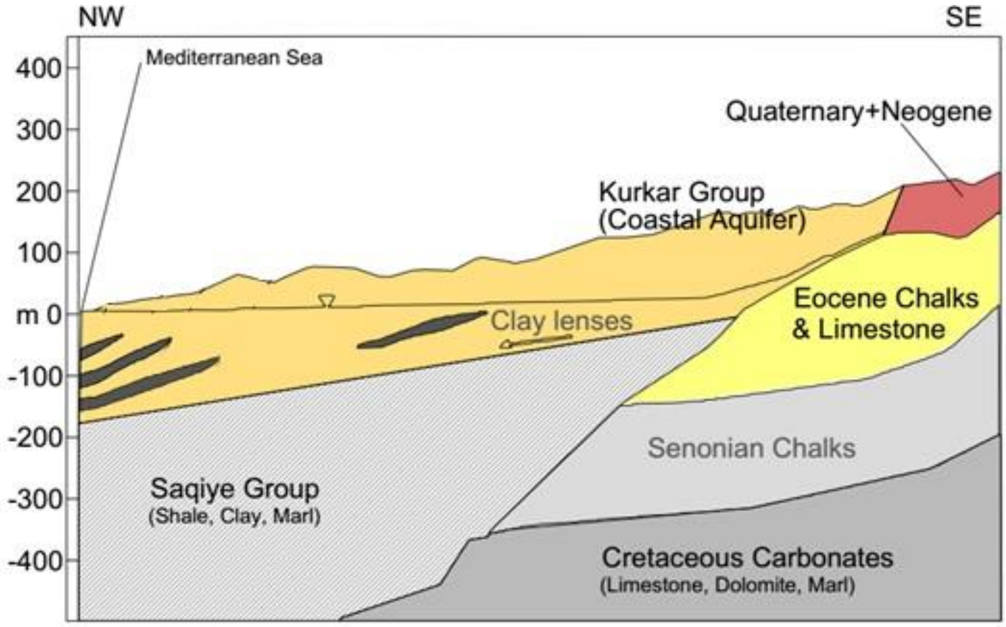

Figure 14. Typical geological cross-section of the Gaza Strip. Source: Greitzer and Dan (1967).

3.2.1.2 Climate

The climate of the Gaza Strip is influenced by the typical climate of the Mediterranean region, with short, mild winters with rainy periods and a hot summer. The Gaza Strip forms a transitional zone between the semi-arid Sinai desert to the south, and the semi-humid coastal area in the north. In general, two well defined seasons are found in the Gaza Strip: the dry season from May to September, and the wet season starting in October extending into April.

Temperature

The average daily temperature over a period of ten years ranges from 13.8 °C in winter to 26.5 °C in summer. The average minimum temperature over the same period ranges from 7.6 °C in winter to 21.2 °C in summer, the average maximum temperature from 19.7 °C in winter to 31.9 °C in summer (EMCC, 2014). Climate change predictions show that the likelihood of heat waves will increase and sea temperatures could increase. The predictions also suggest a potential increase in air temperature of approximately 3.5 to 5 °C by 2100, compared to 1961-1990; with stronger temperature increase in summer than winter (UNDP, 2010).

Precipitation

Over the Gaza Strip, rainfall mainly occurs in the winter months, with peak months for rainfall being December and January. Rain tends to fall in intense storms. The historical average annual precipitation is 360 mm/y, decreasing notably from north to south. Figure 15 shows average rainfall for several years over the course of the past decade as measured at the twelve meteorological stations distributed over the Gaza Strip (Ministry of Agriculture, 2017).

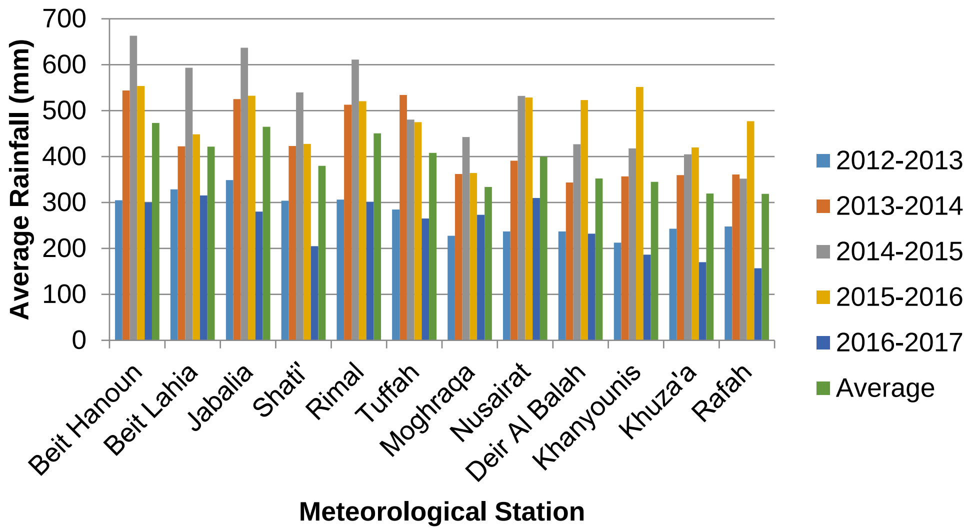

Figure 15. Spatial distribution of annual rainfall in the Gaza Strip. Stations are ordered from north (left) to south (right). Data source: Ministry of Agriculture (2017).

Climate change is expected to cause an overall decrease in mean annual precipitation. At the same time, seasonal variation is expected to increase, leading to an increase in dry periods and a higher frequency and intensity of extreme rainfall events (UNDP, 2010).

Humidity

The proximity of the Gaza Strip to the sea increases humidity; the annual average relative humidity is about 72%. The daily relative humidity fluctuates between 65% during the day and 85% at night in summer, and between 60% and 80% in winter (Ministry of Agriculture, 2017).

Wind

In the eastern Mediterranean Sea, the wind patterns generally change with the season. Winds in summer are predominantly onshore from the Mediterranean, i.e. from the west and northwest, as the result of a low atmospheric pressure region north-east of Cyprus and increasing pressure to the west. Land and sea breezes occur, and in late spring the hot dry (khamasin) wind blows from the desert in the south. Winds often change from land to sea (easterly) during early morning and late night hours as a result of more local temperature differentials between land and sea.

The average maximum ten-year wind speed in summer is 3.9 m/s from the prevailing northwesterly direction. In winter, the average wind speed is 4.2 m/s and the prevailing direction is southwesterly. Storms have occasionally occurred in winter with maximum hourly wind speeds of up to 18 m/s (UNDP, 2010).

Evaporation

Evaporation rates in the Gaza Strip, over a seven-year record period, varied from 2 to 3 mm/day in winter. While a maximum rate of over 6.7 mm/day was reached in summer between June and August. The average annual evaporation rate in the Gaza Strip is around 1,900 mm/y (5.2 mm/day) (ARIJ, 2015).

Monthly evaporation data for the year 2010 shows that the maximum evaporation rate was reached during the summer months (193 mm in July) while minimum evaporation occurred during the winter months (68 mm in January); the average monthly evaporation rate was 131.8 mm (EMCC, 2014).

3.2.2 Surface water

Wadis are the only surface water bodies found in the Gaza Strip. There are three wadis crossing the Gaza Strip from east to west at different locations as shown in Figure 3.4: Wadi Gaza, which is the most important one, lies between Gaza city and the Middle Governorate, while Wadi Al Salqa lies in the southern part of the Gaza Strip, and Wadi Beit Hanoun lies in the northern part of the Gaza Strip.

Figure 16. Wadis in the Gaza Strip. Source: Ubeid (2014).

3.2.2.1 Wadi Gaza

Wadi Gaza, which crosses the central area of the Gaza Strip from east to west, originates from sources in the Hebron Mountains in the West Bank and the northern Negev Desert. The seasonal river flows westward from its source areas through the Negev Desert and into the Gaza Strip, where it feeds a small wetland at the wadi mouth and discharges into the Mediterranean Sea. Its watershed is estimated to cover more than 3,500 km^2 of the northern Negev Desert and Hebron Mountains, as well as the smaller catchment within Gaza (MedWetCoast, 2001). Wadi Gaza has a highly irregular flow pattern characteristic of seasonal rivers in arid to semi-arid climates with intense, short-lived storm floods. The overall estimated annual discharge volumes in the Wadi lie in the range of 5-30 MM^3/yr. However, currently, only minimal amounts of the higher winter flows reach Gaza due to the diversion of water from Wadi Gaza towards artificial recharge and irrigation within Israel (UN ESCWA and BGR, 2013).

In the past, the Wadi Gaza was considered as a national natural reserve area and used to have a significant environmental and socio-economic value. However, prior to the construction of the temporary wastewater treatment plant in the southern part of the wadi, the wadi has been suffering from serious environmental issues; significant amounts of raw sewage were discharged directly into the wadi from the Middle Governorate and Gaza City (ICRC, 2011). Furthermore, the wadi has in some places been converted into an illegal dump site that receives tons of solid waste, randomly dumped into the wadi bed and along its banks (SWEEP-Net, 2014).

The construction of the temporary treatment plant in 2015 was an emergency response to the deteriorating situation, until a permanent central wastewater treatment plant east of Al Bureij, currently under construction, is operational.

3.2.2.2 Wadi Al Salqa

Wadi Al Salqa is located in the southern region of the Gaza Strip, between Deir El Balah and Khanyounis. Its watershed is estimated to cover 40 km^2. The mouth of the wadi is located near the coastal zone of the Mediterranean Sea and is called Al-Berka, where the seasonal water is collected after flowing from east to west. This wadi was observed to remain almost dry during recent rainy periods; however, it is known that when it receives excess water from extremely storm events, the area is flooded.

3.2.2.3 Wadi Beit Hanoun

Wadi Beit Hanoun is located in the northern part of the Gaza Strip. It is considered a main tributary of Wadi El-Hassa which is located behind the armistice line (originating at Dora in Hebron Governorate and ending at the Mediterranean Sea between Beit Lahia and Asqalan). Its watershed is estimated to cover 729 km^2 of Hebron Mountains; around 5.5% of the total catchment area is located in the Gaza Strip (Ubeid, 2014).

The wadi is characterized by short duration floods that occur after heavy rainfall while most of the times it is completely dry. Freshwater flows into the wadi in the winter season. Israeli infrastructure projects have retained and changed the course of the Wadi and it became dry since the early 1970s (Jaradat, 2010).

3.2.3 Groundwater

3.2.3.1 Coastal Aquifer

The Gaza Strip accounts for ca. 2% of the area of the 18,370 km^2 Coastal Aquifer Basin. The general direction of groundwater flow in Gaza follows the dip of the aquifer towards the coast. The western boundary of the aquifer follows the coastline, where both outflows of freshwater to the sea and inflows (intrusion) of seawater are observed (UN ESCWA and BGR, 2013).

The water table lies between 20-50 m below ground; there are more than 5,000 water wells, most of them are for agriculture purposes with an average depth of 40-70 m (PWA, 2013).

With normal flows, the current sustainable yield of the aquifer segment underlying Gaza is estimated at about 57 MM^3, around 15% of the total yield of the shared aquifer, which is estimated at 360-420 MM^3. Abstractions in recent years have been running well above any estimate of sustainable. As a result, there has been a continual decline in the static water level, water quality has been deteriorating, and there is an increase of seawater intrusion (World Bank, 2009).

Most of the abstraction in the basin originates from Israel (ca. 66% of total abstraction), while the Gaza Strip is responsible for 23% and Egypt has the lowest abstraction at about 11%. Gaza abstraction is estimated to be 150-180 MM^3, while the long-term average natural recharge estimates is in a range from 35 to 48 MM^3/yr (UN ESCWA and BGR, 2013).

Based on water level records during the year 2017, the water level contour map (Figure 17) represents that water levels varies from 12.7 m above sea level in the southeastern side of Gaza Strip to about 18.3 m below sea level in the south part of Gaza Strip (Rafah area). In the northern area of Gaza Strip the maximum water level decline reaches 5.8 m below sea level (PWA, 2018).

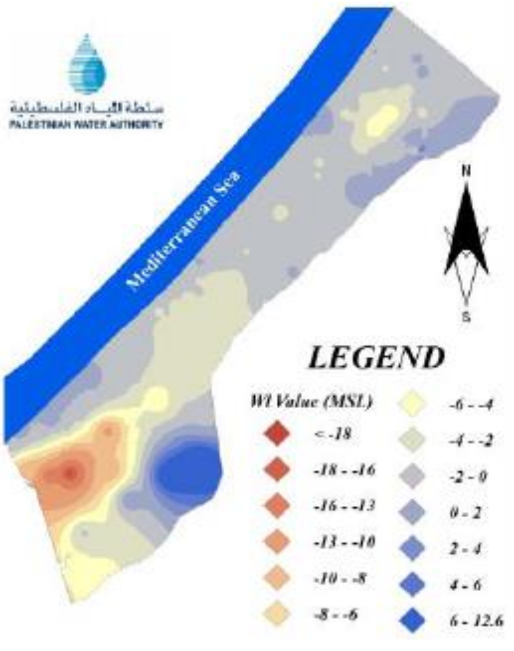

Figure 17. Groundwater level map of 2017. Source: PWA (2018).

3.2.3.2 Groundwater Quality

Currently, only 4% of the groundwater underlying Gaza is drinkable, with more than 96% of all municipal wells having salt and nitrate levels exceeding the WHO acceptable limits and so unfit for human consumption (PWA, 2018; UN, 2017).

Chloride concentration

According to PWA (2018), the majority of the aquifer has a Chloride concentration of 500-1500 mg/l; while along the coastal line it exceeds 2,000 mg/l due to the influence of seawater intrusion. Such high concentrations can be found in the south-eastern part of the Gaza Strip, reflecting the upward leakage of highly saline water from the lower water horizons. The only area with acceptable chloride concentration is located in the northern governorates (Figure 18).

Nitrate concentration

As shown in Figure 18, the Coastal Aquifer also suffers from high levels of nitrate (NO_3). The NO_3 concentration in pumped domestic water generally ranges between 50 mg/l and 300 mg/l. High NO_3 concentrations indicate the percolation of wastewater to the aquifer through damaged networks, cesspits and septic tanks (e.g. Khanyounis aquifer), or the leakage of organic fertilizer through the unsaturated zone (e.g. Beit Lahia aquifer) (PWA, 2018).

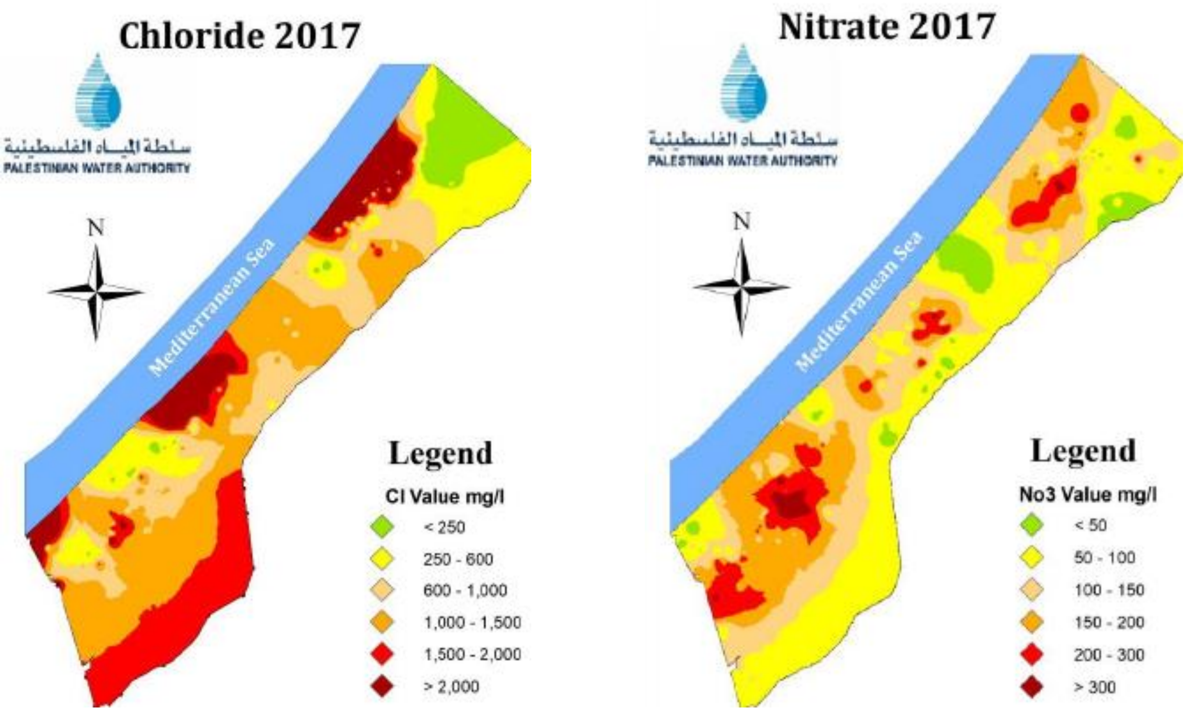

Figure 18. Maps of the chloride (left) and nitrate (right) concentration of the groundwater in the Gaza Strip. Source: PWA (2018).

3.2.4 Non-Conventional Resources

In order to overcome the water scarcity in the Gaza Strip, number of non-conventional water resources were adopted within the PWA plans and strategies (considering the water from the coastal aquifer as the conventional resource of water in Gaza), these include wastewater reuse, rainwater harvesting and desalination of brackish water and seawater. Discussion upon these resources is provided in the following sections.

3.2.4.1 Wastewater Reuse

In the Gaza Strip, there are different small demonstration reuse activities as a pilot projects in scattered areas (Table 8). An additional water resource will become available through the scheduled developments of wastewater treatment plants (WWTP); this resource is already under development in the Gaza Strip. Further developments should be undertaken; this potential resource could be relatively large, but its development raises some important issues that are yet to be resolved (PWA, 2013).

Table 8. Wastewater reuse pilot projects in the Gaza Strip. Source: ALMADINA Consultants (2016).

Reuse pilot projects	Targeted area	Location	Water intake	Planted crops
Beit Lahia pilot project	45 dunums and enlarged to 140 dunums in 2010	Bedouin village	effluent of treated wastewater of the Beit Lahia WWTP	Fodder crops (alfalfa, Sudan grass and ray grass)
Sheikh Ejleen pilot project	100 dunums and enlarged to 186 dunums in 2010	around Salah Eldeen road, close to the network conveying the TWW from The Gaza WWTP to the infiltration basins and wadis	treated wastewater from Sheikh Ejleen WWTP	citrus and olive orchards
Al Mawasi Pilot Project	60 dunums in 2008 and expanded to 90 dunums in 2010	near Al Mawasi WWTP	treated effluent with soil aquifer treatment system (SAT)	Guava and Palm trees
Wastewater Reuse for the Khanyounis and Rafah WWTP				
<u>Phase 1:</u> Wastewater reuse for the existing Khanyounis WWTP	1240 dunums	in Al Mawasi and Al Mohararat of Khanyounis Governorate	from the existing Khanyounis WWTP production	Palm dates, olives and guava
wastewater reuse for the existing Rafah WWTP	850 dunums	in Al Mawasi and Al Mohararat of Rafah Governorate	from the existing Rafah WWTP production	citrus, olives and guava
<u>Phase 2:</u> wastewater reuse for the upgraded Rafah WWTP	9,533 dunums	in Al Mawasi and Al Mohararat in Rafah Governorate	the upgraded Rafah WWTP	Citrus, Olives, Palm dates, Grapes, Guave, Mango, Fruilts, Almonds.

Phase 3: wastewater reuse for the proposed new Khanyounis WWTP	14,895 dunums	Khanyounis governorate excluding Al Mawasi and Al Mohararat areas	Wastewater production from the new Khanyounis WWTP.	alfalfa, citrus, grapes, fruits and almonds
Phase 4: Wastewater reuse for the new Khanyounis WWTP	On the long term, temporary Khanyounis WWTP will stop receiving untreated wastewater, and will instead be used as a storage plant of the treated effluent from the New Khanyounis WWTP. This treated wastewater will then be directly used for irrigation for western farm lands in Khanyounis. The treated effluent from the new Khanyounis WWTP is proposed to be used directly for the irrigation of the farm lands as well as greenhouses in the eastern farm lands in Khanyounis and Rafah during the summer season. While during the winter season, the treated effluent is proposed to be infiltrated into the ground at Al-Fukhari in order to replenish and improve the aquifer in the area, following the soil aquifer treatment system. Another proposed option is to pump the treated effluent to Temporary Khanyounis WWTP to be then directly used for irrigaton for the western farm lands in Khanyounis.			

The reuse projects are surrounded with different constrains, the most important of which is the compliance with WHO and Palestinian standards for reuse purposes. Sustainability of these projects remains the key point if the reuse option is to be considered as a robust solution for the water crisis in Gaza.

3.2.4.2 Rainwater Harvesting

According to the Palestinian national water plan, rainwater harvesting has been identified as one of the strategic options of the water resources management in Palestine (PWA, 2000). There are two main rainwater harvesting systems (ACF, 2015):

- Conventional system that consists of storm water network (gullies and drainpipes) with infiltration/retention basin
- Non-conventional system, which is an onsite harvesting system (soak away) that can be constructed on household, municipal, and community levels

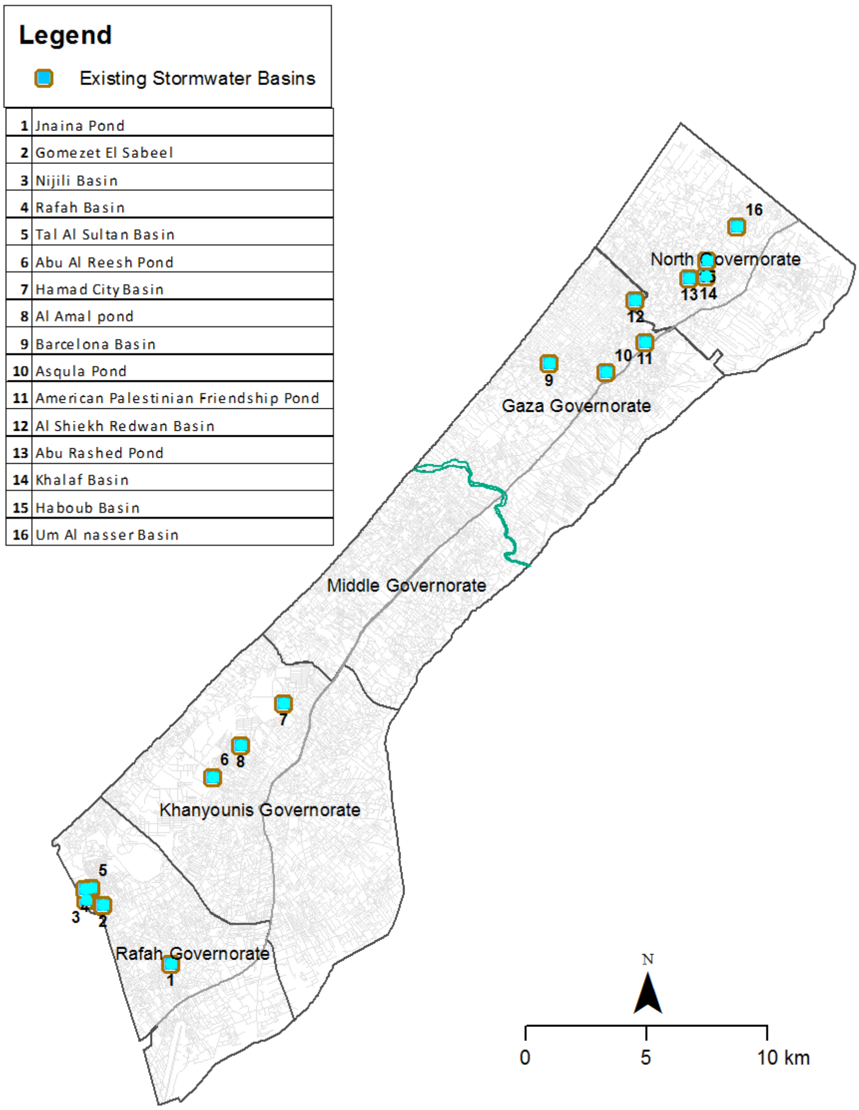

Figure 19. Storm water basins in the Gaza Strip. Updated by project team from Abd Al Rahman (2016).

The conventional system is currently being used in the Gaza Strip. Many large scale rainwater basins have already been implemented as flood management interventions; as shown in Figure 19, 16 infiltration and retention basins, with different scales, are found along the Gaza Strip. Water collected within the infiltration basins is recharged to the aquifer either directly or through boreholes, with average recharge rate of 1.3 m/day (Table 9), while water collected within the retention basins is discharged to the sea or to the infiltration basins (PWA, 2011b).

Table 9. Existing storm water collection basins in the Gaza Strip. Source: Abualtayef et al. (2017).

Governorates	Name	Area (m^2)	Basin Type	Recharge Rate (m/day)
North	Um AlNasser	13,074	Infiltration	1.5
	Haboub	3,519	Infiltration	1.5
	Beit Lahia	102,419	Boreholes	0.5
	Khalaf Basin	5,000	Boreholes	1.2
	Abu Rashed Pond	13,500	Retention Basin	0.0

Governorates	Name	Area (m^2)	Basin Type	Recharge Rate (m/day)
Gaza	AlShiekh Redwan Basin	68,000	Storage-Infiltration	1.2
	Asqula pond	22,667	Storage-Infiltration	1.2
	American Palestinian Friendship	37,523	Infiltration	1.5
	Barcelona	15,000	Infiltration	1.5
Khanyounis	Al-Amal pond	102,419	Storage-infiltration	1.0
	Abu Al Reesh	2,000	Retention	0.0
	Hamad city Basin	4,500	Boreholes	0.1
Rafah	Rafah	1,134	Infiltration	1.5
	Jnaina Basin	30,000	Retention Basin	0.0
	Tal Al Sultan Basin	20,000	Retention Basin	0.0
	Nijili Basin	2,000	Retention Basin	0.0
	Gomezet El Sabeel	2,000	Infiltration Basin	1.4

In the North governorate, storm drainage takes normally place in the streets. While all new roads are being built with storm drains. However, some drainage problems occur in Jabalia Camp during storms, as the camp is located in inland catchments with no natural drainage towards the sea; UNRWA and PWA have implemented some drains in the Camp. Four stormwater basins, with different types and capacities, have been identified in the northern governorate as shown in Figure 19 and Table 9.

Gaza Governorate is divided in two major catchments, the coastal catchment, which slopes toward the sea, and the inland zone, which is divided into two sub-catchments A-1 and A-2. Storm drainage in the coastal catchment takes normally place in the streets; with few drains exist in the lower areas, while the other catchment is being served through three different basins as shown in Figure 19 and Table 9.

There are no facilities for stormwater drainage in the urban areas of the Middle Area, where natural drainage takes stormwater into the Wadi Gaza or toward the sea. Some floods were reported recently due to urban development.

As in the Gaza and North governorates, stormwater in the Khanyounis governorate is generally drained by surface run off in the streets or in ditches, however, stormwater collection basins are found in the areas with depression, see Figure 19 and Table 9.

The stormwater drainage system in Rafah governorate covers some areas in Rafah city, while no facilities for stormwater collection are found in Al Nnaser and Al Shoka cities. Therefore, people are suffering frequently, in winter rainy season, from flood events due to the lack of stormwater infrastructure and other facilities. Even though some areas have stormwater facilities, the flood problem is existed as the capacity of the infrastructure is neither efficient nor sufficient for the hydraulic load (ACF, 2015). Rafah Governorate is served through three main collection basins and two small ponds as shown in Figure 19 and Table 9.

The situation is different in rural areas, where some rainfall collection systems do exist to be used in irrigation and not for flood control. These systems are varied and sporadic and are being privately controlled (Abd Al Rahman, 2016).

The PWA carried out an assessment study for current and proposed situation of storm water harvesting in the Gaza Strip, in which it proposes three levels of strategies for storm water harvesting in the Gaza Strip: household level and street level using soak away systems, and governorate level using storm water networks with reservoirs and infiltration basins (PWA, 2011a).

3.2.4.3 Desalination

The poor water quality in Gaza Strip contributes in highlighting desalination projects as a stopgap solution either public or private plants. A major problem is water quality; high concentrations of salts and nitrates are difficult and costly to remove from drinking water supplies.

As a coping strategy, the Gaza market has responded by providing several types of desalination plants. Figure 20 illustrates the different ownership arrangements of these plans as private (owned by private people), public (owned by CMWU and municipalities), NGOs (owned by different associations), schools (installed in governmental schools) and plants owned by universities.

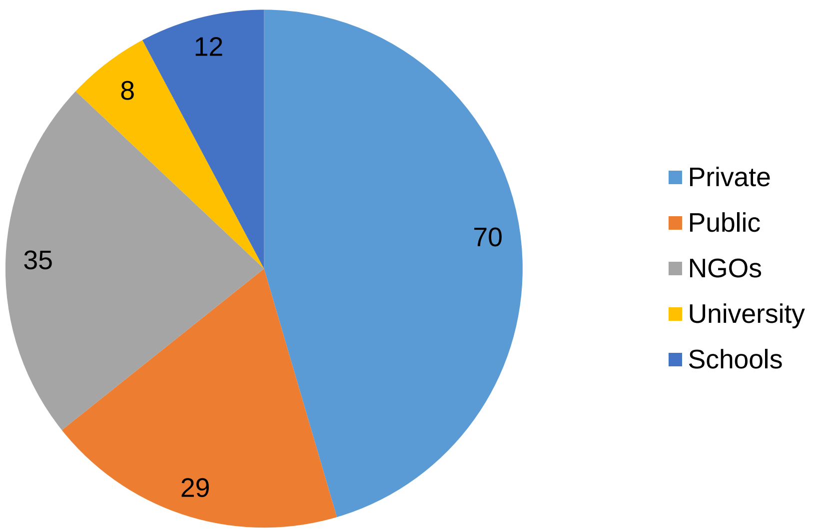

Figure 20. Distribution of ownership arrangements of desalination plants in the Gaza Strip. Source: CEP et al. (2015).

The maximum plant production capacities range between 5 m^3/hour and 500 m^3/hour. The average working hours vary between 9.5 hour/day in summer and 6.4 hour/day in winter. This variance between summer and winter is related to the increasing water consumption in hot weather (CEP et al., 2015).

More than 80% of the Gaza people use this water for fulfilling their drinking and cooking water needs. The remaining 20% use in-house reverse osmosis units for desalination. In addition, there are public desalination plants operated by the CMWU in the Gaza Strip, whose water production capacity is larger than that of private sector. The final product is distributed through the domestic distribution networks, which is mixed with well water to enhance its quality (PWA, 2013).

The current trend for desalination projects relies on seawater desalination, which decreases the abstraction from the aquifer. These projects depend on beach wells to overcome the disadvantages of direct use of seawater as the turbidity and impurities affects the efficiency of RO membrane technologies. Table 10 illustrates some information about seawater public desalination plants.

Table 10. Public desalination plants in the Gaza Strip. Data collected by project team.

Plant name	Governorate	Capacity	Intake source	Recovery rate	Water distribution	Comments
STLV for southern governorates - Albassa	Deir al Balah	200 (m^3/day)	Beach wells	40-45 %	UNRWA including schools	The station is in operation with expansion work. The design capacity for expansion the station 4,500 (m^3/day)
Central desalination plant (Al janoub desalination plant)	Deir al Balah – Al Qararaa	2,500 (m^3/week)	Beach wells	45%	Directly pumped to the network of Rafah and Khan Younis	The station is operation with a future plan for expansion According to the design the current capacity is 6,000 (m^3/day) and the expansion will be 14,000 to become 20,000 (m^3/day)
STLV for northern governorates "Alsodania"	Northern governorate	1,0000 (m^3/day)	Beach wells	--	--	In construction phase

4. Water management in Palestine

The following sections discuss the water management in Palestine in terms of legal and institutional framework and technical issues, where environmental and social issues related to the water sector are also discussed.

4.1 Legal and Institutional Framework

This section provides information on the legal and institutional framework of the water sector in Palestine, including international regional agreements and regulations, national laws, actors in the Palestinian water sectors, water strategies and plans and water programs and interventions.

4.1.1 International and Regional Agreements and Regulations

4.1.1.1 The Gaza-Jericho Agreement (also Cairo Agreement), 1994

Cairo agreement: the agreement transferred the control of the whole process for water supply system (management, development and maintenance) to the Palestinian authority, excluding the water supply for the Israeli settlements and some Palestinian land surrounding the settlements remains under Israeli security responsibility existed in that period.

4.1.1.2 The Oslo Accord II, 1995

Issues related to water and sewage are detailed in the agreement's Annex III, Article 40, including the following provisions.

Water rights

Israel recognized the Palestinian water rights in West Bank and the necessity to develop additional water for various uses with emphasis on respecting each side's powers and responsibilities in the sphere of water.

Allocation of groundwater shares

The Oslo II Agreement included a specific allocation of groundwater shares in the Mountain Aquifer between Israel and the West Bank. The allocation is given in Table 11.

Table 11. Allocation of groundwater shares in the Mountain Aquifer in the Oslo II Agreement 1995.

Aquifer basin	Allocated to Israel	Allocated to Palestine
Eastern Aquifer	40 Mm^3	54 Mm^3 (+78 Mm^3 to be developed)
North-eastern Aquifer	103 Mm^3	42 Mm^3
Western Aquifer	340 Mm^3	22 Mm^3

Future needs

It is agreed that future water needs for Palestinian estimated between 70-80 MM^3/yr. Israel will transfer 23.6 MM^3/yr for West Bank and 5 MM^3/yr for Gaza Strip. The remainder of the estimated quantity of the Palestinian shall be developed by the Palestinians from the Eastern Aquifer and other agreed sources in the West Bank. The Palestinians will have the right to utilize this amount for their needs (domestic and agricultural).

The agreement also emphasized the need to develop and produce more water through wastewater treatment and desalination. In addition, this agreement prohibits any step that might lead to contamination of water.

Joint Water Committee

In order to implement this commitment, the agreement parties set up a Joint Water Committee. This committee has been working since 1995. In addition, at the same year another committee was set up to deal with policy and encouragement of cooperation on water issues this committee consists of the previous parties in addition to American representative member.

4.1.2 National laws

4.1.2.1 Palestinian National Water Policy (1999)

The national strategy, issued by PWA, provides the planning and management framework necessary for the protection, conservation, sustainable management and development of water resources and for the improvement and sustainable management and provision of water supply and standards in the Palestinian Territories.

The policy aims to:

- Reinforce the Palestinian Authority's approach to sustainable water resources management by ensuring that all arms of government work together in the pursuit of shared water resources management goals.
- Establish a framework for the coordinated development, regulation and financial sustainability of water supply and wastewater services to ensure concerted efforts towards improved water systems management, rehabilitation and maintenance.

4.1.2.2 Palestinian Environmental Law (1999)

The Palestinian Authority legislates and regulates all activities and projects in water and costal zones through the Palestinian Environmental Law. The Ministry of Environment Affairs was replaced by the Environmental Quality Authority (EQA) by the Presidential Decree No 6 of 2002. The decree also moved all the responsibilities and the Ministry of Environmental Affairs to the EQA.

This basic enactment of the Palestinian Legislative creates a framework for the protection of the environment, public health and biodiversity in Palestine including marine areas. Its 82 sections are divided into five titles: 1) Definitions and general provisions; 2) Environmental protection; 3) Environmental impact assessment, licensing, inspection and administrative procedure; 4) Penalties; 5) Final provisions.

It is now the body responsible for protecting and developing environment in Palestine according to the "Law Concerning the Environment, No 7, of 1999" with reference to articles 28 through 39 which are specifically related to water and marine issues.

4.1.2.3 Palestinian Water Law (2002)

The Palestinian Water Law aims to develop and manage the water resources, increasing their capacity, improving their quality, and preserving and protecting them from pollution and depletion. The law considers water as a public property and shares the responsibility of protecting it between the Palestinian Water Authority and the National Water Council.

4.1.2.4 Decree Law No. 14 of 2014 related to water law ('2014 Water Law')

In June 2014, Palestinian president Mahmoud Abbas issued a presidential decree in relation to the existing water law that is commonly referred to as the '2014 Water Law'. The decree is part of a bigger reform process that is aiming to restructure the water sector in order to clarify the mandates and responsibilities of the different actors involved with water management. It also promotes inclusion of the private sector both as service providers and as investors to improve the financial standing of the Palestinian water sector.

The 2014 Water Law and the larger reform process aim to improve the development and management of Palestinian water resources, through a reorganization of its governance structure (PWA, 2013). The key aspects of the new water law are:

- The redefinition of the PWA's mandate to focus on ministerial functions, i.e. setting policies and strategies, and water resources management, i.e. developing new infrastructure projects and issuing abstraction licenses
- The introduction of the Water Sector Regulatory Council as an independent regulatory body overseeing bulk water supply and the service provision of all utilities
- The restructuring of the West Bank Water Department into the publicly owned National Water Company
- The integration of water service providers into four large regional water utilities, three for the West Bank and one for the Gaza Strip

As of spring 2016, the implementation of the 2014 Water Law was far behind schedule (Schillinger, 2016).

4.1.3 Key Actors in the Palestinian Water Sector

4.1.3.1 Palestinian Water Authority

The Palestinian Water Authority (PWA) was established under Presidential Decree No 90 of 1995 on the establishment of the Palestinian Water Authority, which exists as an independent legal personality with its own budget, to follow the President of the Palestinian National Authority (PNA). The PWA's head is appointed by the President of the PNA.

The PWA strives for an integrated and sustainable asset management of the water resources. They work towards a healthy environment by ensuring a balance between quantity and quality of water available and the needs of the Palestinian people to achieve sustainable development through water resources.

4.1.3.2 The Water Sector Regulatory Council

The Water Sector Regulatory Council (WSRC) was established under the 2014 Water Law as an independent legal entity that reports directly to the Palestinian Cabinet of Ministers. The WSRC is responsible for overall monitoring and regulation of all matters related to the operation of water and sanitation service providers (SP). These responsibilities include approving tariffs, licensing and regulating SPs, and protecting consumers. The WSRC also collects valuable data per SP and has initiated a benchmarking process. It publishes a summary of this data in an annual report. Once the National Water Company (see 4.1.3.3) is established, the WSRC will set a unified price for all bulk supply to SPs. However, most of these statutory functions have not yet been legally transferred to the WSRC, including the approval of the licensing bylaw which would give the WSRC the eligibility to collect fees for its financial sustainability from licensed SPs.

4.1.3.3 National Water Company

The National Water Company (NWC) was part of the reform process initiated by the 2014 Water Law. It is supposed to be in charge of producing and purchasing bulk water, and transporting bulk water to service providers in different regions, in the most efficient way. However, it has yet to be established.

4.1.3.4 National and Regional Water Utilities

The Water Law No. 3 of 2002 provided the legal basis for the establishment of national and regional water utilities which are responsible for providing water in bulk, at the national and regional level, respectively.

4.1.3.5 Other ministries involved in the water sector

The PWA has been given its mandate through the Water Law No. 2 (1996) and has been stressed as key authority in the water sector in its amendment law no. 3 in 2002 to manage the water resources, to execute the water policy, to establish, supervise and monitor water projects, and to initiate co-ordination and co-operation between the parties affected by water management. However, other line ministries and agencies have leadership on specific issues:

- **Ministry of Local Government**: implementing and supporting Joint Service Councils (JSCs)
- **Environmental Quality Authority**: defining environmental regulations, including standards for the discharge of treated wastewater into natural water courses, carbon footprint and water footprint regulations
- **Ministry of Agriculture**: policy and regulation of irrigation and promotion and organization of farmers' associations

4.1.3.6 International organisations

There are many international and Palestinian NGOs that implement a range of water projects and programs throughout Palestine. The majority focus on targeting vulnerable and marginalized populations, either in Area C, inside the Green Line, East Jerusalem and Gaza. Their contribution to capacity development is more heavily focused on advocacy for water rights, both nationally and internationally, promotion of hygiene and the support of direct service provision. Some of them are listed below in alphabetical order.

- **Action Against Hunger (ACF)**: Works mostly in infrastructure in the water sector, targeting vulnerable communities, but also does some advocacy, awareness raising and capacity development as components of their projects.
- **Cesvi**: Focuses on awareness raising in water and hygiene as well as developing JSC capacities in Taybe and Ramon villages.
- **Dan Church Aid**: Focuses on hygiene trainings as well as supporting water availability through cistern rehabilitation and construction.
- **Diakonie Katastrophenhilfe**: Works on enhancing the resilience of vulnerable communities through improving their capacities to harvest rainwater.
- **GVC Italia**: Working in Palestine since 1997, GVC has worked on developing databases and GIS systems for the water sector, implemented awareness and hygiene campaigns, and supported municipalities and JSC with targeted trainings.
- **International Committee for the Development of People (CISP)**: Focuses on increasing awareness, knowledge and practices about hygiene and sanitation as well as supporting the PWA in water provision and providing information, data and technical recommendations.
- **International Committee of the Red Cross (ICRC)**: In partnership with the PWA, the ICRC has been working to improve water supply since 2006. Currently it is focusing on supporting the PWA and the Coastal Municipalities Water Utility in Gaza for the operation and maintenance of water and wastewater infrastructure.

- **MA'AN Development Centre**: An independent Palestinian organization established in 1989, Ma'an has been supporting capacity development in rural areas through cistern construction and rehabilitation efforts. Their main strategy is to enhance water management and encourage environmentally friendly practices across the sector.
- **Oxfam**: In the water sector, Oxfam focuses mostly on advocacy through its hosting of the EWASH Advocacy Task Force and on hygiene and sanitation promotion in elementary schools.
- **Save the Children**: Supports in access to potable water for marginalized communities and supports hygiene promotion.
- **YMCA East Jerusalem**: Aside from various water related projects, with regards to capacity development in the water sector, the YMCA works mainly on hygiene promotion and hygiene trainings.

There are frequent collaborations between international organisations and other domestic actors. One example is the collaboration between ACF, GVC and PWA to address the water problems in Area C. In coordination with the related water service providers, village councils and Area C communities' representatives, the three organisations have developed a water master plan aiming to identify and promote feasible short, medium, and long term technical solutions to the problems of water accessibility and availability in Area C.

4.1.4 Water Strategies and Plans

4.1.4.1 National Water Strategy 2012-2032

The National Strategy was prepared in 2012 to formulate a planning and management framework to promote the protection, conservation, sustainable management and development of water resources, water supply and wastewater services processes and standards in the Palestinian Territories.

The strategy aims to:

- Reinforce sustainable water resources management by endorsement the cooperation of all governmental arms work together in the pursuit of shared water resources management goals.
- Establish a framework for the coordinated development, regulation and financial sustainability of water supply and wastewater services to ensure concerted efforts towards improved water systems management, rehabilitation and maintenance.
  The strategy has been defined through a set of quantitative objectives that reflect the improvements made to the water and wastewater services delivered to customers. Such quantitative objectives will make it possible to:
- Evaluate the progress made towards implementing the strategy over the next 20 years.
- Estimate the level of investment required for strategy implementation.

The objectives and relevant performance indicators have been selected to provide a comprehensive description of the sector from the customers' viewpoint, rather than from the point of view of planners.

4.1.4.2 Water Sector Reform Plan 2016 – 2018

The principle of water sector reform plan was endorsed by the Cabinet of Ministers of the Palestinian National Authority in 2009 in order to establish and activate an effective Water Governance System and improve the water management mechanisms.

This reform is considered as a guide for water reform implementation for three years, defines the critical aspects, principles, purpose in addition to define stakeholders and responsibility that affects water management system and gives a clear cooperation and coordination among all stakeholders to achieve the goal.

4.1.5 Water Programmes and Interventions

4.1.5.1 Programmes and interventions in Gaza

Many programs and plans were prepared by the PWA to address the problems in the water sector in the Gaza Strip. The Coastal Aquifer Management Plan (CAMP) is one of the main plans that provided an integrated plan for the management of the coastal aquifer in Gaza through number of strategic projects; such as desalination plants, WWTPs, and carrier lines. Another plan for the storm water harvesting was prepared aims to develop a good strategic plan for storm water harvesting and infiltration for aquifer recharge at three levels which are the home level, the street level using soak-away system, and the governorate level using storm water networks with reservoirs and infiltration basins.

Moreover, a Comparative Study of Options for an Additional Supply of Water for the Gaza Strip (CSO-G) was prepared recently as part of the Gaza Emergency Technical Assistance Program (GETAP). The study sorted the options into a set of interventions that can be introduced in Gaza including desalination, both short-term low-volume (STLV) desalination and regional long term desalination at high volume, transfers of water from Israel, regional wastewater treatment plants, and reuse of treated wastewaters for agricultural proposes.

The study produced a rolling schedule of interventions, to form a coherent program that addresses the critical issues in the water sector in Gaza by involving projects that are inter-linked. Along with the establishment of a Gaza Program Coordination Unit (GPCU) to drive and coordinate the proposed CSO-G interventions as a whole, the interventions are summarized as follows (PWA, 2011b):

- **The Water and Health Monitoring Project**: The introduction of an integrated water and health monitoring project, to ensure that comprehensive and fully reliable data are available to act as a driver for the desired future changes in the sector, and also to monitor the success of the entire program of interventions.
- **Domestic Water Distribution Systems**: The accelerated upgrading and/or re-provision of the domestic water distribution and supply network in Gaza.
- **Imported Water**: Enhanced levels of water imports from “Israel” to Gaza, in relatively small volume at different locations of the Gaza Strip.
- **Short-term Low-volume (STLV) Desalination**: The introduction of short-term low-volume (STLV) desalination of sea water in Gaza, to provide relatively minor volumes of water of acceptable quality for domestic use in the early years of the CSO-G program, and to ensure that public health may be protected.

- **Regional Desalination**: The phasing-in of higher levels of sea water desalination through the construction of two regional facilities, in as short a time as possible. These regional desalination facilities are proposed to act as one of two key drivers of the initiative to reduce the present levels of over-abstraction of the groundwater in Gaza, and are therefore critical to the CSO-G program as a whole (as well as to the long-term protection of human health in Gaza).
- **Groundwater Supplies to the Agricultural Sector:** The introduction and/or extension of pilot schemes for the reuse of treated wastewaters in Gaza, with the reused flows replacing pumped groundwater, as soon as possible.
- **The Increased Reuse of Treated Wastewater**: The accelerated completion of the major wastewater treatment plants in Gaza, with large-volume reuse being introduced as rapidly as possible and becoming the predominant source of water used in the agricultural sector in Gaza.
- **Other Interventions in the Agricultural Sector**: The completion of a high-quality review of the use of water in the agricultural sector in Gaza, this being focused on reducing the overall demand for water; the introduction of large-scale wastewater reuse; and the optimization of the economic returns from the sector.

4.2 Technical Issues

Technical issues regarding the water supply and water consumption in the Gaza Strip, along with wastewater collection, treatment and disposal are discussed in the following sections.

4.2.1 Water Supply

Hindrances to the development of the Palestinian water and sanitation sector have had a number of consequences for human consumption and the sustainability of Palestinian water management. Daily water consumption in most parts of the Palestinian territories lies far beneath the threshold of 100 L per day and capita set by the World Health Organisation (PWA, 2012).

According to the PCBS (2018a), the majority of households in the West Bank receive their water via the public water network, however, the supply is often intermittent. Households in the Gaza Strip are predominantly served by water trucks rather than piped water, although most houses are connected to the network

Table 12. Households in Palestine by governorate and main source of water in the housing unit in 2017. Source: PCBS (2018a).

Households in Palestine* by Governorate and Main Source of Water in The Housing Unit, 2017

Governorate	Main Source of water								Total
	piped into dwelling	protected dug well/protected spring	unprotected dug well/unprotected spring	rainwater	tanker truck/cart with small tank	bottled water	Others**	Not Stated	
Palestine	**494,220**	**12,073**	**865**	**9,904**	**318,932**	**9,122**	**10,027**	**11,186**	**866,329**
West Bank	**468,094**	**10,147**	**522**	**9,597**	**24,573**	**7,293**	**285**	**11,108**	**531,619**
Jenin	54,824	3,074	193	933	5,821	593	29	28	**65,495**
Tubas	11,652	194	3	161	238	122	41	0	**12,411**
Tulkarm	38,587	449	12	120	13	172	5	2	**39,360**
Nablus	78,537	646	31	1,025	1,679	262	14	41	**82,235**
Qalqiliya	22,009	145	3	197	29	117	5	2	**22,507**
Salfit	15,354	5	0	212	15	90	1	0	**15,677**
Ramallah and Al-Bireh	62,665	910	41	274	445	4,433	81	1,339	**70,188**
Jericho and Al Aghwar	8,992	61	4	1	501	58	10	607	**10,234**
Jerusalem*	22,476	79	10	136	123	466	21	9,031	**32,342**
Bethlehem	43,767	307	5	277	415	743	11	31	**45,556**
Hebron	109,231	4,277	220	6,261	15,294	237	67	27	**135,614**
Gaza Strip	**26,126**	**1,926**	**343**	**307**	**294,359**	**1,829**	**9,742**	**78**	**334,710**
North Gaza	7,818	471	57	33	54,419	352	836	26	**64,012**
Gaza	10,783	625	152	96	99,972	1,028	563	19	**113,238**
Dier al Balah	1,442	89	25	56	45,474	171	1,915	30	**49,202**
Khan Yunis	3,864	563	83	94	56,551	203	5,149	3	**66,510**
Rafah	2,219	178	26	28	37,943	75	1,279	0	**41,748**

*Data excluded those parts of Jerusalem which were annexed by Israeli Occupation in 1967

**Others: Include public tap and any other resources.

4.2.1.1 Water quantity and water quality in the West Bank

The Palestinian water allocation according to the Oslo Agreement is 118 MM³. Out of the annual Palestinian water consumption, 51% is used to in agriculture, irrigating 115,000 dunums of agricultural land, while 49% are used for domestic and industrial purposes. With an Unaccounted for Water (UfW) rate of more than 35%, and additional purchases from the Israeli water company Mekorot of about 51 MM³ per year (4 MM³ for agricultural purposes and 47 MM³ for domestic purposes), the total Palestinian consumption of water is 151 MM³ per year (PWA, 2016).

62% of Palestinian households use an improved drinking water source (piped into dwelling, protected dug well/protected spring, rainwater, bottled water and public tab); 95% in the West Bank and 11% in Gaza Strip (Figure 21). The decrease in the Gaza Strip was due to the deterioration in the quality of water extracted from the coastal basin. As for the type of localities, improved drinking water sources are in use at 58% in urban localities, 94% in rural localities and 44% in camps (PCBS and PWA, 2019).

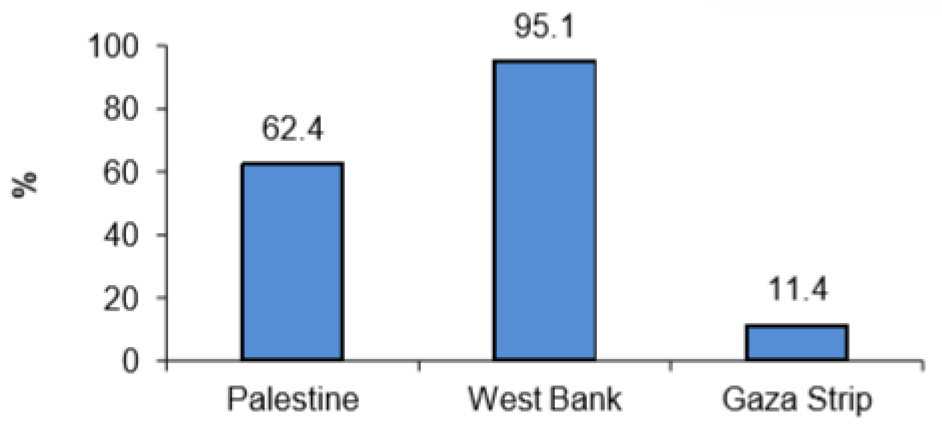

Figure 21. Percentage of households in Palestine who used an improved drinking water by region. Source: PCBS and PWA (2019).

A large portion of the water that is available for Palestinian extraction is indeed produced and used. Figure 22 shows the percentage of abstraction over the past decade. It should be noted here that the Palestinians have been denied access to the Jordan River since 1967, meaning that approximately 250 MM^3 remain out of reach each year. The Palestinian groundwater abstraction rates from the Eastern, Western and North-Eastern aquifers added up to 86 MM^3 in 2017 (PCBS and PWA, 2019).

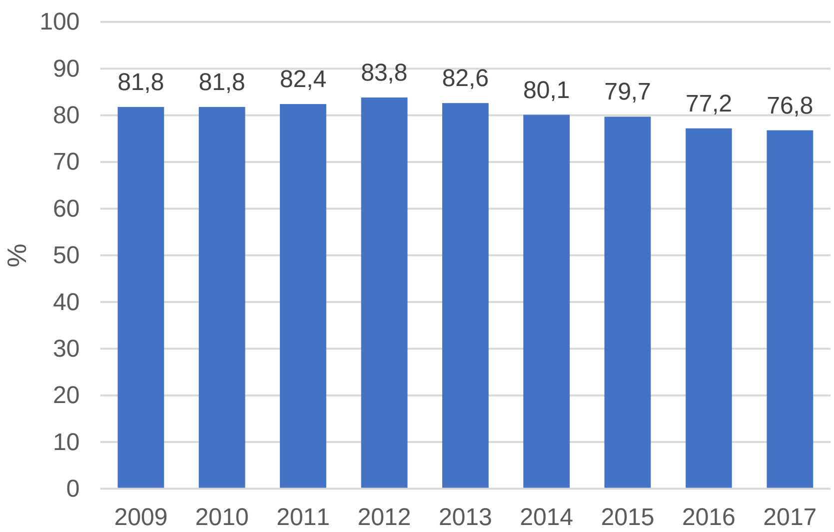

Figure 22. Percentage of abstracted surface and ground water from available water, 2009 – 2017. Data source: PCBS and PWA (2019).

With scarce water and Israeli restrictions on access to resources, Palestinian cities are forced to purchase water from the Israeli water company Mekorot. In 2017, cities purchased 83 MM^3, corresponding to 22% of the water available in Palestine (375 MM^3). An additional 23.5 MM^3 were produced from Palestinian springs, while 264.5 MM^3 are pumped from ground water wells and 4.0 MM^3 originated from desalinated water (PCBS and PWA, 2019).

4.2.1.2 Water quantity and water quality in Gaza

Groundwater from the coastal aquifer forms the main source of water in the Gaza Strip. This resource provides about 84.8% of all domestic water supplies. There are 25 municipalities responsible for providing domestic water through municipal wells distributed over the Gaza

Strip municipal areas; these wells provide water for both municipal and industrial uses. The remaining amount is provided through purchases from the Israeli water company Mekorot and the desalination of brackish water and seawater desalination. Table 13 provides an overview of the different sources of water in the Gaza Strip (PWA, 2018).

Table 13. Sources of water supply for domestic use in the Gaza Strip in 2017. Data source: PWA (2018).

	Water supply for domestic use	**Percentage of total amount**
Municipal wells (273)	78.79 MM^3	81.8%
UNRWA wells (9)	2.91 MM^3	3.0%
Mekorot	10.57 MM^3	11.0%
Desalination	4.04 MM^3	4.2%
Total	**96.31 MM^3**	**100%**

Although About 98% of the Gaza Strip population is served by a water network, the rapid population growth and associated increasing demand create a great challenge for the development of the network further to consider them. In addition, significant parts of the existing network were constructed more than 20 years ago. Therefore, comprehensive upgrading of older parts of the network will be required to ensure it remains in a good condition to operate in the future (CMWU, 2012).

According to CMWU (2017), the total length of the water distribution networks in the Gaza Strip is about 800 km, with pipe diameters varying from 2 to 20 inches according to purpose and capacity. The distribution network efficiency is about 64.7% due to physical and commercial loss, leading to a reduction of the water quantity effectively available for consumption.

The water supply in the Gaza Strip is an intermittent distribution system. This is due to insufficient water infrastructure and the lack of water sources. The methods for distribution water networks depend on two schemes; direct supply from wells and supply by water tanks to networks. Annex-II provides a brief description of the water supply quality and quantity for each municipality in the Gaza Strip.

4.2.2 Water Pricing

4.2.2.1 Water tariffs

Water tariffs should be set to cover investment and operational needs, according to the financial sustainability of the water sector strategy (PWA, 2013). Although setting may appear simple, yet the implementation is formidable as it is governed by more than mere socio-economics but also by cultural and historical determinants.

The production and distribution costs vary across the Palestinian territories from region to region and from system to system, according to physical features (elevation, groundwater quality) and to the condition of the water network (leakages, breakdown frequency). The water tariff implemented by each water utility would reflect these differences and the tariff would, therefore, vary from one municipality to another. Having a valid set of data and information that would allow proper determination of tariffs is not easy. In all events, however, principles and procedures behind the setting should be uniform across all utilities (GWP, 2015).

The adaptation of water tariff system should take in consideration the balance between the three basic principles in the management of the water sector:

- The ability of the water facilities to recover the costs of the water from the participants.
- Attain the principle of social justice and taking into account the different social strata, especially the poor.
- Achieve the principle of economic efficiency and guiding the use of this vital natural resource.

That means a balance between the economic value of water as a public good and the availability at a fair price for different social classes is key factor for the success of tariff collection system (MAS, 2013).

The new 2014 water law states that the Water Sector Regulatory Council (WSRC) shall set a definite tariff for water without any consideration to the differences of cost of water production and transmission of the various resources. This means that a source of subsidy shall be well defined to compensate for these differences, one ways to subsidize water through sectoral difference of water price which means whenever the consumed water amount increased, a shift from one category to another will happen and water price increased consecutively. That means that those who can pay will cover the gap of poor people who cannot pay for water consumption. Table 14 illustrates the different Palestinian water tariff classes for both West Bank and Gaza.

Bulk water tariff need to collect in a short period to cover the cost of operation as well as investment, whereas the collection is a serious problem for the utilities, as it depends highly on willingness and affordability. The basic principle remains valid, in that the willingness to pay increases when the quality of service is good and when there is a feeling that tariffs are equitable and just. In addition, if there is a culture of non-payment for water, this will not change because the services are improved. Changing a behavioral pattern will require extensive customer outreach and political commitment (GWP, 2015).

Table 14. Average consumer water tariff by regions in 2016. Source: PCBS (2017a).

Description	**Gaza Strip**	**West Bank**	**Palestine**
Water tariff for 0-5 m^3/month	1.03 NIS/m^3	4.10 NIS/m^3	3.12 NIS/m^3
Water tariff for 5.1 -10 m^3/month	1.13 NIS/m^3	4.21 NIS/m^3	3.32 NIS/m^3
Water tariff for 10.1 -20 m^3/month	2.50 NIS/m^3	5.55 NIS/m^3	4.57 NIS/m^3

4.2.2.2 Non-Revenue Water

Palestine is suffering a high shortage of water as well as high water loss. Both financial and technical constrains are the main bottlenecks that limit the water network’s ability to satisfy the highly growing needs of its residents. Technical constrains means that not all water supplied by a utility reaches the consumer, while financial and economic means that not all water supplied is paid for (GWP, 2015).

The term non-revenue water (NRW), as defined by UNEP (1999), refers to an accumulated range of losses that will be experienced by a water utility when comparing the system demand of a hydraulic water network with the quantity of water that is acknowledge as consumed by the water consumers residing within the network.

Non-revenue water can thus be described as those components of system input volume which are not billed and do not produce revenue. NRW can be broken down into the following categories:

- Unbilled Authorized Consumption
- Commercial losses (unauthorized consumptions and customer metering inaccuracies/data handling errors)
- Physical Losses or Real Losses

While non-payment of bills is not part of NRW, increased collection ratios form part of the same management strategies that also aim for a reduction in NRW.

The positive impacts of NRW reduction include greater access to scarce water resources and increased financial revenue, leading to a more efficient and sustainable water sector and improved service to the customer.

NRW in the West Bank accounts for 44% of the produced water, mainly due to leakage, theft or false metering. Additionally, bill collection rates lie below 50% in some governorates, with Tulkarem being lowest at 41% (GWP, 2015).

In the Gaza Strip, NRW is estimated to be about 42%, of which 5% are attributed to unregistered connections and meter losses (GWP, 2015). The NRW strategy published in 2017 (PWA, 2017) primarily aims to introduce main concepts to reduce the levels of NRW over Gaza strip to reach 20% NRW by the year 2030. The PWA's strategy includes interim targets of 31% NRW by the year 2020 and 25.5% NRW by the year 2025.

The strategy to reduce NRW is broken down into the different steps to achieve its objectives which summarized in assessing works and required funding, auditing, developing priority action plans and developing public awareness and education campaigns. The success of the NRW reduction strategy is highly related to the availability and reliability of information and data about the entire water system (PWA, 2017).

The implementation of a NRW reduction strategy in the Palestinian water sector brings many organizational and practical challenges as described below (PWA, 2017):

- Insufficient manpower of PWA to promote and monitor a NRW reduction campaign performed by service provider in Gaza
- Gaza is currently divided in 25 services providers and some of them could not afford dedicated teams to set up and implement NRW schemes and a national team, offering practical advice and help them is not available.
- Lack of funding and efforts to gain access to funding required to implement the strategy.
- Inadequate operation and maintenance policies by the service providers.
- Political, cultural and social influences.

4.2.3 Water Consumption

4.2.3.1 Water consumption in the West Bank

The daily allocation per capita from consumed water for domestic purposes is 88.3 liter/capita/day in Palestine. The West Bank and Gaza Strip had the same rate in 2017. There are some localities where the average per capita consumption does not exceed 50.4 liters per day, while this rate exceeds 150 liters per day in other localities such as Jericho. Thus, the goal of achieving justice in distribution among the localities is one of the main challenges faced by the State of Palestine (PCBS and PWA, 2019).

Table 15 below shows the quantity of water supply for domestic sector, water consumed, total losses, population and daily consumption per capita in the West Bank by governorate in 2017.

Table 15. Quantity of water supply for domestic sector for West Bank by governorate in 2017. Data source: PCBS (2017b).

Governorate	Domestic water supply (Mm³)	Domestic water consumption (Mm³)	Total Losses (Mm³)	Daily consumption per capita (l/c/d)
West Bank[1,2]	116.8	84.1	32.7	88.3
Jenin	8.2	5.8	2.4	50.4
Tubas and Northern Valleys	3.1	2.3	0.8	103.1
Tulkarm	10.4	6.4	4.0	93.8
Nablus	14.5	10.0	4.5	70.4
Qalqiliya	8.2	6.1	2.1	148.2
Salfit	3.2	2.6	0.6	94.1
Ramallah and Al-Bireh and Jerusalem	25.2	20.4	4.8	115.3
Jericho and Al-Aghwar[3]	6.4	4.3	2.1	235.3
Bethlehem and Hebron[4]	37.6	26.2	11.4	76.9

[1] Data excludes those parts of Jerusalem which were annexed by Israel in 1967. These parts are inhabited by 281,913 Palestinian citizens who are holding a Jerusalem identity card. No information on their water supply is available.
[2] This quantity is supplied for non-agricultural uses and includes water supplied for commercial and industrial uses; hence, the actual supply and consumption rates per capita are less than the indicated numbers.
[3] Includes recreational, touristic and economical activities in Jericho and Al-Aghwar governorate.
[4] Due to water supply system in Bethlehem and Hebron governorates, separation of data for each governorate is not applicable.

4.2.3.2 Water consumption in Gaza

The average water consumption in the Gaza Strip is 84 liters per capita per day (CMWU, 2017). Table 16 summarizes the total water supply and consumption per governorate. Households in the Gaza Strip currently do not use publicly supplied water as a drinking water source. Instead. the publicly supplied water is for general domestic use, such as cleaning and sanitation. The only source of drinking water is the filtered water provided by the private sector for a price significantly higher than the publicly supplied water, or through individual in-house reverse osmosis units (Ismail, M., 2003). Such results indicate the reliance on desalinated water for consumption in communities throughout Gaza.

The current cost per cubic meter of purchased desalinated drinking water from private vendors is approximately 30 NIS/m³, including the delivering cost (CEP et al., 2015). The CMWU, the public service provider, charges between 0.5 NIS/m³ and 2 NIS/m³, however, the water is of a lower quality and often not suited for drinking. Therefore, households deal differently with the two sources of water. They usually have different systems to deal with drinkable water, such as special tanks and pipes that are frequently cleaned, while the tanks and pipes for the public supplied water are not cleaned (Global Vision Consultants, 2013).

Table 16. Water supply for domestic use in the Gaza Strip by governorate, 2015. Data source: PCBS (2016a).

Governorate	Domestic water supply (Mm³)	Domestic water consumption (Mm³)	Total losses (Mm³)	Daily consumption per capita (l/c/d)
North Gaza	24.5	12.5	12.0	92.5
Gaza	32.4	19.0	113.4	81.9
Middle Area	14.9	7.5	7.4	76.4
Khanyounis	13.8	8.7	5.1	68.7
Rafah	9.7	5.8	3.9	69.2
Total	**95.3**	**53.5**	**41.8**	**79.2**

4.2.4 Wastewater collection and treatment

4.2.4.1 Wastewater in the West Bank

Wastewater quantities, generated in Palestine, are estimated at 106 MM³ per year, of which 62 MM³ are generated in West Bank; including municipal and industrial wastewater. Only 60% of the generated quantity is collected. This is in addition to 35 MM³ per year of untreated wastewater discharged by Israeli settlements and industrial zones into the West Bank environment. Sewage networks in the West Bank are limited to main cities with partial coverage in most cases, which makes wastewater treatment infrastructure incapable of dealing with all collected wastewater quantities and wastewater in many West Bank cities is still discharged into wadis and natural waterways. In some cases, wastewater even flows beyond West Bank boundaries, where it is collected and treated in treatment plants built originally to treat the Israeli wastewater or plants built specifically to treat the Palestinian wastewater crossing the borders (PWA, 2016).

4.2.4.2 Wastewater in the Gaza Strip

The National Water and Wastewater Strategy for Palestine cites the overall sewage network coverage in the Gaza Strip as 72% for 2011; coverage and wastewater generation per governorate is given in Table 17 (PWA, 2013).

Table 17. Sewage network coverage and wastewater generation in the Gaza Strip in 2011. Source: PWA (2013).

Governorate	Sewage network coverage	Wastewater generated
North Gaza	80%	8.40 Mm³/yr
Gaza	90%	21.90 Mm³/yr
Middle Area	75%	3.65 Mm³/yr*
Khanyounis	40%	3.65 Mm³/yr
Rafah	75%	3.65 Mm³/yr

Total	**72%**	**41.25 Mm³/yr**

* No treatment in the Middle Area, wastewater is discharged into the Wadi Gaza

About 83.5% of households in the whole Gaza Strip were disposing their wastewater via the sewage network in 2015, while about 9.8% were using porous cesspits and about 6.7% were using tight cesspits (PCBS, 2016). According to CMWU plans, new connections are planned to increase the sewage network coverage in Khanyounis city to 83% of the population and in the surrounding areas in the same governorate to 63% of the population (CMWU, 2017) New connections are continuing to be implemented, that is in 2025, 83% of the population of Khanyounis city and 63% of the population in the surrounding area are expected to be served by piped sewage system (CMWU, 2017).

In general, the Gaza Strip wastewater network is developed as conventional, gravity systems. They are designed to be separate from storm drainage. However, the separation is not fully effective and storm flows do enter the sewers in the frequent winter storms.

Currently, there are five existing wastewater treatment plants in the Gaza Strip, as shown in Figure 4.1, two of them are considered as intermediate plants located in Gaza (Sheikh Ejleen) and Rafah cities along with two temporary treatment plants in Khanyounis (Mawasi WWTP) and the newly constructed Wadi Gaza WWTP, and one central plant in Jabalia (NGEST). Another intermediate WWTP used to be located in Beit Lahia; this plant was closed when the NGEST started operating. Moreover, the intermediate WWTP in Rafah will be upgraded to a permanent WWTP of 20,000 m^3/day capacity, to serve Rafah Governorate (ALMADINA Consultants, 2016).

Three central WWTPs are proposed to serve the Northern, the Middle and Gaza and the Khanyounis governorates (Figure 23). The northern governorates will be served through the Northern Gaza Emergency Sewage Treatment (NGEST) plant, which started operating in early 2018 with a total capacity of 36,000 m^3/day. The Gaza and the Middle Area governorates will be served by the Gaza Central WWTP which is expected to be fully implemented by 2047, with a total capacity of 180,000 m^3/day (Dorsch International Consultants and TECC, 2015). Lastly, in the Khanyounis governorate, the construction of phase 1 of the Khanyounis central WWTP, with a capacity of 26,600 m^3/day, will be completed in 2020. This plant is proposed to have a full flow capacity of 44,948 m^3/day (CMWU, 2017).

Throughout the Gaza Strip, more than 75% of the domestic wastewater is discharged into the environment without any treatment due to leakages after the collection in cesspits or due to partial treatment through overloaded treatment plants (Baalousha, 2008). Wastewater from the WWTPs is currently being disposed into the Mediterranean Sea through ca. 20 sewage outfalls; only 40% of this wastewater is properly treated (EEA, 2014). All treated wastewater from the new North Gaza WWTP (NGEST) will be infiltrated into the groundwater aquifer, while the wastewater from the existing Gaza, Wadi Gaza, Khanyounis, and Rafah WWTPs is discharged to the Mediterranean Sea (Abualtayef et al., 2017). The effluent from the two central WWTPs in Khanyounis and Al Buraij will be infiltrated to the groundwater aquifer, and discharged to the Wadi Gaza, respectively (ALMADINA Consultants, 2016; Dorsch International Consultants and TECC, 2015).

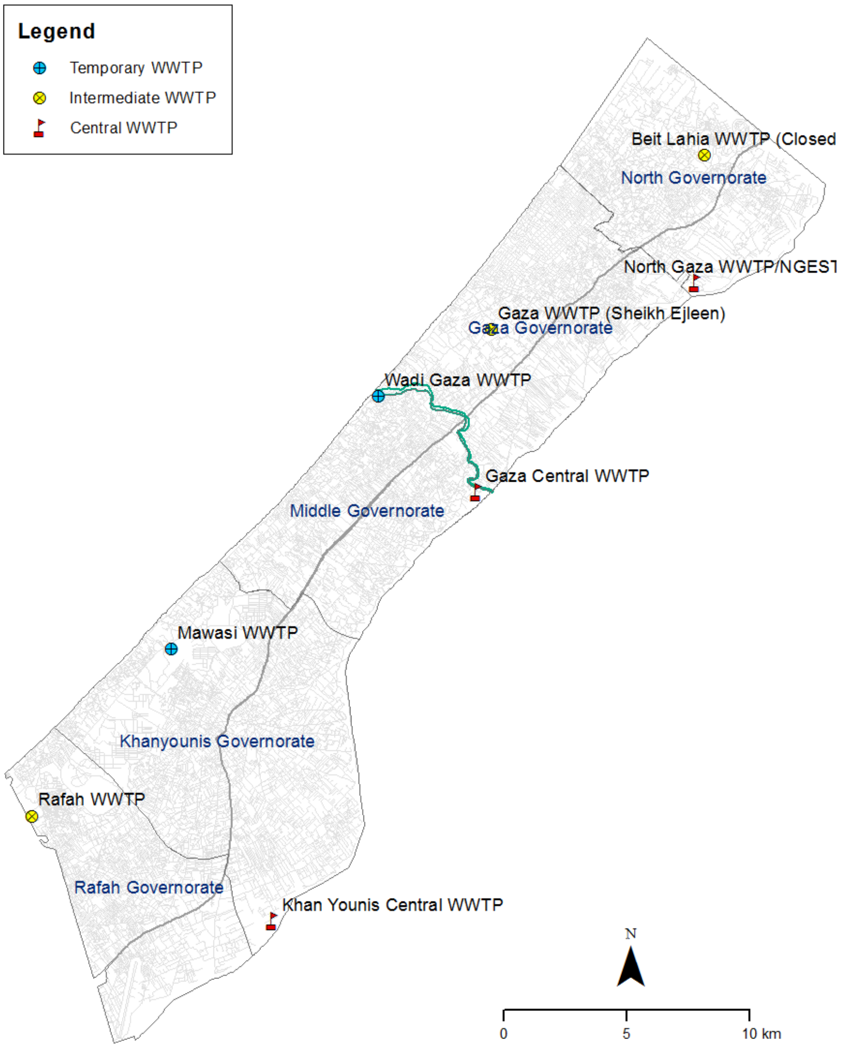

Figure 23. Current and planned wastewater treatment plants in the Gaza Strip. Source: ALMADINA Consultants (2016).

5. Local water management projects

5.1 Projects implemented by GVC Italia

The Italian NGO GVC Italia, project partner of this research, implements and manages a number of humanitarian and development projects in the Middle East region. The two projects analysed as case studies in this research are introduced below. Both projects are funded by UNICEF and require annual re-application for new funds.

5.1.1 Emergency water supply in the West Bank

The project is fully titled “Emergency Supply of Water Trucking to vulnerable communities in Area C of the West Bank” and has been running since 2014. The project aims to improve the access to drinkable water for the most vulnerable households in Area C through increasing their connectivity with Area A and B. It includes the provision of an institutionalised, efficient and predictable service of distribution of safe high quality drinkable trucked water, within a multilevel governance system. High quality, safe drinking water is supplied to the targeted communities at a subsidized rate throughout summer.

Target communities in Area C are identified each year based on the following criteria (humanitarian benchmarks):

- Daily per capita water consumption below 60 L
- Water price above 20 NIS/m³

The 58 communities targeted in the 2018 project cycle are highly dependency on the direct purchase of water and rely exclusively on water supplied by water trucks for 84% of the summer months. Water prices range between 20 and 50 NIS/m³.

In an internal assessment report on the year 2016, the geographic split of the then 72 targeted communities is shown, with a clear focus on the Hebron governorate (Figure 24).

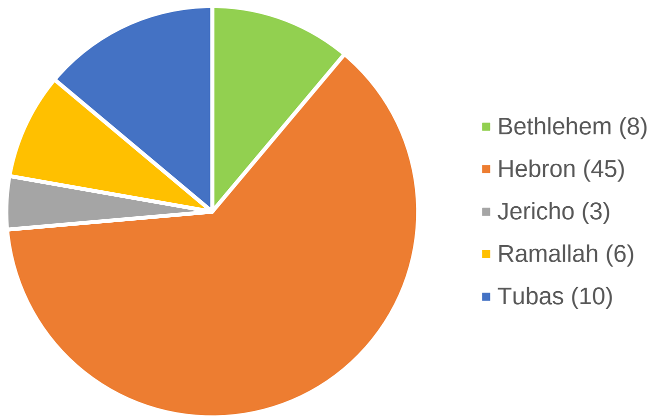

Figure 24. Number of targeted communities over different West Bank governorates in 2016.

The project is based on the precondition that political stability can guarantee physical access to the target area. Without access to the area, it would not be possible to provide water services via trucks or to monitor the service provision. Internal GVC documents further identify four sources of risk to the projects effectiveness (Table 18).

Table 18. Risks and their impacts on the West Bank emergency water supply project identified in internal GVC documents.

Risk	Impact
Bureaucratic obstacles delay the procurement of materials	Coupons needed for the service provision will not be available as scheduled.
The filling point cannot guarantee sufficient water availability throughout the implementation of the project	There will not be enough water to fulfill all the communities' needs. No trucks will be used.
The Israeli civil administration or army imposes seizures or confiscations of the water trucks	Trucks will be stopped and it will be impossible to adequately provide service to the communities. Police fees might incur.
The local authorities are unable to fulfill their duties and provide the public service	Water distribution services will be inefficiently provided. There will be increased waiting times for water delivery.

5.1.2 WASH service provision in the Gaza Strip

The project in question is fully titled "Humanitarian response to improve household WASH services for the most vulnerable families in Gaza" and has been running since 2016. The project aims to improve the access to hygiene and sanitation services for the most affected families through the rehabilitation of several WASH components at household level. The project includes, among others, the improvement of the access to services like domestic and potable water supply and storage, wastewater connections, sanitation and hygiene facilities, etc. In its 2018 cycle, the project included 960 households across four communities in three governorates, composed of 5940 people in total, 3214 of whom are children.

The infrastructural component of the project is complemented by the distribution of hygiene kits and awareness campaigns as well as the collaboration with local authorities and civil society organizations to improve local WASH competences.

Internal project documents anticipate several risk factors given in Table 19.

Table 19. Risks and their impacts on the Gaza Strip WASH rehabilitation project identified in internal GVC documents.

Risk	Impact
Deterioration of the security situation, either due to Israeli incursion or due to conflicts between political groups	Access to areas of intervention within the Gaza Strip will be limited due to movement restrictions such as checkpoints, closures and curfews. GVC staff members and beneficiaries will suffer from growing insecurity.
Tightening of the blockade around the Gaza Strip or deterioration of the economic situation	Availability and access to raw materials that are required for the project will be reduced.
Natural disasters	Access to beneficiaries will be limited, overall security for GVC staff will be reduced.
Managerial complications with second tier partners	The capacity of GVC's implementing partners will be limited with regards to fund management, supply and procurement, management and reporting. Weak internal control mechanisms at the level of the partners working within communities and households will limit oversight.

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Annex

Annex I – Type of Locality and Population in Different Governorates in the Gaza Strip (PCBS, 2016b)

	Locality Name	Locality Type	2016
Gaza Governorate	Ash Shati' Camp	Camp	45,033
	Gaza	Urban	583,870
	Madinat Ezahra	Rural	4,010
	Al Mughraqa	Rural	8,496
	Juhor ad Dik	Rural	3,795
	Urban Total		**583,870**
	Rural Total		**16,301**
	Camps Total		**45,033**
North Governorate	Umm AlNaser (Bedouin village)	Rural	3,923
	Beit Lahia	Urban	89,949
	Beit Hanoun	Urban	53,094
	Jabalia Camp	Camp	58,517
	Jabalia city	Urban	171,642
	Urban Total		**314,686**
	Rural Total		**3,923**
	Camps Total		**58,517**
Deir Al Balah Governorate	An Nuseirat Camp	Camp	37,366
	An Nuseirat	Urban	48,769
	Al Bureij Camp	Camp	31,932
	Al Bureij	Urban	13,099
	Az Zawayda	Urban	22,530
	Deir al Balah Camp	Camp	8,563
	Al Maghazi Camp	Camp	21,380
	Al Maghazi	Urban	8,696
	Deir al Balah	Urban	72,409
	Al Musaddar	Rural	2,491
	Wadi as Salqa	Urban	6,145
	Urban Total		**171,649**
	Rural Total		**2,491**
	Camps Total		**99,241**
Khanyounis Governorate	Al Qarara	Urban	25,675
	Khan Yunis Camp	Camp	48,969
	Khan Yunis	Urban	185,250
	Bani Suheila	Urban	41,174
	'Abasan al Jadida(as Saghira)	Rural	7,878
	'Abasan al Kabira	Urban	23,914
	Khuza'a	Rural	11,880
	Al Fukhkhari	Urban	7,194
	Urban Total		**283,207**
	Rural Total		**19,758**
	Camps Total		**48,969**
Rafah Governorate	Rafah	Urban	164,000
	Rafah Camp	Camp	46,541
	Al-Nnaser (Al Bayuk)	Rural	8,495
	Shokat as Sufi	Urban	14,453
	Urban Total		**178,453**
	Rural Total		**8,495**

	Locality Name	Locality Type	2016
	Camps Total		**46,541**

Annex II - Water Quality and Quantity in Gaza Municipalities (PWA, 2018)

Gov.	Municipality	Water Supply Status	Quality
North	Beit Hanoun	• Water supply through 9 water wells with a total production of 3,504,320 m^3/y. • The water network efficiency 47.6%.	• Three Water wells out of 9 comply with WHO standards for the chloride concentration. • The nitrate concentration of 8 wells is higher than WHO standard, only one well has a low nitrate concentration of less than 50mg/l. • 88.9% of Beit Hanoun municipality groundwater does not comply with WHO standard.
	Beit Lahia	• Water Supply through 11 water wells with a total production of 4,994,104 m^3/y • The water network efficiency is 40%.	• Ten water wells out of 11 comply with WHO standards for the chloride concentration • All wells have high nitrate concentration above the WHO standard.
	Jabalia	• Water Supply through 25 water wells with a Tika ground circular reservoir with capacity of 3000 m^3 located geographically in Beit lahia. • The total production is 14,256,905 m^3/y. • The water network efficiency is 55%.	• Only 17 Water wells out of 25 comply with WHO standards for the chloride concentration. • The nitrate concentration of 19 wells out of 25 wells is higher than WHO standard. • 20% of Jabalia municipality groundwater complies with the WHO standard
	Um Al Nasser	• Water supply through one well with a production of 288,633 m^3/y. • The water network efficiency is 82%.	• The Water well does not comply with the WHO standards
Gaza	Gaza City	• Water Supply through 77 wells • Al-Montar ground circular reservoir with capacity 5,000 m^3 • Al-Kawther reservoir (out of service). • The total production is 24,782,170 m^3/y. In addition to 6,401,683 m^3/y from Mekorot. • The network efficiency does not exceed 63%.	• Three out of 72 wells comply with WHO standards for the chloride concentration. More than 48% of the water wells in Gaza governorate are located in the western area of the governorate which where high chloride concentrations dominate. • The nitrate concentration of 71 wells is higher than WHO standard.

Gov.	Municipality	Water Supply Status	Quality
			**72 out of the total 77 water wells were included in the quality study, since the other five wells were still newly constructed.
Middle Area *	Al Zahra	• Water supply through two wells and one reservoir • The total production is 355,640 m^3/y. • The water network efficiency is about 63.2%.	• The chloride concentration of these two wells is higher than WHO standard. While the nitrate concentration comply with WHO standard.
	Al Moghra-qa	• Water supply through two water wells with a total production of 701,800 m^3/y. • The water network efficiency in the governorate is 40.5%.	• The chloride concentration of one well is higher than WHO standard. While its nitrate concentration is below the WHO standard. • The chloride and nitrate concentrations of other well comply with the WHO standards.
	Al Nusairat	• Water supply through 15 water wells located in Al Nusairat and two wells located in Al Mograqa. With a total production of 3,325,164 m^3/y. • Mekorot pipeline which provides 979,200 m^3/y. • Al-Nusairate reservoir (out of service) • The water network efficiency is 68.3%	• Only one out of the 11 wells complies with the WHO standards for chloride concentration. • Four wells out of 11 comply with WHO standards for the nitrate concentration ** 11 out of the total 15 water wells were included in the quality study
	Al Buraij	• Water supply through 8 water wells 1,562,178 m^3/y. In addition to Mekorot pipeline which provides 195,344 m^3/y. • The water network efficiency is 69.7%.	• None of the five water wells complies with the WHO standards for the chloride concentration. • Three wells out of 5 comply with the WHO standards for the nitrate concentration. ** Five out of the 8 water wells were included in the quality study
	Al Maghazi	• Water supply through 5 wells with, with a production of 957,256 m^3/year. • Mekorot pipeline, which provides 386,527 m^3/y. • A new water tank is currently under construction. • The water network efficiency is 56%.	• None of the four wells complies with the WHO standards for the chloride concentration. • Two wells out of the four wells comply with the WHO standards for the nitrate concentration. ** Four out of the 5 water wells were included in the quality study.
	Al Zawaida	• Water supply through 4 wells, with a production of 1054908 m^3/y.	• None of the four wells complies with the WHO standards for the chloride concentration.

Gov.	Municipality	Water Supply Status	Quality
		• The water network efficiency is 74.5%.	• Only one well out of the four wells complies with the WHO standards for the nitrate concentration
	Deir Al Balah	• Water supply through 13 water wells • Four water reservoirs: o Desalination plant elevated circular reservoir 100 m^3 o Abu Hamam ground rectangular reservoir 2,000 m^3 o Abu Gharaba ground circular reservoir 1,000 m^3 o Deir Al Balah reservoir (out of service). • The total production is 4,226,666 m^3/y. • The water network efficiency is 53.5%.	• None of the 12 wells complies with the WHO standards for the chloride concentration. • Two wells out of the 12 wells comply with the WHO standards for the nitrate concentration. ** Twelve out of the 13 water wells were included in the quality study.
	Al Musadar	• Water supply through 1 well, with a production of 198,021 m^3/y. • The water network efficiency is 58.6%.	• The chloride concentration of the well is higher than WHO standard. While its nitrate concentration is below the WHO standard.
	Wadi Al Salqa	• Water supply through 2 water wells and one ground circular reservoir of 350 m^3 capacity, with a total production of 241,010 m^3/y. • The water network efficiency is 66.5%.	• The well does not comply with WHO standards for the chloride concentration. But comply with the WHO standards for the nitrate concentration. ** One of these two water wells was included in the quality study.
Khanyounis	Khanyo-unis city	• Water supply through 32 wells. • 5 reservoir: o Rahma ground circular 5000 m^3 o Maan ground circular 2000 m^3 o Ayah elevated circular 500 m^3 o Saada elevated circular 300 m^3 o Saada ground circular 1000 m^3 • The total production is 8,874,391 m^3/y. The water network efficiency is 60.4%.	• Six Water wells out of 28 comply with the WHO standards for the chloride concentration. • The nitrate concentration of 27 wells is higher than the WHO standard. • 100% of Khanyounis Governorate ground water does not comply with the WHO standards ** 28 out of the 32 water wells were included in the quality study.
	Al Qarara	• Water supply through two wells, with a production of 1,355,756 m^3/y.	• The chloride concentration in the two wells is higher than WHO standard, on the other hand, the

Gov.	Municipality	Water Supply Status	Quality
		• The water network efficiency is 62.0%.	nitrate concentration is less than the WHO standard
	Bani Suhailla & Eastern Villages Municipalities	• Water supply through 7 wells. • 9 reservoirs: ○ Ground circular reservoir 1000 m^3 ○ Elevated circular 250 m^3 ○ Ground rectangular 4000 m^3 ○ Ground circular 1000 m^3 ○ Khuzaa elevated circular 150 m^3 ○ Khuzaa elevated circular 400 m^3 ○ Abassan K ground circular 1800 m^3 ○ Abassan K elevated circular 320 m^3 ○ new Abassan elevated circular 250 m^3 • The total production is 1,680,342 m^3/y. • In addition to Mekorot pipeline which provides 2,603,490 m^3/y. • The water network efficiency is 62.3%.	• None of the seven wells complies with the WHO standards for the chloride and nitrate concentration.
	Al Fukhary	• Water supply through 1 well, with a production of 286,040 m^3/y. • The water network efficiency is 66.7%	• The water well does not comply with WHO standards for the chloride and nitrate concentrations.
Rafah	Rafah city	• Water supply through 21 wells. • 5 reservoirs: ○ Saudi ground circular 2,500 m^3 ○ UNDP ground circular 3,000 m^3 ○ TIKA ground circular 3,000 m^3, ○ ground circular 4,000 m^3 ○ Ground circular 2,000 m^3. • The total production is 8,219,480 m^3/y. • The water network efficiency is 61%.	• Two Water wells out of 21 comply with WHO standards for chloride concentration • The nitrate concentration of 7 wells comply with WHO standards • 95.2% of Rafah Governorate groundwater does not comply with WHO standards
	Al Nasser	• Water supply through three wells. • One ground circular reservoir of 1800 m^3 capacity • The total production is 408,870 m^3/y.	• Two water wells comply with WHO standards for the chloride concentration • The three wells do not comply with WHO standards for nitrate concentration.

Gov.	Municipality	Water Supply Status	Quality
		• The water network efficiency is 94.0%.	
	Al Shoka	• Water supply through 4 wells, with a production of 4,013,850 m^3/y. • The water network efficiency is 61%.	• None of the four wells complies with the WHO standards for the chloride and nitrate

*Wadi Gaza Municipality is not included in the table, but its share of water production is 135,157 m^3/y. and the system efficiency is 67%.