Faculty of Graduate Studies
Institute of Environmental and Water Studies
MSc Program in Water and Environmental Engineering

The Possibility of Achieving Water Security in Palestine: Between Current and Potential Resources

إمكانية تحقيق الأمن المائي في فلسطين: بين الموارد الحالية والمتاحة

A Master Thesis

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Prof. Dr. Issam A. Al-Khatib

June 2022

BIRZEIT UNIVERSITY

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This Thesis was submitted in partial fulfillment of the requirements for the Master's degree in Water and Environmental Engineering from the Faculty of Graduate Studies at Birzeit University, Palestine.

Examination Committee Approval

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This Thesis was prepared under the supervision of Prof. Dr. Issam A. Al-Khatib and has been approved by all members of the examination committee.

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Date of Defense: June 14, 2022

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

Dedication

To the soul of my dear father

My mentor and my first teacher, who always believed in me and for whom I will be eternally thankful.

To my beloved husband and children

My strength and power, on whom I can always rely and who have accompanied me on every step of my Master's journey.

To my mother

My biggest supporter, who is always there for me.

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I would like to express my special thanks to both the Palestinian Water Authority and the Water Sector Regulatory Council for their support and the valuable data and information they provided me.

Abstract

Water scarcity in Palestine has been widely discussed in publications by the Palestinian Authority (PA), academics, and international and local organizations. However, the majority of these publications described water scarcity in Palestine, using the metric indicator of per capita allocation, rather than the state of water security, and none of them quantified the level of water security in Palestine. Because water security is a function of the human wellbeing, sustainable development, environmental protection, and political stability, addressing it from the human wellbeing perspective only obscures the importance of the other three dimensions, resulting in insufficient solutions that will stymie inclusive and sustainable growth for current and future generations. To address the gap in measuring the actual state of water security in Palestine, the Babel Water Security Index (Babel WSI) was adopted in this study. The results revealed that Palestine's score on Babel Water Security Index is 2.24 of 5, with 2.22 for the West Bank and 2.26 for the Gaza Strip. This score indicates that Palestine has a 'fair' water security state and is regarded as water insecure from the perspective of some aspects including imported water, wastewater collection and treatment, water quality in Gaza, agricultural water productivity, as well as disaster mitigation and preparedness. A nationwide survey was also conducted using the Household Water Insecurity Experiences Scale (HWISE) to identify the percentage of Palestinian households who lack access to safe, reliable, affordable, and sufficient water for their good health and wellbeing. The HWISE Scale results revealed a very high percentage of water insecure households in Palestine of 45 percent, with 43 percent in the West Bank and 48 percent in Gaza Strip.

The study also quantified and analyzed the current and future water demands for all users through 2032 to quantify the water supply-demand gap. Based on which untapped potential resources were identified and analyzed in order to determine whether developing new resources over the next ten years will result in achieving water security in the West Bank and Gaza by 2032. These untapped potential resources were developed and framed under the "most likely water scenario for 2032", which assumes that no significant progress on the permanent status negotiations will be made by then. The "most likely water scenario for 2032" revealed that if all the identified additional resources are developed by 2032 at a cost of $619 million, the West Bank's supply-demand gap will be significantly narrowed but not closed, limiting sustainable development and increasing political instability. This shows that improving water resource management practices alone will not be sufficient to achieve water security in the West Bank, given the hydropolitical dimension's dominance. As for Gaza Strip, the results demonstrated that Gaza Strip can achieve water security by 2032 with a $741 million capital expenditure, but only if critical constraints including power grid reliability, financial sustainability, and political reality are overcome. Finally, the study concludes with a set of recommendations that go beyond the untapped potential resources to help Palestine achieve and maintain a state of water security.

الملخص

تمت مناقشة ندرة المياه في فلسطين على نطاق واسع في منشورات السلطة الفلسطينية والأكاديميين والمنظمات الدولية والمحلية. ومع ذلك، فإن غالبية هذه المنشورات وصفت ندرة المياه في فلسطين، باستخدام المؤشر المتري "نصيب الفرد"، بدلاً من حالة الأمن المائي، ولم يحدد أي من هذه منشورات مستوى الأمن المائي في فلسطين. ولأن الأمن المائي اساسي ليس فقط لصحة الإنسان وانما ضروري ايضا لتحقيق التنمية المستدامة، وحماية البيئة، والاستقرار السياسي، فإن معالجته من منظور صحة الإنسان فقط يحجب أهمية الأبعاد الثلاثة الأخرى، مما يؤدي إلى حلول منقوصة من شأنها إعاقة النمو الشامل والمستدام للأجيال الحالية والمستقبلية. لمعالجة الفجوة في قياس حالة الأمن المائي الفعلية في فلسطين، تم اعتماد مؤشر بابل للأمن المائي في هذه الدراسة. أظهرت النتائج أن مجموع نقاط فلسطين على مؤشر بابل للأمن المائي هو 2.24 من 5 ، بواقع 2.22 في الضفة الغربية و 2.26 في قطاع غزة. مما يشير إلى أن فلسطين تتمتع بحالة أمن مائي "متدنية" وتعتبر غير آمنة مائيًا من منظور بعض الأبعاد من ضمنها المياه المستوردة، وجمع مياه الصرف الصحي ومعالجتها ، ونوعية المياه في غزة ، وإنتاجية المياه الزراعية ، والتخفيف من الكوارث والاستعداد لها. علاوة على ذلك، تم إجراء مسح على الصعيد الوطني باستخدام "مقياس تجارب انعدام الأمن المائي المنزلي" لتحديد النسبة المئوية للأسر الفلسطينية غير القادرة على الحصول على مياه ميسورة التكلفة ومناسبة وموثوقة وآمنة من أجل وصحتها ورفاهيتها. كشفت نتائج مقياس تجارب انعدام الأمن المائي المنزلي عن نسبة عالية جدًا من الأسر الفلسطينية التي تعاني من انعدام الأمن المائي في فلسطين وصلت الى 45 بالمائة ، بواقع 43 بالمائة في الضفة الغربية و48 بالمائة في قطاع غزة.

كما قامت الدراسة أيضًا بتحديد وتحليل الطلب على المياه الحالي والمستقبلي لجميع مستخدمي المياه حتى عام 2032 لتحديد فجوة العرض والطلب على المياه. وعلى أساسها تم تحديد وتحليل الموارد المحتملة غير المستغلة من أجل تحديد ما إذا كان تطوير موارد جديدة على مدى السنوات العشر القادمة سيؤدي إلى تحقيق الأمن المائي في الضفة الغربية وقطاع غزة بحلول عام 2032. لقد تم تطوير وتأطير هذه الموارد المحتملة غير المستغلة في إطار "سيناريو المياه الأكثر ترجيحًا لعام 2032" ، على افتراض أنه لن يتم إحراز تقدم ملحوظ في مفاوضات الوضع النهائي. وكشف "سيناريو المياه الأكثر احتمالاً لعام 2032" أنه إذا ما تم تطوير جميع الموارد الإضافية المقترحة بحلول عام 2032 بتكلفة تصل الى 619 مليون دولار ، فإنه سيتم تضييق فجوة العرض والطلب في الضفة الغربية ولكن لن يتم سدها ، مما سيحد من التنمية المستدامة ويزيد من عدم الاستقرار السياسي. وهذا يدل على أن تحسين ممارسات إدارة الموارد المائية وحده لن يكون كافياً لتحقيق الأمن المائي في الضفة الغربية ، نظراً لهيمنة البعد السياسي المائي. أما بالنسبة لقطاع غزة، أظهرت النتائج أن يمكن تحقيق الأمن المائي في قطاع غزة بحلول عام 2032 بإنفاق رأسمالي قدره 741 مليون دولار، ولكن فقط إذا تم التغلب على بعض القيود الحساسة بما في ذلك موثوقية شبكة الطاقة والاستدامة المالية والواقع السياسي. وأخيرًا، تختتم الدراسة بمجموعة من التوصيات، التي تتجاوز الموارد المحتملة غير المستغلة، لمساعدة فلسطين على تحقيق حالة الأمن المائي والحفاظ عليها.

ACRONYMS AND ABBREVIATIONS

Babel WSI	Babel Water Security Index
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe- Federal Institute for Geosciences and Natural Resources.
CMWU	Coastal Municipalities Water Utilities
DOP	Declaration of Principles on Interim Self-Government Arrangements dated September 13, 1993
EQA	The Environment Quality Authority, Palestine
ESCWA	United Nations Economic and Social Commission for Western Asia
GPCU	Gaza Program Coordination Unit
HWE	The House of Water and Environment
HWISE	The Household Water Insecurity Experiences Scale
IPCC	Intergovernmental Panel on Climate Change
MAR	Managed Aquifer Recharge
MCM	Million cubic meters
MENA	Middle East and North Africa
MFA	Ministry of Foreign Affairs
MoA	Ministry of Agriculture, Palestine
MoLG	Ministry of Local Government, Palestine
NGEST	Northern Gaza Emergency Sewage Treatment
NRW	Non-revenue water
OCHA	UN Office for the Coordination of Humanitarian Affairs
OHCHR	Office of High Commissioner for Human Rights (UN Human Rights)
OQ	Office of the Quartet
PA	Palestinian Authority
PCBS	Palestinian Central Bureau of Statistics
PWA	Palestinian Water Authority
RPI	The Rolling Program of Interventions for Additional Supply of Water for Gaza Strip
SAT	Soil Aquifer Treatment
STLV	Short Term Low Volume
UfM	Union for the Mediterranean
UN	United Nations
USGS	The United States Geological Survey
WHO	World Health Organization

WRIS	Water Regulatory Information System (of the WSRC)
WSRC	Water Sector Regulatory Council
WWTP	Wastewater Treatment Plant

UNITS

km^2	square kilometer
l/c/d	liters per capita per day
MCM/year	million cubic meters/year

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Chapter One: Introduction

1.1 Background And Significance

Water is a finite resource that is essential for life, health, food security, recreation, energy generation, economic growth, and ecological balance. Recognizing the significance of water in people's lives, the United Nations declared access to water a basic human right in Resolution 64/292 on July 28, 2010. Resolution 64/292 stated, "The General Assembly recognizes the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights" (United Nations General Assembly, 2010, p. 2). In 2003, the Office of the High Commissioner for Human Rights (UN Human Rights) broadened the legal basis for the right to water to encompass the right to adequate, safe, accessible, and affordable water for personal and household use (OHCHR, 2003, p. 1).

Despite international recognition of the right to water, Palestinians' access to their water resources is dominated by a complex and contentious hydropolitical context, resulting in their limited sovereignty over the water resources and a final resolution deferred to the final status negotiations between Palestine and Israel, which have yet to take place (Bashir & Talhamy, 2006, p. 55). In addition to the hydropolitical dimension, water security challenges in Palestine are exacerbated by over-exploitation of groundwater resources, dwindling renewable water resources, inadequate water resource management, degraded water quality, ineffective water governance, and climate change (Jarrar, 2015).

In terms of climate change, the Intergovernmental Panel on Climate Change (IPCC) predicted that global surface temperatures will continue to rise until at least the mid-twentieth century (IPCC, 2021, p. 22). Heatwaves, heavy rains, agricultural and ecological droughts are expected to become more severe and frequent as temperatures rise, while precipitation and surface water flows will become more variable intra- and interannually (IPCC, 2021, p. 15). Climate change is projected to affect the quantity and quality of groundwater available to Palestinians, as well as intensify competition for limited water resources between Palestine's ever-growing population and the agricultural sector. Furthermore, investment in climate adaptation measures is required to improve Palestinian communities' resilience to climate change. According to the Palestinian National Action Plan, the total cost of adaptation measures for the agriculture and water sectors is estimated to be $123.7 million and $89.3 million per year over ten years, respectively (Tippmann & Baroni, 2017, pp. 18-27), putting additional fiscal strain on a financially strained Palestinian Authority.

The Palestinian Water Authority (PWA) has continued to advocate for Palestine's water scarcity challenges using the per capita metric indicator (PCBS & PWA, 2021). However, when used alone, the per capita metric indicator does not correctly reflect the magnitude of Palestine's water scarcity. For example, it fails to account for the intermittent nature of water supply, conceals regional and temporal disparities in allocations, overlooks quality aspects, and fails to account for agricultural or industrial water needs. To assess the current state of water security in Palestine, this research used an international water security index that can be applied to the Palestinian context and for which reliable data are available to ensure integrity and precision. The research also undertook a nationwide survey to determine the water insecurity state at the household level using the internationally recognized Household Water Insecurity Experiences (HWISE) Scale. This was followed by the quantification of available resources, the determination of current and projected water supply-demand gaps through 2032, and the identification and quantification of untapped potential resources to determine if the West Bank and Gaza Strip can achieve water security by 2032. The results of this research are expected to lay the framework for the Palestinians water-rights negotiations by demonstrating how Palestine is inextricably related to the political context. Furthermore, the findings of this research are expected to help secure funds for the Palestinian water sector by correctly placing Palestine on the world map of water insecurity.

1.2 RESEARCH OBJECTIVES

The objective of this research are as follows:

1. Determine the current state of Palestine's water security.
2. Determine the percentage of Palestinian households who lack access to safe, reliable, affordable, and sufficient water for their good health and wellbeing.
3. Determine the current and projected water supply-demand gaps in the West Bank and Gaza Strip by 2032 and identify untapped water resources that can help West Bank and Gaza in achieving water security by 2032.
4. Determine the possibilities and scenarios for achieving water security in the West Bank and Gaza Strip by 2032.

1.3 RESEARCH QUESTIONS

The research's central question is:

- Is it possible for the West Bank and Gaza Strip to achieve water security by 2032, and if so, under what scenario?

To answer this central question and meet the stated objectives, the research aims to answer the following sub questions as well:

- What is the current state of Palestine's water security?
- What are the current and projected domestic and agricultural water deficits in the West Bank and Gaza 2032?
- Are there any untapped resources that can help West Bank and Gaza in achieving water security by 2032?

1.4 LITERATURE REVIEW

1.4.1 COUNTRY PROFILE

1.4.1.1 GEOGRAPHICAL LOCATION

Palestine is located between longitudes 34˚15' and 35˚40' east and between latitudes 29˚30' and 33˚15' north. It is one of the twenty Middle East and North Africa (MENA) countries (World Bank, 2018a), and is located on the eastern coast of the Mediterranean Sea, bordered to the north by Lebanon and Syria, to the south by the Gulf of Aqqba, to the west by the Mediterranean Sea, and to the east by Jordan (See Figure 1).

Figure 1: Geographical Location of Palestine

Source: World Atlas, 2022.

Palestine's historical area is 27,000 square kilometers (PCBS, 2021a). This research focuses on the West Bank and Gaza Strip, which together make up 6,025 square kilometers of historical Palestine, with 5,660 square kilometers in the West Bank and 365 square kilometers in Gaza Strip (PCBS, 2021a), and are currently under the Palestinian Authority's full or partial sovereignty and control (See Figure 2).

Figure 2: The Portion of Palestine's Historical Area Covered by this Research: The West Bank and Gaza Strip

Source: World Atlas, 2022

1.4.1.2 DEMOGRAPHY

It is estimated that the population of Palestine has reached 5,227,193 people by mid-2021, with 3,120,448 living in the West Bank and 2,106,745 in Gaza Strip (PCBS, 2021b). Table 1 and Figure 3 depict the distribution of this population across the Palestinian territories' sixteen governorates: eleven

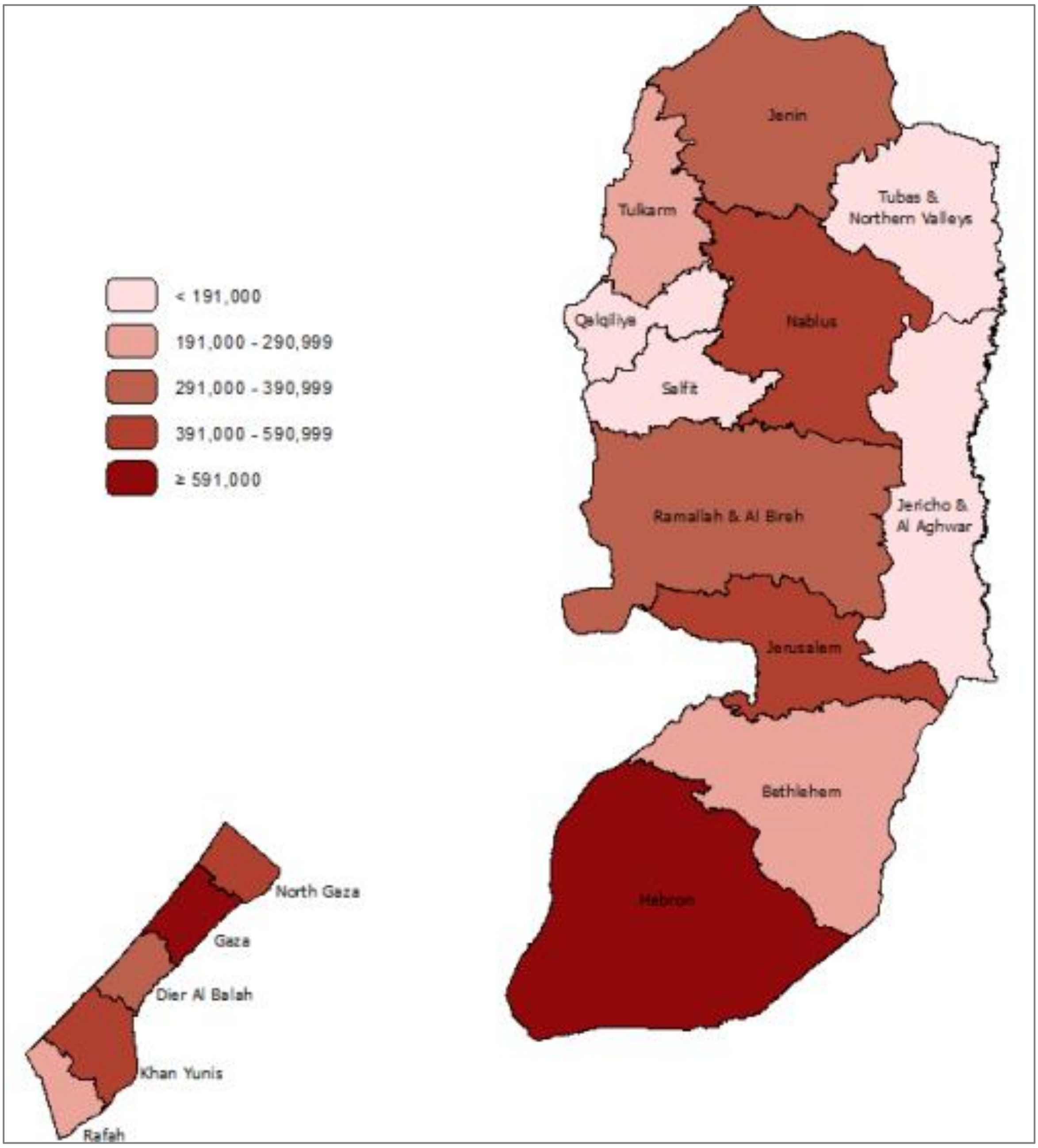
(11) in the West Bank and five (5) in Gaza Strip. The West Bank has a substantially lower population density than the Gaza Strip, which has a population density ten times that of the West Bank. Gaza Strip has a population density of 5,772 people/km^2, compared to 551 people/km^2 in the West Bank. In terms of rural-to-urban population distribution, 77 percent of the Palestinians reside in urban areas, 15 percent live in rural areas, and 8 percent live in refugee camps (PCBS, 2018).

Table 1: Estimated Population in Palestine by Governorate by mid-2021

Governorate Name	**Estimated Population (mid-2021)**
West Bank Governorates	
Jenin	338,919
Tubas and the Northern Valleys	65,915
Tulkarem	198,856
Nablus	415,606
Qalqilya	121,671
Salfit	82,099
Ramallah & Al-Bireh	355,202
Jericho & Al -Aghwar	53,317
Jerusalem	471,834
Bethlehem	234,802
Hebron	782,227
Total Population in West Bank	**3,120,448**
Gaza Strip Governorates	
North Gaza	416,906
Gaza	713,488
Dier al Balah	302,507
Khan Yunis	413,727
Rafah	260,117
Total Population in Gaza Strip	**2,106,745**

Source: PCBS, 2021b

Figure 3: Population Distribution in Palestine



Source: PCBS, 2020a, p. 10

1.4.1.3 Population Growth Rate

According to the Palestinian Central Bureau of Statistics (PCBS, 2021a), the population growth rate in Palestine in 2021 is 2.4 percent, representing the weighted average of the West Bank and Gaza Strip growth rates of 2.2 percent and 2.8 percent, respectively.

1.4.1.4 Number of Households in Palestine

The number of households in the West Bank and Gaza Strip shown in Table 2 is computed using the population figures included in Table 1 and the Palestinian Bureau of Statistics' average household size of 4.9 people per household in the West Bank and 5.5 people per household in Gaza Strip (PCBS, 2020a, p. 8).

Table 2: Number of Households in Palestine by mid-2021

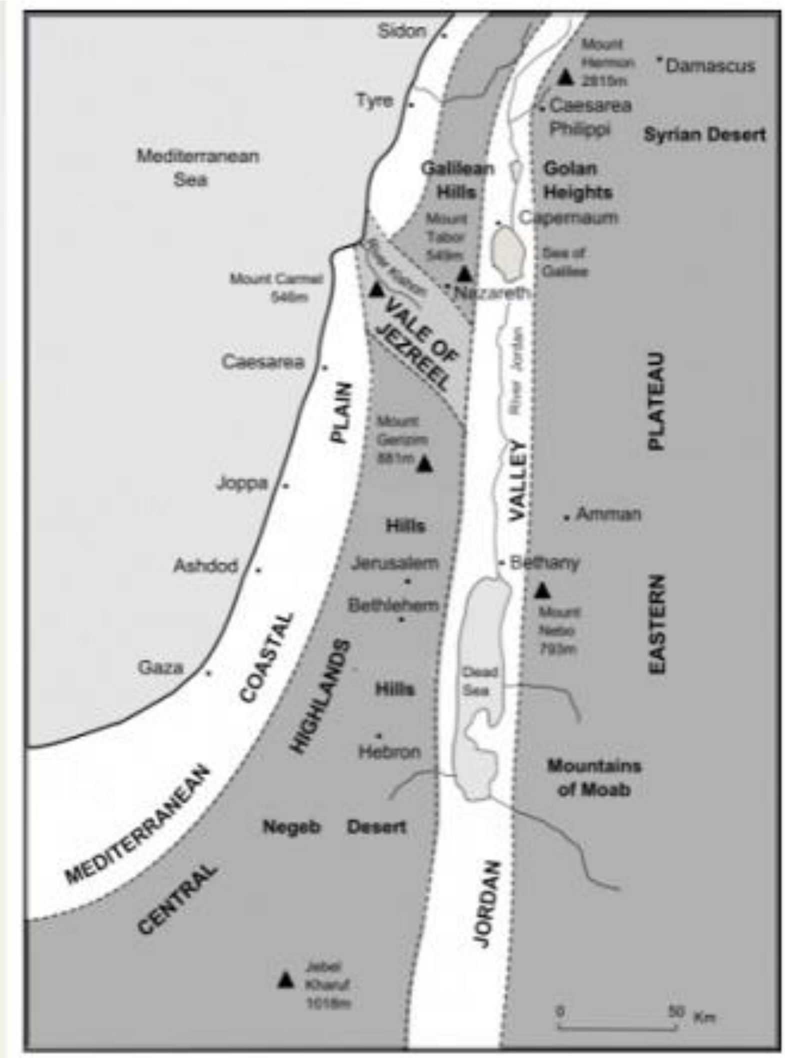
Governorate Name	Estimated Number of Households (mid- 2021)
West Bank Governorates	
Jenin	69,167
Tubas and the Northern Valleys	13,452
Tulkarem	40,583
Nablus	84,818
Qalqilya	24,831
Salfit	16,755
Ramallah & Al-Bireh	72,490
Jericho & Al -Aghwar	10,881
Jerusalem	96,293
Bethlehem	47,919
Hebron	159,638
Total Number of Households in the West Bank	**636,826**
Gaza Strip Governorates	
North Gaza	75,801
Gaza	129,725
Dier al Balah	55,001
Khan Yunis	75,223
Rafah	47,294
Total Number of Households in Gaza Strip	**383,045**

Note. Adapted from PCBS, 2020a, p. 8 and PCBS, 2021b

1.4.1.5 Topography

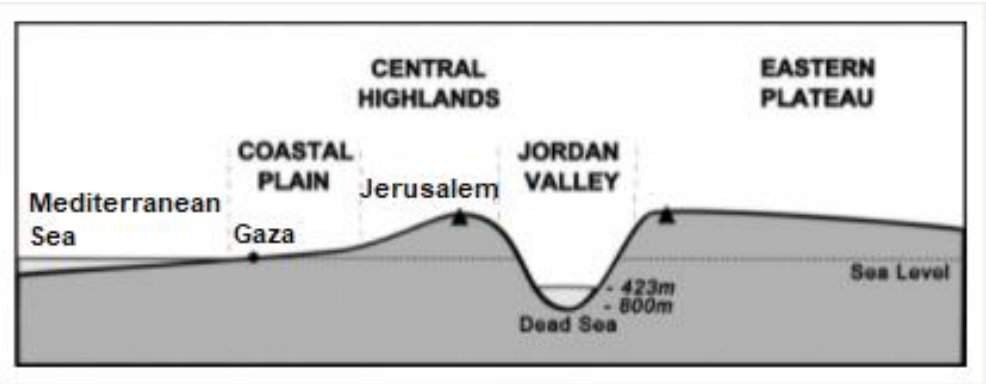
Palestine is distinguished by the clarity of its land surface forms and the simplicity of its geological formations. Figures 4 and 5 depict Palestine's landscape, which is divided into four geographical regions: Jordan valley and Ghawr, coastal and inner plains, Mountain and Hills, and Negev Desert (wafa, 2022a) (See Figures 4 and 5). Sedimentary rocks cover approximately 98 percent of the land area of Palestine, while igneous rocks cover approximately 1.8 percent and metamorphic rocks cover approximately 0.2 percent of the land area of Palestine (wafa, 2022b).

Figure 4: Landscape of Palestine



Note. Adapted from Chris & Jenifer Taylor, 2022

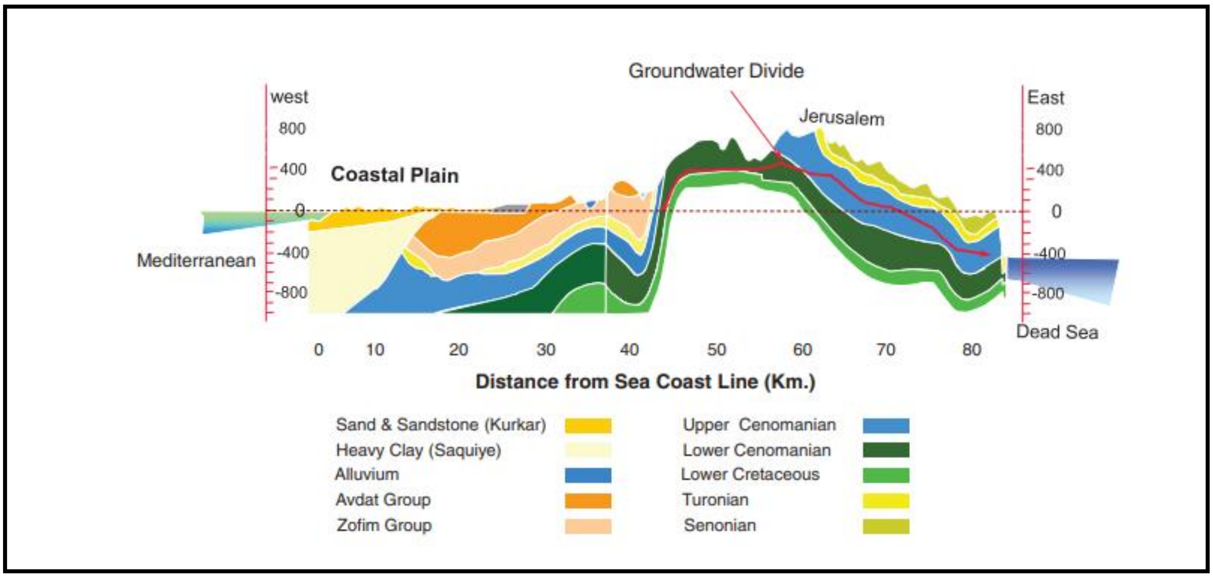
Figure 5: Simplified Cross-Section of Palestine's Landscape



Note. Adapted from Chris & Jenifer Taylor, 2022

The West Bank has four geomorphic zones: Nablus Mountains, Jerusalem Mountains, Hebron Mountains, and Jordan Valley (PCBS & EQA, 2020). These mountainous and hilly zones of the West Bank serve as the primary replenishment zone for the Mountain Aquifer, and are composed primarily of upper cretaceous limestone, dolomite, and dolomitic limestone rocks belonging to the Cenomanian Stage underlain by lower cretaceous Nubian sandstone (See Figure 6). While sandstone and dolomite outcrops can be found in the West Bank's hilly and mountainous areas, limestone outcrops are the most common rock formation running north to south. With regards to the Jordan Valley, the main soil type in the Jordan Valley is Lisan marls, which are loose diluvial marls with 10-20 percent clay content and 25-50 percent lime content (Dudeen, 2001, p. 210).

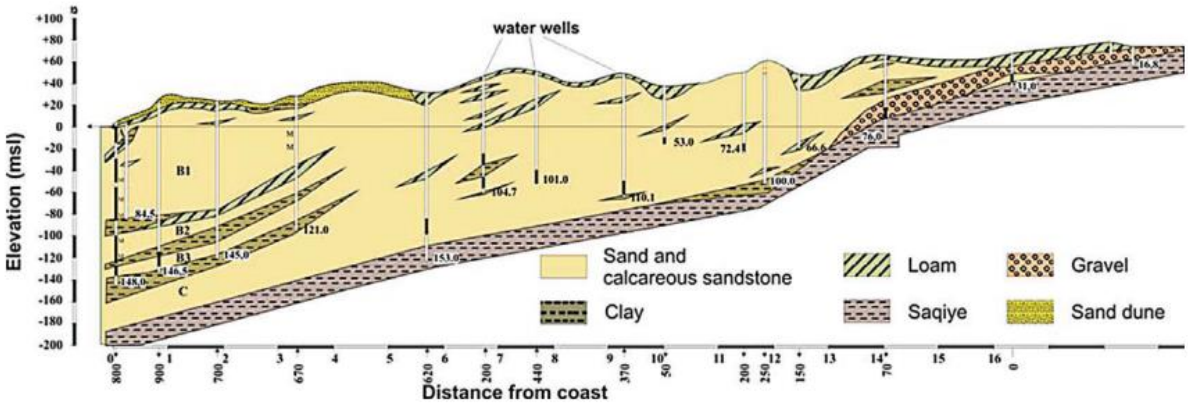
Figure 6: Geological Cross-Section of the Mountain Aquifer



Source: Schwarz et al., 2015, p. 144

The topography of Gaza Strip is divided into four ridges: Al Montar, Gaza, Beit Hanoon, and the coastal ridges, which are separated by alluvial depressions (NJS Consultants & Yachiyo Engineering, 2017, pp. 2-7). These ridges are made up of calcareous sandstones interspersed with brown-reddish, fine-grained deposits known as "hamra". Gaza Strip's soil is primarily made up of three types: sandy soil, clayey soil, and loess soil. The sandy soil can be found in the form of sand dunes along the Gaza Strip's coastline and in the middle of the strip. The clayey soil can be found in the Gaza Strip's northeastern region, while the loess soil can be found in the Wadis area (Ubeid & Albatta, 2015, p. 132). The schematic hydrological cross section of the Coastal Aquifer, the primary source of water in Gaza Strip, is shown in Figure 7.

Figure 7: Schematic Geological Cross-Section of the Coastal Aquifer in Gaza Strip



Source: Schwarz et al., 2015, p. 144

Palestine's elevation ranges from 412 meters below sea level at the Dead Sea to 1,030 meters above sea level at Mount Nabi Yunis (World Atlas, 2022). The elevation map of Palestine is shown in Figure 8.

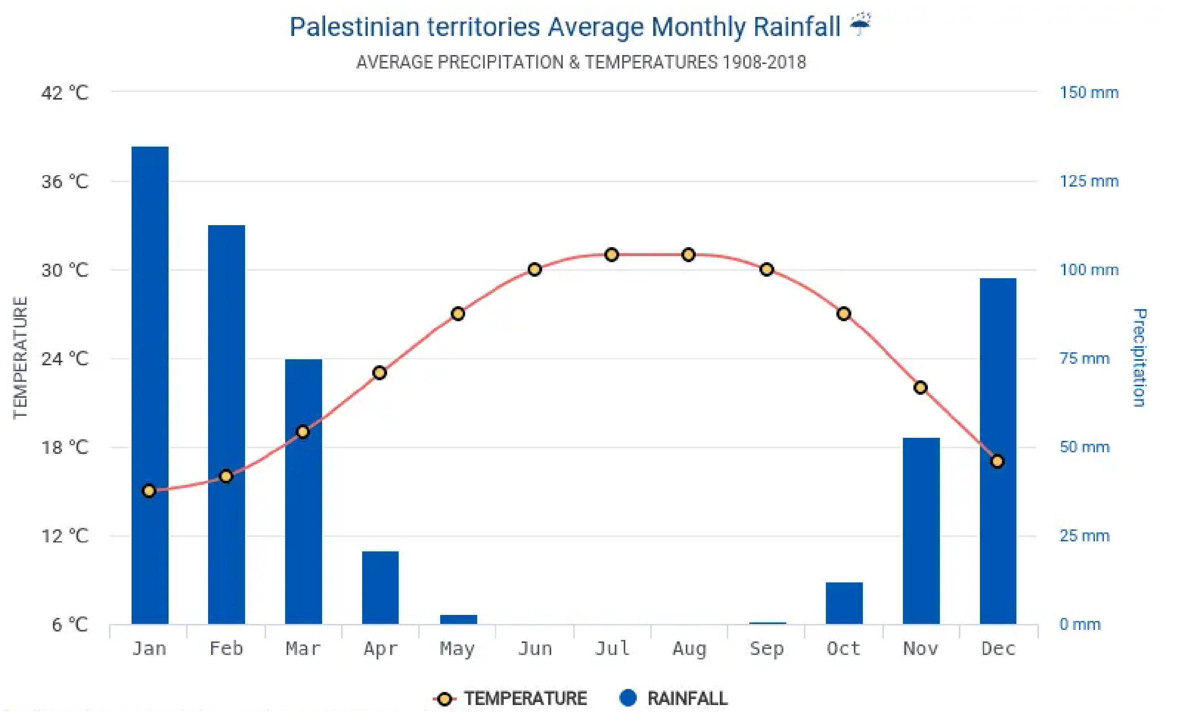
Figure 8: Elevation Map of Palestine

Source: Ighbareyeh et al., 2014

1.4.1.6 CLIMATE

Despite its small size, Palestine is known for the diversity of its climate zones, which are influenced by the Mediterranean Sea, the Sinai desert, and the Jordanian desert (wafa, 2022c). The country has three climate zones: arid (annual rainfall < 200 mm), semiarid (annual rainfall = 200-500 mm), and Mediterranean (annual rainfall > 500 mm) (Dudeen, 2001, p. 204), as well as two distinct seasons: a rainy winter from November to May and a dry summer from October to April. Despite seasonal and geographic variations, Palestine's climate is generally described as moderate, with plenty of sunshine. The average annual temperature in Palestine is 24°C. The hottest month of the year in Palestine is July, with an average temperature of 31°C, and the coldest month is January, with an average temperature of 15°C. The average annual rainfall in Palestine is 511 mm, with the majority precipitation falling in the months of January, February, and December (HikersBay, 2022) (See Figure 9).

Figure 9: Average Monthly Rainfall and Temperature in Palestine for the Period from 1908 to 2018



Source: HikersBay, 2022

1.4.2 THE GEOPOLITICAL SITUATION IN PALESTINE

The 1993 Declaration of Principles on Interim Self-Government Arrangements (DOP) was intended to be a five-year interim agreement during which Palestinian and Israeli delegates would begin negotiations on the permanent status of a number of critical issues, including Jerusalem, refugees, security arrangements, borders, and water (ARIJ, 2001). Following the DOP, several interim agreements resulted in the division of the West Bank into three areas: A, B, and C, the most recent of which was Sharm Al Sheikh III, during which the percentages of Areas A,B,C were set at 18.2 percent, 21.8 percent, and 60 percent respectively (ARIJ, 2001). Area A is under the full control of the Palestinian Authority. In Area B, the Palestinian Authority has only civil society sovereignty, not security, which Israel retains. While in Area C, Israel retains complete control over land, security, people, and natural resources (PCBS, 2017a). Table 3 below shows the West Bank area classification per governorate.

Table 3: West Bank Area Classification According to Oslo Agreement per Governorate in km²

Governorate	**Area A**	**Area B**	**Area C**	**Others**					**Grand Total (km²)**
				Natural Reserves	Jerusalem J1	Hebron H2	Not specified	Total	
West Bank	**1,000.2**	**1,035.0**	**3,375.0**	**166.5**	**71.0**	**4.0**	**8.3**	249.8	**5,660.0**
Jenin	284.5	103.5	195.2	-	-	-	0.5	0.5	**583.7**
Tubas & Northern Valleys	67.4	20.8	320.1	-	-	-	0.4	0.4	**408.7**
Tulkarem	56.1	88.0	101.8	-	-	-	0.6	0.6	**246.5**
Nablus	107.6	231.2	259.7	-	-	-	-	-	**598.5**
Qalqilya	4.0	41.0	120.0	-	-	-	0.3	0.3	**165.3**
Salfit	16.3	35.1	153.0	-	-	-	-	-	**204.4**
Ramallah & Al-Bireh	95.3	209.8	550.0	-	-	-	0.1	0.1	**855.2**
Jericho & Al-Aghwar	68.2	0.8	523.2	-	-	-	0.7	0.7	**592.9**
Jerusalem	0.9	29.2	244.9	2.4	71.0	-	1.0	74.4	**349.4**
Bethlehem	49.6	37.2	441.4	126.8	-	-	0.4	127.2	**655.4**
Hebron	250.3	238.4	465.7	37.3	-	4.0	4.3	45.6	**1,000.0**

Source: PCBC, 2017

This division of the West Bank, which was only supposed to last five years from 1993, is still in effect today, mandating the status quo. Beyond the issues of sovereignty, this division impacted Palestinians in numerous ways. Because Areas A and B are dispersed throughout the West Bank in 165 disconnected dots (See Figure 10), and the potential for urban, agricultural, and economic growth remains in Area C (B'Tselem, 2019), Palestinians' ability to develop and govern their resources has been severely hampered. In practice, Israel's sovereignty over Area C, which is the most resource-rich, provided it with the political cover it needed to control planning, construction, infrastructure, and development in Palestinian territories that connect Areas A and B.

Figure 10: Oslo II Map Outlining Areas A, B, and C in the West Bank

Source: Kersel, 2014, p. 28

Although the Gaza Strip is under Palestinian sovereignty, Israel controls entry and movement of people and goods into the strip and has been imposing a total siege on Gaza Strip since 2007. The following four crossings, which are highlighted in Figure 11, govern the flow of people and goods into Gaza Strip:

- The Erez Crossing, which is operated and controlled by Israel, is Gaza Strip's only access to the West Bank and the outside world, especially when the Rafah Crossing is closed.
- Karam Abu Salem, the primary commercial crossing, is located on Gaza Strip's southernmost tip and is operated and controlled entirely by Israel. Most construction materials are classified

as dual use by Israel, and their entry into Gaza Strip is managed by the Gaza Reconstruction Mechanism, which was activated in 2014 to give Israel the control of materials and equipment entry to Gaza Strip.

- Rafah Crossing, the only pedestrian crossing between Gaza Strip and Egypt, is governed by the Palestinian Authority and Egypt, with Israel exerting indirect authority.
- Salah Al Deen Gate, a Hamas-controlled crossing point, is used to transport goods from Egypt. Except for cooking gas, material entry through this crossing accounts for less than 10 percent of all goods entering through Karem Aby Salem.

Figure 11: Gaza Strip Crossing Points

Note. Adapted from OCHA, 2018

Understanding the current geopolitical situation including land sovereignty is crucial to effectively managing the water crisis in a realistic manner. Because water security is a function of institutions, governance, resources, and infrastructure, the opportunities and challenges presented by the current geopolitical situation must be recognized; otherwise, the plan will be merely aspirational.

1.4.3 HYDROPOLITICAL CONTEXT IN PALESTINE

The Palestinians' access to and control of their water resources is still governed by an out-of-date DOP, which was intended to serve as a 5-year interim plan until permanent status negotiations are concluded (mfa, 1993). The current political situation gives the hydropolitical dimension precedence over hydrological, geographical, geological, and demographic factors, particularly in the West Bank, as discussed further in Chapter 3.

1.4.4 LAND USE

The built-up area comprises only 8.3 percent of the total area of the West Bank and Gaza Strip, while cultivated and arable land account for 34 percent of the land area. Although rangeland covers 2020 dunums, only 621 thousand dunums are allowed for ruminant grazing, resulting in overgrazing in these regions (MoA, 2016, p. 10).

1.4.4.1 LAND USE IN THE WEST BANK

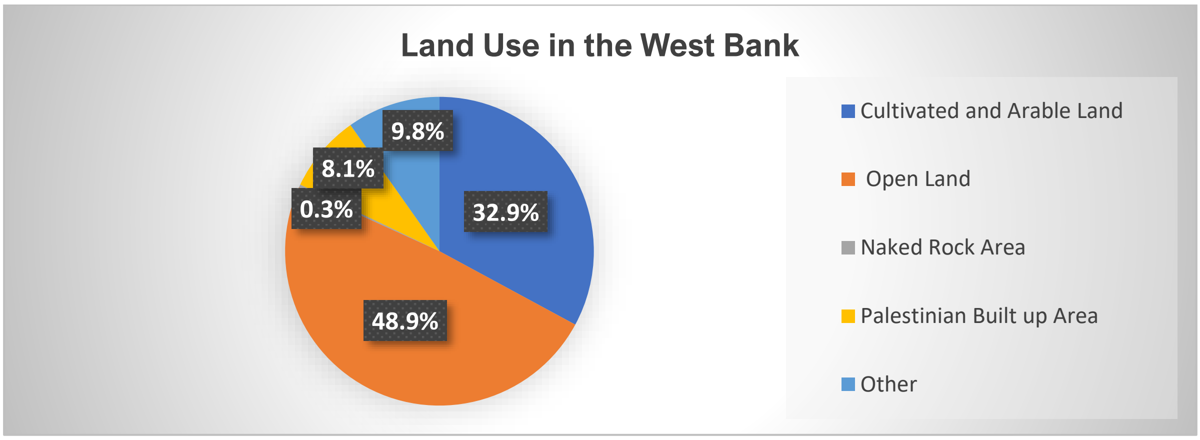
Table 4 and Figure 12 depict the different land uses in the West Bank. Out of the total 1,862 km^2 of cultivated and arable land, 1,390 km^2 are currently cultivated with fruit trees, vegetables, and field crops (MoA, personal communication, Feb 6, 2022). Furthermore, Israel declared 1,016 km^2 of the open lands as restricted military bases and confiscated 550 km^2 of the Palestinian territory for settlements, limiting Palestinian access to and control of their lands even further *(PCBS, 2019)*.

Table 4: Land Use in the West Bank in km^2

Land Use in the West Bank in km^2					
Cultivated and Arable Land	**Pasture and Open Land with no Vegetation or with no Significant Vegetation Cover**	**Naked Rock Area**	**Palestinian Built-up Area**	**Other**	**Total**
1,861.6	2,767.8	17.9	459.2	553.5	5,660.0

Source: PCBS, 2017b

Figure 12: Land Use in the West Bank



1.4.4.2 LAND USE IN GAZA STRIP

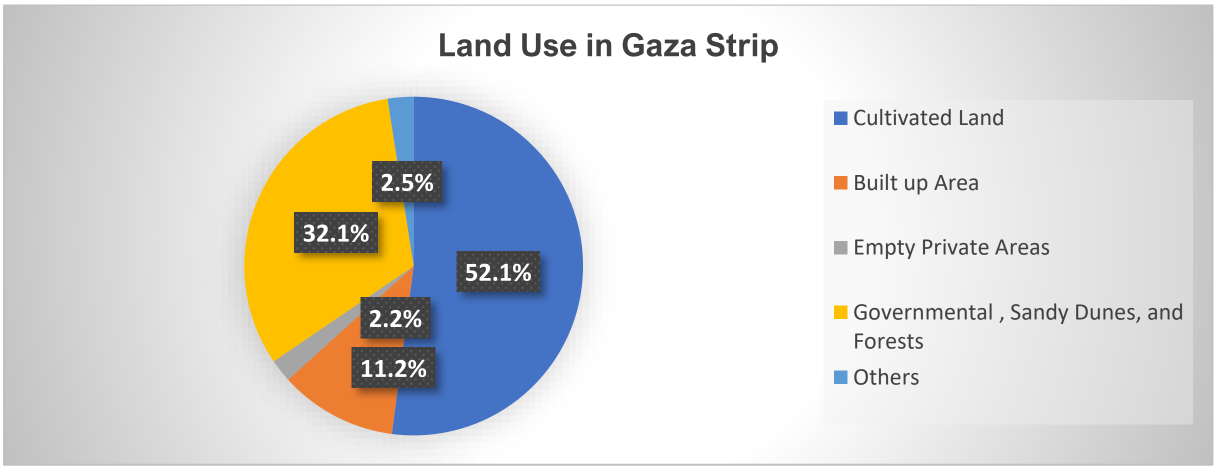
The agricultural land comprises over 50 percent of Gaza Strip's land versus a built-up area of 11 percent as shown in Table 5 and figure13.

Table 5: Land Use in Gaza Strip in km²

Land Use in Gaza Strip in km²					
Cultivated Land	**Built up Area**	**Empty Private Areas**	**Governmental, Sand Dunes, and Forests**	**Others**	**Total**
190	41	8	117	9	365

Source: NJS Consultants & Yachiyo Engineering, 2017, p. 2-10; MoA (personal communication, Feb 6, 2022)

Figure 13: Land Use in Gaza Strip



1.5 WATER SECURITY DEFINITIONS AND MEASUREMENT

Water security is critical to promoting inclusive and sustainable growth for current and future generations, and the first step toward putting the country on a water security roadmap is to measure the country's water security level using appropriate indicators. Despite the debate over whether water security can be quantified and measured, the truth is that "If you can't measure it, you can't manage it" (Patrinos, 2014). This quote, attributed to Peter Druck, the father of management, is particularly relevant to water security because it emphasizes the importance of developing appropriate water security to monitor the state of water security and track performance. However, while selecting among relevant water security indicators, special consideration should be given to the availability of reliable and timely data, as well as the cost of obtaining such data.

1.5.1 THE EVOLUTION OF THE WATER SECURITY CONCEPT

Water security is a relatively new concept that emerged in the 1990s (Marcal et al., 2021, p. 2) and has evolved since then from a narrow focus on human basic needs to a broader, all-encompassing definition that includes environmental protection, economic development, and climate-related risks. It is a concept that may be applied at all levels, including domestic, national, and global (Hoekstra et al., 2018, p. 1).

In the 1990s, water security was predominantly defined from the perspective of basic human needs, and it was framed alongside broader human security challenges such as military and food securities, with environmental factors being rarely considered (Cook & Bakker, 2012, p. 97). Water security definitions from the 1990s also overlooked the destructive forces of water. Nevertheless, it is important to note that that several early civilizations, particularly those established along floodplains, recognized the destructive force of water as well as its producing potentials and responded appropriately to these risks and opportunities, resulting in the development of great civilizations (Grey & Sadoff, 2007, p. 547).

The United Nations Ministerial Declaration of The Hague on Water Security in the 21st Century that was issued at the second World Water Forum held in 2000 was a turning point in the modern era in emphasizing the water security concept. The Ministerial Declaration of The Hague of the United Nations (UN) embraced a broader and more comprehensive water security concept that included access, affordability, ecological health, political stability, and sustainable development. The Ministerial Declaration of The Hague (2000) defined water security as:

> "Ensuring that freshwater, coastal and related ecosystems are protected and improved; that sustainable development and political stability are promoted, that every person has access to enough safe water at an affordable cost to lead a healthy and productive life and that the vulnerable are protected from the risks of water-related hazards". (p. 1)

In 2001, Malin Falkenmark took his notion of water security a step further, linking it to safe sanitation and emphasizing the importance of wastewater management in achieving water security. Falkenmark (2001) stated:

> "Water security is linked to a safe water supply and sanitation, water for food production, hydro-solidarity between those living upstream and those living downstream in a river basin and water pollution avoidance so that the water in aquifers and rivers remains usable". (p. 553)

Since then, several definitions of water security have emerged, the majority of which emphasize the dynamic relationship between water quality and quantity, the correlation between water for health and water for the environment, and the need to balance environmental, economic, social, cultural, health, and political needs to ensure sustainability (Norman et al., 2010, p. 8). For example, in 2013, UN-Water proposed the following definition to somewhat expand on the Hague's water security definition (UN-Water, 2013):

> "The capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability."

The World Bank, on the other hand, adopted the water security definition of Grey & Sadoff's which states, "water security is the availability of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies" (Grey & Sadoff, 2007, p. 545). Most recently, the Sustainable Water Partnership (SWP) program, which is supported by a team of globally recognized entities involved in water management including Winrock International, Tetra Tech, International Union for Conservation of Nature (IUCN), Stockholm Environmental Institute (SEI), World Resources Institute (WRI), CEO Water Mandate, and mWater defined Water Security as, "the adaptive capacity to safeguard the sustainable availability of, access to, and safe use of an acceptable and reliable quantity and quality of water for health, livelihoods, ecosystems, and productive activities resilient to risks and conflicts" (Sustainable Water Parternship, 2017, p. 2).

Given that water is a key enabler for economic growth, water security has attracted the attention of economic growth leaders. The World Economic Forum (2011, p.1), for example, described water security as: "the gossamer that links together the web of food, energy, climate, economic growth and human security challenges that the world economy faces over the next two decades."

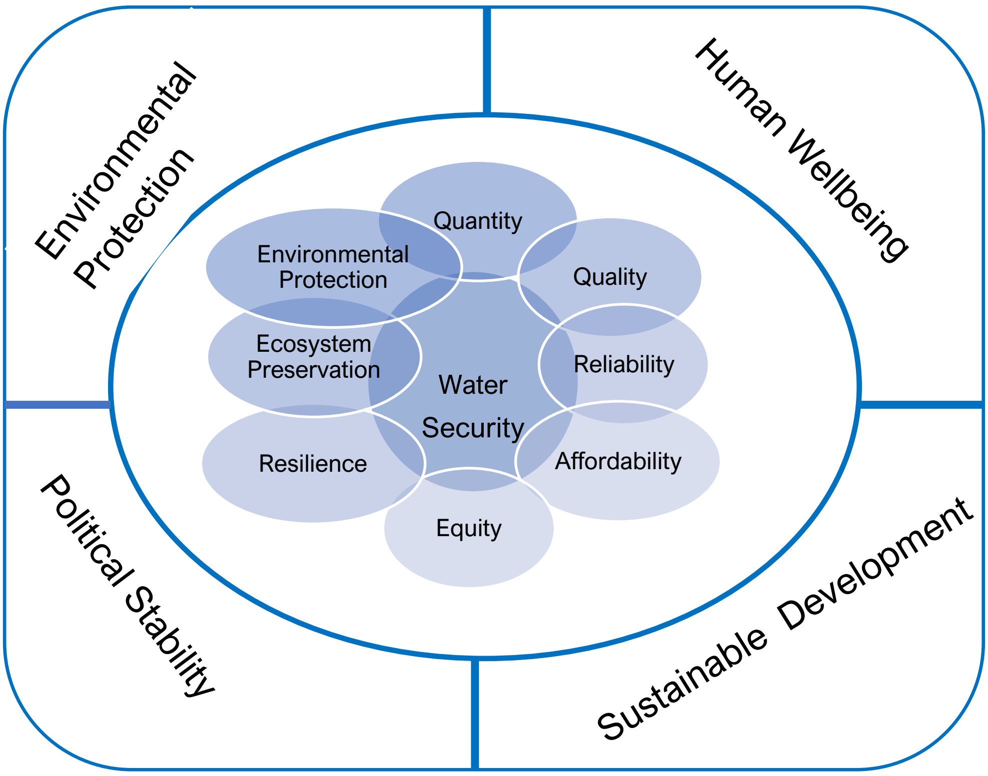
1.5.2 WATER SECURITY DIMENSIONS

The analysis of water security definitions presented by international organizations, humanitarian agencies, water practitioners, academics, and renowned economic entities reveals a broad consensus that achieving water security requires a multidisciplinary approach that address the following elements to ensure human wellbeing, sustainable development, environmental protection, and political stability (See Figure 14):

- Adequacy.
- Reliability.
- Affordability.
- Equity.
- Safe quality for intended use
- Environmental protection.
- Ecosystem preservation.

All, while harnessing the potential power of water and protecting against its destructive forces, which are expected to become more pronounced and severe with climate change.

Figure 14: Water Security Dimensions and Elements



These elements are consistent with the literature review conducted by (Hoekstra et al., 2018, p. 3), which highlighted four key foci when researchers define and analyze water security: “welfare, social equity, sustainability, and risk”.

Clearly, water security is a dynamic condition that is susceptible to changes in demography, climatic, social, economic, and political conditions over time. This adds complexity to achieving and maintaining water security on the one hand, and necessitates transitioning toward multi-level water governance, while diversifying water resources, building resilient infrastructure, and strengthening the water sector's financing on the other (Mishra et al., 2021, p. 7). Because achieving water security always involves social and environmental costs (Grey & Sadoff, 2007, p. 564), striking the right balance between infrastructure, social, and environmental needs is critical to achieving and maintaining the state of water security.

1.5.3 WATER SECURITY DRIVERS

Since water security is a dynamic condition, achieving and sustaining is a function of striking the right balance between supply and demand through effective water governance. On the water supply side of the equation, the hydrologic environment, with its inter- and intra-annual variability and spatial distribution governs the supply side to a great extent. According to Grey & Sadoff (2007, p. 548), there are three main types of hydrologic environments:

- "Easy" hydrologic legacy, with relatively little inter- and intra-annual rainfall variability.
- "Difficult" hydrologic legacy, distinguished by its short rainy season followed by a long dry season, or by substantial inter-annual rainfall variability, including flood and drought extremes.
- “Transboundary” hydrologic environment where the political dimension predominates, and the hydrologic cycle and water sovereignty become increasingly linked. The "transboundary" hydrologic environment predominates in Palestine, with Israel's control of natural resources limiting Palestinian access to water and making the management of the hydrological water cycle management more challenging.

On the demand side of the equation, water security is determined by the size of the community, the types of natural environment and key ecosystems that exist, as well as the structure and behavior of the economy and community. Managing the right balance between supply and demand requires effective water governance, which is defined by Bakker & Morinville (2013) as:

> “Range of political, organizational and administrative processes through which community interests are articulated, their input is incorporated, decisions are made and implemented, and

decision-makers are held accountable in the development and management of water resources and delivery of water services." (p. 2)

Despite having limited control over the hydrological water cycle, communities must plan for and adapt to the prevailing hydrologic environment, which is expected to be more variable in space and time as a result of rising temperatures and climate change (IPCC, 2021, p. 19).This is where water governance come into play. Effective water governance moves away from the traditional water supply paradigm and toward a more comprehensive, inclusive, accountable approach that is influenced by the nature of the water-society interaction (Empinotti et al., 2018, p. 3).

1.5.4 Difference Between Water Security and Water Scarcity

Water scarcity is defined as "the point where the demand for water exceeds supply and where available water resources are approaching or have exceeded sustainable limits" (unicef, 2021, p. 5). It is commonly assessed in terms of the amount of renewable water resources available to meet water demand. Water scarcity, in contrast to water security, ignores both a country's physical and economic capabilities to meet its water needs through non-conventional resources, as well as the water-related risks associated with its destructive forces on humans and the environment (Gunda et al., 2014, p. 99). It also obscures water's critical role in promoting peace and stability.

While most studies and humanitarian organizations, including UNICEF (2021, p. 5), distinguish between two types of water scarcity: physical scarcity and economic scarcity, Molle & Mollinga (2003, p. 531) were among the few to identify the following five categories of water scarcity, making their definition of water scarcity more comprehensive and closer to the water security concept:

1. Physical scarcity corresponds to an absolute scarcity, in which the accessible water sources are limited by nature. This is a regular occurrence in arid and desert region.
2. Economic scarcity refers to the inability to meet the water needs due to a lack of human resources or financial resources.
3. Managerial scarcity is related to weak management capacity or poor maintenance. Improper management affects the service delivery and thus induces water scarcity.
4. Institutional scarcity is a type of induced scarcity that happens when a society fails to predict supply and demand trends and falls behind in deploying required technology and structural reforms to address water-supply imbalances in a timely manner. This type of scarcity could also be caused by a lack of collaboration between upstream and downstream water users.
5. Political scarcity occurs when people are denied access to a readily available source of water because of their political status.

It is not an exaggeration to state that Palestine faces all these types of scarcity, albeit to varying degrees.

Since water scarcity is primarily concerned with the quantity of renewable water resources, it is often measured from a water stress perspective. To that extent, Falkenmark indicator is the most commonly used indicator for measuring water scarcity (Lallana & Marcuello, 2004, p. 4). This metric, also known as the 'Falkenmark stress index,' measures water scarcity from a hydrological standpoint by calculating the amount of renewable freshwater available for each person annually using equation 1, which is expressed in cubic meters per person per year:

$$\text{Falkenmark Indicator} = \frac{\text{Total renewable freshwater resources (TRWR) } in\ the\ country/region}{Population\ of\ a\ country/region} \qquad (\ equation\ 1)$$

Falkenmark et al. (1989) used equation 1 to identify four types of water scarcity: no water stress, water stress, water scarcity, and absolute water scarcity (See Table 6). Despite its widespread adoption, the Falkenmark indicator has several flaws, including delivering a value that reflects the average annual water availability without accounting for temporal and spatial variabilities, as well as ignoring the factors of affordability, reliability, and quality.

Table 6: Falkenmark Classification of Water Scarcity

Water Security Category	**Falkenmark Indicator Value (m^3/person/year)**
No Water Stress	>1,700
Water Stress	1,000 - 1,700
Chronic Water Scarcity	500 - 1000
Beyond the 'water barrier' of manageable capability or Absolute Water Scarcity	< 500

Source: Falkenmark et al., 1989, p.260

1.5.5 Selected Water Security Index: Babel Water Security Index

Water security has many dimensions that must be examined, and each of these dimensions must be turned into metrics or indicators to capture the interest of policymakers. Therefore, developing a comprehensive, universal, and robust water security indicator that captures all dimensions and can be implemented with reasonable effort, despite data limitations in certain region, is a challenging task. Over the past 20 years, water practitioners and academics have attempted to operationalize the concept of water security resulting in the release of tens of water security indicators. A recent study by Octavianti & Staddon (2021, p. 2) concluded that there are 80 distinct water security assessment tools.

Many of these metrics, particularly the non-composite indicators, have limitations because they typically target only one aspect of water security, rendering the results uncomprehensive and portraying an incomplete picture of the state of water security (Howlett & Cuenca, 2016, p. 7).

Following a thorough review of the various published water security indicators, the Water Security Index proposed by Babel et al. (2020), herein referred to as Babel WSI, emerged as a comprehensive indicator that captures the various dimensions of water security. The comprehensiveness of the Balel's Water Security Index was confirmed in Octavianti et al.'s (2021) evaluation of eighty (80) water security assessment tools, which revealed that the Balel Water Security Index is one of the most comprehensive water security indicators. Octavianti et al.'s study concluded that Babel WSI meets eight of the nine water security dimensions namely, water resources, water supply, sanitation, hygiene, water hazards, climate change, adaptive capacity, and water hazards. Apart from climate change, the study indicated that Balel WSI fulfills all of these dimensions. Though climate is not included as a standalone component in Balel WSI, it is implicitly captured within Babel WSI subcomponents of water availability, water-related disasters, and water governance.

The Babel Water Security Index was developed in 2020 to promote practical water security interventions. It is a three-tiered framework that includes five dimensions, elven indicators, and a number of recommended variables used to quantifythe indicators (Babel et al., 2020, p. 3) (See Table 7). The index's dimensions and indicators are fixed, whereas the variables are the framework's generic component, designed to capture basin-specific characteristics, making the framework adaptable and universal. Though the framework was designed for city-scale analysis, using this index at country or basin levels does not jeopardize the framework's integrity or constitute a deviation from its intended purpose because the framework's generic component is designed for adaptability to site-specific conditions. One of the reasons for using the Babel WSI is the ability to obtain reliable and valid data required to measure the generic component of the framework for both the West Bank and the Gaza Strip.

Table 7: Babel's Water Security Index Framework

Dimension	Indicator	Potential Variable
Water Supply and Sanitation	Water Availability	Per Capita water use (l/c/day)
		Number of people using improved water sources (number)
		Investment in water supply ($)
		Percentage of imported water (%)
	Accessibility	Population access to piped water (%)
		Service area coverage for piped water supply (%)
		Average distance traveled to fetch water from improved source
		Safe drinking water accessibility (%)
	Quality of water supplied	Customer satisfaction with water quality (1:n)
		Type of water treatment employed (No. unit)
		Coliform count of supplied water
		Residual Chlorine (%)
		Turbidity of water (NTU)
		pH of water supplied (no unit)
	Hygiene and sanitation	Number of people using improved sanitation facilities (number)
		Water borne diseases (%)
		Investment in sanitation facilities ($)
Water Productivity	Economic value of water	Commercial water productivity ($/m3)
		Agricultural water productivity ($/m3)
		Water wealth ($/m3)
		Water price ($/m3)
Water-related Disasters	Disaster mitigation	Disaster budget factor (%)
		Per capita GDP ($)
		Flood damage ($)
	Disaster preparedness	Drainage factor ($)
		Disaster preparedness workshop with vulnerable communities (number)
		Flood risk mapping (no unit)
Water Environment	Sate of natural water bodies	Natural quality index (no unit)
		Water quality index (no unit)
		Biochemical Oxygen Demand (BOD) in water bodies (mg/l)
	Effect of polluting factors	Wastewater treatment index (no unit)
		Water pollution factor (%)
		Industrial effluent treatment factor (%)
Water Governance	Overall management of water sector	Institution factor (Likert scale)
	Potential to adapt to future changes	Adaptability factor (Likert scale)
	Citizen support for water	Public support factor (%)

Source: Babel et al., 2020

1.6 The Household Water Insecurity (HWISE) Scale

1.6.1 HWISE Scale Objective

Household water insecurity is a term that incorporates the numerous characteristics of water acquisition and usage at the level at which they are experienced. It is described as the inability to get and benefit from safe, adequate, reliable, and affordable water for wellbeing and a healthy living (Young et al., 2019, p. 4).

Progress toward equitable and sufficient water has primarily been measured using the per capita allocation metric indicator, which, as previously discussed, masks temporal and spatial differences in access within the population and does not capture the health, economic, or psychosocial impacts of water scarcity, making household water insecurity difficult to quantify. To address this global challenge, the Household Water Insecurity Experiences (HWISE) Scale was established by a group of over forty (40) international scholars that collected data from over 8,000 families in 28 sites across 23 low- and middle- income countries (Young et al., 2019, p. 5).

The purpose of this scale is to measure household water insecurity using the twelve (12) indicators namely: Worry, Interrupt, Clothes, Plans, Food, Hands, Body, Drink, Angry, Sleep, None, Shame. Each item is framed in such a way that it captures the experiences that anyone in the family has encountered in the last four weeks.

The scale was developed for low- and middle-income countries utilizing data collected from over 8,000 households across 23 low- and middle-income countries in 28 sites (Young et al., 2019). Its cross-cultural validity and reliability in producing comparable results in a variety of ecological settings has been thoroughly demonstrated. For these reasons, it was chosen for use in this research.

1.6.2 Definition of Household per the HWISE Scale

The HWISE Scale defines a household as, “one that includes all people who sleep under the same roof and share food from the same pot.” (Young et al., 2019, p. 8).

1.6.3 Why Is the Scale Based on a 4-week Recall period?

According to HWISE Scale, water access challenges are not necessarily encountered daily. As a result, a 4-week recall interval was chosen to better capture a household's experiences with water insecurity, particularly because previous research on water insecurity has shown that a 4-week retrospective period is reliable (Young et al., 2019, p. 8).

1.6.4 HWISE Scale Elements and Questionnaire

The HWISE Scale comprises of twelve questionnaire that capture the impact of water access challenges on the daily lives of the people in order to determine the percentage of households in the targeted country or region who lack access to safe, reliable, affordable, and sufficient water for their wellbeing and healthy living (The HWISE questionnaire is included in Annex I).

1.7 Thesis Outline

This thesis is divided into four chapters. The first chapter summarizes the findings of the literature review and provides an outline of the thesis, its significance, objectives, and the questions it aims to answer. The methodology of the research is discussed in detail in Chapter 2. The third chapter presents and discusses Palestine's current state of water security; the extent of water insecurity at the household level using the Household Water Insecurity Experiences (HWISE) Scale; the quantity and quality of all available and accessible water resources in Palestine; the current and projected water demands and deficits by 2032; the untapped potential resources that could be developed within the next ten years; and the possibility of achieving water security in the West Bank and Gaza Strip by 2032. Finally, chapter four summarizes the research's findings and conclusions and offers a set of recommendations to assist Palestine achieve and maintain a water security state.

Chapter Two: Research Methodology and Approach

2.1 Research Type And Data Sources

This quantitative research aims to analyze and answer the research questions in depth through the collection and analysis of numerical data. Given that the research seeks to address several questions, data from both primary and secondary sources was collected, analyzed, and used to draw conclusions, as shown in Figure 15.

Figure 15: Data Sources Used in this Research

Primary Sources

- Governmental reports
- Statistics published by the Palestinian Central Bureau of Statistics (PCBS)
- Reports and data from the Water Sector Regulatory Council (WSRC)
- Reports prepared by service providers
- Survey
- Questionnaires
- Interviews

Secondary Sources

- Journal articles
- Manufacturers' data
- Opinion articles

2.2 Research Approach for Data Synthesis

Data was synthesized by region: West Bank and Gaza Strip because each has its own independent water resources and unique water security challenges. Furthermore, data were classified by the two main water users' sectors: domestic and agriculture since each requires different quality standards and may benefit from different additional resources. It should be noted that domestic water users include water for industrial, commercial, touristic, and governmental water use water following PWA's strategy to include them under the domestic water use (PWA, 2013).

2.3 Research Time Horizon

Given the dynamic geopolitical and hydropolitical environments, as well as the increased uncertainties involved with long-term planning, this research focused on a 10-year time horizon to improve projection accuracy and constructability of the identified additional resources.

2.4 METHOD OF DATA COLLECTION FOR SUPPLY- DEMAND GAP ANALYSIS

The analysis of water supply-demand gaps relied mainly on data obtained from primary sources, which were collected, synthesized, and cross-checked for validity and accuracy. Primary sources included published and unpublished reports and data by the Palestinian Water Authority (PWA), the Coastal Municipalities Water Utilities (CMWU), and the Ministry of Agriculture (MoA); statistics published by the Palestinian Central Bureau of Statistics (PCBS); Water Sector Regulatory Council (WSRC) reports; and National Institute for Environment and Development (NIED) reports. Additionally, data needed to analyze non-revenue water components, real losses, water quality, and percentage of domestic water allocations were obtained from the Water Regulatory Information System (WRIS). The WRIS, to which I was granted access, is a data collection and monitoring system for Palestine's water sector operated by the Water Sector Regulatory Council. Furthermore, data on the actual treatment capacity of wastewater treatment plants in the Gaza Strip were collected through interviews with plant operators.

Secondary sources, such as relevant published journal articles and research papers, were used to supplement primary sources.

2.5 SUPPLY - DEMAND GAP DATA ANALYSIS METHODOLOGY

The following equations were used to compute the domestic and agricultural water supply-demand gap

- *Population Projection in 2032:*
  Population in 2021 × (1+population growth rate)^{11}

- *Per Capita Allocation in l/c/day:*
  [(Total water supplied per governorate in MCM/year) × (1- real losses percentage) × (1- commercial, industrial, touristic, and governmental use percentage) × 1,000,000,000] ÷ [365 × population size]

- *Current /Projected Household Water Demand in MCM/year:*
  [Population size × 120 l/c/day × 365] ÷ 1,000,000,000
  The targeted per capita allocation for household use of 120 l/c/day is based on the Palestinian Water Authority's National Water Strategy for Palestine (PWA, 2013, p. 56).

- *Current /Projected Domestic Water Demand in MCM/year:*
  [Current /Projected household water demand in MCM/year] ÷ (1- commercial, industrial, touristic, and governmental use percentage)

- *Current/Projected Domestic Water Deficit (MCM/year)*
  [(Current /Projected domestic water demand in MCM/year) - (Total water available for domestic use reduced by real losses)

- *Current/projected irrigation water demand per crop type (MCM/year):*
  [Total irrigated land in dunum × estimated water demand per crop type in m^3/dunum/year] ÷ 1,000,000

- *Current/projected livestock water demand per animal type (MCM/year):*
  [Total number of livestock type × estimated water demand of the subject livestock in l/head/day $\times 365$*] ÷ 1,000,000*

2.6 METHOD OF DATA COLLECTION FOR THE HWISE SCALE

Using the Household Water Insecurity Experiences (HWISE) Scale, a nationwide survey was undertaken for Palestine to assess the degree of water insecurity at the household level. The HWISE Scale questionnaire (See Annex I) was utilized verbatim after being translated into Arabic (See Annex II) and sent to all field researchers.

2.6.1 TARGETED GROUP

The HWISE Scale survey included Palestinian households in the West Bank and Gaza Strip. Because the purpose of this survey is to reflect the experiences of all family members, not just the individual who responds, only adults who considered themselves knowledgeable about water access and use in the household were chosen to participate in this questionnaire. To avoid double counting the same household, only one adult per household was interviewed.

2.6.2 TIMING OF THE SURVEY

With the support of twelve (12) field researchers; six (6) in the West Bank and six (6) in Gaza Strip, the survey started on November 13, 2021, and was completed on November 16. The survey's timing was carefully chosen to try to reflect the average throughout the year; it was not conducted during the summer, when consumption would normally increase, resulting in more water access challenges, and it was not conducted during the winter, when consumption would normally decrease and people would begin relying on harvested rainwater, resulting in fewer water access challenges. November is recognized as a transition period between summer and winter, with outcomes that can be correlated to the all-year average.

2.6.3 SAMPLE SIZE

Using Herbert Arkin's below formula (Arkin, 1982) and the number of households in the West Bank and Gaza Strip (See Table 2), a sample size of 400 households from the West Bank and 400 households from Gaza Strip is considered a representative sample of Palestinian households.

Herbert Arkin's formula:

$$n = \frac{p(1-p)}{(SE \div t) + [p(1-p) \div N]}$$

Where:
n: sample size
N: No. of Households in the West Bank or Gaza Strip
t: Z-score corresponding to the level of significance equal to 1.96
S.E: margin of error and equal to 0.05
p: The proportion of property and equal to 0.50

2.6.4 SAMPLE DESIGN

Using the Random Cluster Sample Method, Palestinian localities were divided into 46 stratums based on governorate and locality type. Except for two governorates with no camps, there are 16 governorates with three localities: urban, rural, and camp. The total number of households in each stratum was then divided by the total number of households in the West Bank/Gaza Strip to calculate the number of clusters in each stratum, with each cluster comprising of 20 households. Following that, a regular random sampling of one household from every three households was selected. The selected clusters for this survey are shown in Table 8.

Table 8: Selected Palestinian Localities (Clusters) for the HWISE Scale

West Bank				
Serial No.	**Governorate Name**	**Locality Name**	**Locality Type (*)**	**No. of Cells**
1	Jenin	Jenin	1	1
2	Jenin	A'nin	2	1
3	Tulkarem	Tulkarem	1	1
4	Nablus	Nablus	1	2
5	Nablus	Beit Imrin	2	1
6	Nablus	Balata Camp	3	1
7	Qalqilya	Qalqilya	1	1

Serial No.	Governorate Name	Locality Name	Locality Type (*)	No. of Cells
8	Salfit	Salfit	1	1
9	Ramallah & Al-Bireh	Al-Bireh	1	1
10	Ramallah & Al-Bireh	A’rura	2	1
11	Jerusalem J2	Ar Ram	1	1
12	Jerusalem J1	Kufur Aqab	1	1
13	Bethlehem	Bethlehem	1	1
14	Bethlehem	Dar Salah	2	1
15	Hebron	Hebron	1	3
16	Hebron	Adh Dhahiriya	1	1
17	Hebron	Beit A’mra	2	1
Gaza Strip				
1	North Gaza	Beit Lahia	1	1
2	North Gaza	Jabalya	1	2
3	North Gaza	Jabalya Camp	3	1
4	Gaza	Gaza	1	6
5	Gaza	Ash Shati' Camp	3	1
6	Dier al Balah	Beir al Balah	1	2
7	Dier al Balah	An Nuseirat Camp	3	1
8	Khan Yunis	Khan Yunis	1	2
9	Khan Yunis	Bani Suheila	1	1
10	Khan Yunis	Khan Yunis Camp	3	1
11	Rafah	Rafah	1	2

(*): (1): Urban, (2): Rural, and (3) Refugee Camp

2.6.5 HWISE Scale Score Analysis

The field researchers used the HWISE Scale form (see Annex 1) to record responses to each of the twelve items, which were coded as follows: never= 0 times, rarely= 1–2 times, sometimes= 3 -10 times, often= 11-20 times, and always > 20 times. The codes were then converted to scores using the following scoring system: Never= 0 points, rarely= 1 point, sometimes= 2 points, and often and always= 3 points. The scale total score, which goes from 0 to 36, is calculated by adding the scores of all twelve questions for each household.

Before calculating the percentage of water insecure households in the West Bank, Gaza Strip, and Palestine, the collected raw data were synthesized, analyzed using the statistical software SPSS 27, and then adjusted to reflect the weight of the statistical units in the sample. The weight of statistical unit in the sample is defined as the mathematical inverse of the selection probability and is used to make the sample match the actual situation. It is computed by dividing the actual proportion of the stratum from the total number of households in the West Bank (or Gaza) by the proportion of the same stratum in the sample.

2.6.6 HWISE Scale Score Interpretation

The developers of the HWISE scale have set a cut-point of 12 for water insecure households, meaning that households with a HWISE Scale score of 12 or higher are deemed to be water insecure (Young et al., 2019, p. 15). Accordingly, the proportion of Palestinian households experiencing water insecurity was computed by dividing the number of households with a HWISE Scale score of 12 or more by the total number of households in the sample, after making the necessary adjustments to reflect the weights of the statistical unit in the sample:

$$\text{Proportion of water-insecure households} = \frac{\text{Number of households with HWISE scores} \geq 12}{\text{Total Number of households in the sample}}$$

2.7 Approach for Measuring the Water Security State in Palestine

Among the different available water security indicators that were reviewed, Babel WSI (Babel et al., 2020) was selected in this research for measuring the state of water security in Palestine for a variety of reasons, including its comprehensiveness, reliability, and adaptability to the site-specific context. The fixed parts of Babel's framework; dimensions and indicators were used as suggested by Babel et al. (2020), except for the public support indicator under the "Water Governance" dimension, which was replaced by “The Household Water Insecurity Experiences (HWISE) Scale. Additionally, twelve (12) variables relevant to the Palestinian context were carefully selected from among those recommended by Babel et al.'s list of variables shown in Table 7. When selecting these variables, attention was given to ensuring that the indicator’s quality standards, namely validity, reliability, data availability, relevance, coherence, appropriateness of data collection methods, and timeliness (Lehtonen, 2012, p. 185) could be satisfied. Table 9 shows the Babel WSI framework used in this research to calculate the water security index scores for the West Bank and Gaza Strip independently before calculating the weighted average of both scores to arrive at Palestine's water security index score.

Table 9: Babel WSI Framework Used to Calculate the Water Security Index Score for the West Bank and Gaza

Dimension	Indicators	Variables	Reference Values for Each Score				
			1	2	3	4	5
Water supply and sanitation	Water Availability	Per capita water use (l/c/d)	< 20	21-50	51-90	91-100	> 100
		Percentage of imported water (%)	> 50	30-50	10 - 29	0-9	0
	Accessibility	Population access to piped water supply (%)	< 60	60-70	71-80	81-90	> 91
	Quality of water supplied	Percentage of piped water that meet WHO drinking water standards (%)	< 50	50-60	61-75	76-99	100
	Hygiene and sanitation	Percentage of people using improved sanitation facilities (%) (i.e., connected to public sewer lines)	< 60	61-70	71-80	81-90	91-100
Water Productivity	Economic value of water	Agricultural water productivity ($/m3): Agricultural GPP/Agricultural water use)	0-2.1	2.2-5.5	5.6-20	21-50	> 51
Water-related disasters	Disaster mitigation	Disaster budget factor (%): Percentage Investment in disaster response mechanism/total budget)	0	0-1	1-5	5 - 10	> 10
	Disaster preparedness	Flood hazard areas as percentage from total area (%)	> 50	36-50	21-35	10-20	< 10
Water Environment	Effect of polluting factors	Wastewater Treatment factor (%): Percentage of wastewater treated to acceptable levels for intended use from total generated wastewater	< 60	61-70	71-80	81-90	91-100
Water Governance	Overall management of water sector	Institution Factor Questionnaire	Likert scale interpretation				
	Potential to adapt to future changes	Adaptability Factor Questionnaire	Likert scale interpretation				
	Public satisfaction with the level of water security	The proportion of water-insecure households in West Bank/Gaza Strip (%) measured using the Household Water Insecurity Experiences (HWISE) Scale	> 40	30-39	20-29	10-19	< 10

Note. Adapted from Babel et al., 2020, p. 10

2.7.1 METHOD OF DATA COLLECTION FOR BABEL WSI

The primary and secondary sources discussed in Section 2.4 were used to develop the water security scores for all variables except the institution and adaptability factors. In the case of the institution and adaptability factors, the questionnaire proposed by Babel et al. (2020, p. 8) was employed to collect the information needed to measure these two variables. The Palestinian Water Authority, the West Bank Water Department, the Water Sector Regulatory Council, and the Coastal Municipalities Water Utility were given the questionnaire in Table 10 and asked to rate their performance on a scale of 1 to 5. Using Likert scale interpretation, the responses were aggregated and averaged to produce an overall score for these two factors.

Table 10: Institution Factor and Adaptability Factor Questionnaire

Factor	**Not Yet Considered (1)**	**Under Consideration Development (2)**	**In place but not yet implemented (3)**	**Partially Implemente d (4)**	**Mostly Implemented (5)**
Institution Factor					
1. Is public opinion sought when developing water-related plans?					
2. Is there an official mechanism to monitor Non-Revenue Water (NRW)?					
3. To what extent does the tariff structure consider the full cost recovery of the service provision?					
4. To what extent the current revenue collection system and/or adopted financial system support self-sustainability of the water sector?					
5. Is there a provision to incentivize water conservation?					
Adaptability Factor					
1. To what extent do existing policies incentivize or support reuse of treated wastewater?					
2. Is there a centralized database for water related information at national and local levels?					
3. Is climate change taken in consideration when developing long-term water-related plans?					
4. Is there a system to forecast water availability?					
5. Is there a system to forecast water quality?					

Note. Adapted from Babel et al., 2020, p. 10

2.7.2 METHOD OF DATA ANALYSIS FOR BABEL WSI

To compute the Babel WSI score, each variable is first normalized in the range of 1–5 using the reference values shown in Table 10. After all of the variables have been normalized, the indicator score is calculated by aggregating and averaging all of the variables that contribute to the indicator. Similarly, the dimension score is calculated by aggregating and averaging all of the indicators that contribute to the dimension. The average of all dimensions is then used to get the Babel WSI score (Babel et al., 2020, p. 3), which is subsequently translated into qualitative description using the interpretation presented in Table 11.

Table 11: Interpretation of the Babel's Water Security Index Score

Babel WSI Score	Condition	Description
< 1.5	Poor Water Security	The country/basin is highly water insecure. It is dealing with several water-related issues. There is a lack of adequate institutional management and a lack of preparedness for future water challenges.
1.5 - < 2.5	Fair Water Security	The country/basin is water insecure in terms of some dimensions. It is dealing with some water-related issues. The country/basin needs to improve the institutional management and strengthen its preparation for future water challenges.
2.5 - < 3.5	Good Water Security	The country/basin is reasonably water secure in terms of most dimensions. It is dealing with a relatively few water-related issues. The country/basin has some institutional management and plans in place to address future water issues.
3.5 - < 4.5	Very good Water Security	The country/basin is quite water secure in terms of most dimensions. It has very few water-related issues. The country/basin has adequate institutional management and plans in place to deal with future water challenges.
≥ 4.5	Excellent Water Security	The country is highly secure in terms of all dimensions. It has no water-related issues. The country/basin has strong institutional management and is well-prepared to address future water challenges.

Source: Babel et al., 2020, p. 4

2.8 METHOD OF DATA COLLECTION FOR UNTAPPED ADDITIONAL WATER RESOURCES

The primary sources outlined in Section 2.3, as well as meetings with related stakeholders including international donors, were used to identify and analyze potential untapped resources. In terms of capital cost estimation, and in the absence of capital cost estimates from credible sources such as the PWA, the analogous estimating method combined with expert judgment was used. Manufacturers' data and opinion articles provided additional information that was used to validate the estimated costs.

Chapter Three: Results and Discussion

3.1 RESULTS

3.1.1 AVAILABLE AND ACCESSIBLE WATER RESOURCES IN THE WEST BANK

3.1.1.1 RENEWABLE FRESHWATER RESOURCES IN THE WEST BANK

Surface water and groundwater are the two renewable resources in the West Bank that Palestinians do not have access to or have limited access to because of the hydropolitical situation in which the Palestinian right to water is still governed by the out-of-date 1993 Declaration of Principles, which was intended to serve as a 5-year interim plan until permanent status negotiations on a variety of issues, including water rights, were concluded, but is still in effect to this day (mfa, 1993).

3.1.1.1.1 SURFACE FRESHWATER IN THE WEST BANK

Despite the fact that the Jordan River is an international river shared between Lebanon, Jordan, Palestine, Israel, and Syria (Tamimi, 2009, p. 141), Palestinians have had no access to the Jordan River Basin since 1967 (PWA, 2013, p. 27). Even the most recent water treaties have ignored the Palestine's right to the Jordan River Basin, notably Annex 2 of Israel and Jordan's 1995 Peace Treaty (mfa, 1995a) and the 1995 Israeli-Palestinian Interim Agreement (mfa, 1995b). Depriving Palestinians of their water rights to the Jordan River Basin is considered a violation of the 1997 United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses, the only widely accepted treaty governing shared freshwater resources. Part II, Article 5 of this treaty requires:

> "Watercourse States to participate in the use, development and protection of an international watercourse in an equitable and reasonable manner. Such participation includes both the right to utilize the watercourse and the duty to cooperate in the protection and development thereof, as provided in the present Convention". (UN, 2017, p. 4).

The Jordan River's and its tributaries' total yearly runoff is estimated to be around 1.3 billion cubic meters (Tamimi, 2009, p. 141). While, and as shown in Figure 16 and Table 12, Palestinians have no access to this date to the Jordan River Basin.

Figure 16: Jordan River Basin and Tributaries

Source: Passia, 2002

Table 12: Jordan River Basin Water Allocations between Riparian Countries

Exploited by Israel	From the Upper Jordan	130 MCM
	Diverted from Late Tiberias through the National Water Carrier	420 MCM
	Used in Tiberias Basin	90 MCM
Exploited by Syria	From Yarmouk River	160 MCM
Exploited by Jordan	From Yarmouk River	90 MCM
	From Zarka River and eastern valleys	200 MCM
	Transferred from Israel according to Peace Treaty	30 MCM
Exploited by Palestine	Denied access and utilization	0 MCM

Source: Passia, 2002

In terms of streams, PWA estimates that the average annual flow through wadis in the West Bank is around 165 MCM, with peak flows occurring during flash floods and the rainy season, making the wadis dry most of the time, except for a few weeks during the rainy season (PWA, 2013, p. 28). The amount harvested from wadis in the West Bank per year is just 1 MCM, indicating that this resource is currently underutilized.

3.1.1.1.2 GROUNDWATER IN THE WEST BANK

The Mountain Aquifer is the primary source of renewable water for Palestinians in the West Bank (PCBS & PWA, 2022). The Mountain Aquifer comprises of three basins: The Eastern Mountain Aquifer Basin, the Northeastern Mountain Aquifer Basin, and the Western Mountain Aquifer Basin. It is approximately 130 km long and 35 km wide (Fanack Water, 2022) (See Figure 17) and precipitation is the primary source of the Aquifer's natural renewable replenishment (Harpaz et al., 2001, p. 44)

Figure 17: The Mountain Aquifer and the Coastal Aquifer in Palestine

Source: Fanack after UNEP, 2002.

The Palestinian Water Authority estimates that the average annual recharge rate of the three Mountain Aquifers subbasins is between 578 MCM and 814 MCM (PWA, 2013, p. 29), while the Israeli Water Authority estimates that the average annual recharge of the three subbasins is between 731 MCM and 641 MCM, with the top range reflecting the average rate from 1973 to 1992 and the lower range reflecting the average from 1993 to 2009 (Weinberger, 2012, p. 63). However, no recent groundwater resource mapping has been done to estimate the actual sustainable safe yield based on climate change, land use changes, and actual abstraction rates from both Israelis and Palestinians. Because the aquifer safe yield is a dynamic value that reflects how the aquifer system changes over time and provides a sustainable management approach (Meyland, 2011, p. 822), Palestinians should make mapping of groundwater resources a top priority agenda item for the Joint Water Committee.

Even though the Mountain Aquifer is shared between Israel and Palestine, the share of Palestinians and Israelis is asymmetrically allocated in favor of Israel. Following the signing of the Declaration of Principles on Interim Self-Government Arrangements by the Palestine Liberation Organization (PLO) and Israel in 1993, the Israeli-Palestinian Interim Agreement – Annex III, including Article 40 and Schedule 10, was signed on September 28, 1995, and under which 20 percent of the Aquifer's estimated safe yield was allocated to Palestinians versus 80 percent to Israelis as shown in Table 13 (mfa, 1995b).

Table 13: Water Allocations from the Mountain Aquifer based on Article 40, Schedule 10 of the 1995 Israeli-Palestinian Interim Agreement

Aquifer	**Allocation for Israeli Users (MCM/year)**	**Allocation for Palestinian Users (MCM/year)**
Eastern Mountain Aquifer Basin	40	54 (+78) (Including 30 MCM from springs)
North-Eastern Mountain Aquifer Basin	103	42 (Including 17 MCM from springs)
Western Mountain Aquifer Basin	340	22 (Including 2 MCM from springs)
Total	**483**	**118 (+78)**
Allocation Percentages	**80%**	**20%**

The actual Palestinian abstraction from the Eastern Mountain Aquifer Basin, the Northeastern Mountain Aquifer Basin, and the Western Mountain Aquifer Basin for all water users was approximately 144 MCM per year in 2020 (PWA, personal communication, April 6, 2022) (See Tables 14, 15, and Figure 18). The 1995 Israeli-Palestinian Interim Agreement recognized Palestinian rights to an additional 78 MCM/year over and above the 118 MCM/year until permanent status negotiations are completed. However, due to Israel's continued denial to allow Palestinians to develop additional wells, the Palestinians have not been able to exercise this right, and they are still unable to access their remaining 52 MCM/year from the interim allocation of groundwater resources (See Table 16). It should be noted that according to Schedule 8, paragraph 1.a. of the 1995 Israeli-Palestinian Interim Agreement - Annex III, "all licensing and drilling of new wells and the increase of extraction from any water source, by either side, shall require the prior approval of the Joint Water Committee" (mfa, 1995b). Israel has taken advantage of this clause in the agreement to repeatedly deny the PWA's requests to develop new wells in the West Bank.

Table 14: Total Quantity of Accessible Groundwater Resources for Domestic Use in the West Bank by Governorate in 2020

Governorate	Annual Abstraction Rates from Palestinian Domestic Wells in the West Bank (MCM/year) (1) (2)	Annual Average Springs Discharge Allocated for Domestic Use (MCM/year) (3)	Total Quantity of Accessible Groundwater Resources Allocated for Domestic Use (MCM/year)
Jenin	6.10	0.36	6.46
Tubas and the Northern Valleys	1.60	0.00	1.60
Tulkarem	11.80	0.00	11.80
Nablus	8.70	3.09	11.79
Qalqilya	8.70	0.00	8.70
Salfit	0.20	0.28	0.48
Ramallah & Al-Bireh	1.71	0.29	2.00
Jericho & Al -Aghwar (4)	0.60	3.50	4.10
Jerusalem (5)	1.09	0.00	1.09
Bethlehem (6)	10.60	0.00	10.60
Hebron			
Totals	**51.10**	**7.52**	**58.62**

(1): These volumes represent the average annual abstraction rates from PWA- and/or local government units- owned wells. Domestic wells supply water for household, commercial, institutional, recreational, touristic, and industrial uses.
(2): Source: PWA (personal communication, April 6, 2022).
(3): Each figure represents the average spring discharge rate from 2013 through 2020 as obtained from PWA (personal communication, April 6, 2022). The amount is derived by multiplying the yearly discharge rates of all springs in each governorate by the percentage allocation for domestic use, as established by PWA's status report titled "The Reality of Water Resources in the West Bank and Gaza Strip" (PWA, 2017, p. 14).
(4): Jericho and Al -Aghwar used 3.5 MCM from Ein Sultan and Dyouk springs in 2020 (PWA, personal communication, April 6, 2022).
(5): Excluding the parts of Jerusalem annexed by Israel in 1967.
(6): Because Bethlehem and Hebron's water production and distribution systems are interconnected, the values displayed for Bethlehem and Hebron are interchangeable and difficult to separate.

Table 15: Total Quantity of Accessible Groundwater Resources for Agricultural Use in the West Bank by Governorate in 2020

Governorate	Annual Abstraction Rates from Palestinian Agricultural Wells in the West Bank (MCM/year) (1) (2)	Annual Average Springs Discharge Allocated for Agricultural Use (MCM/year) (3)	Total Quantity of Accessible Groundwater Resources Allocated for Agricultural Use (MCM/year)
Jenin	2.10	0.00	2.10
Tubas and the Northern Valleys	14.10	1.33	15.43
Tulkarem	12.80	0.00	12.80
Nablus	5.70	3.77	9.47
Qalqilya	8.40	0.00	8.40
Salfit	0.00	0.03	0.03
Ramallah & Al-Bireh	0.00	1.75	1.75
Jericho & Al -Aghwar (4)	14.40	19.81	34.21
Jerusalem (5)	0.00	0.00	0.00
Bethlehem	0.00	0.83	0.83
Hebron			
Totals	**57.50**	**27.52**	**85.02**

(1): These volumes represent the average annual abstraction rates from licensed agricultural wells only.
(2): Source: PWA (personal communication, April 6, 2022).
(3): Each figure represents the average spring discharge rate for the period from 2013 through 2020 as obtained from PWA (personal communication, April 6, 2022). The amount is derived by multiplying the yearly discharge rates of all springs in each governorate by the percentage allocation for domestic use, as established by PWA's status report titled, "The Reality of Water Resources in the West Bank and Gaza Strip" (PWA, 2017, p. 14).
(4): Jericho and Al -Aghwar used 3.5 MCM from Ein Sultan and Dyouk springs in 2020 (PWA, personal communication, April 6, 2022), and the remaining quantity was allocated for agricultural use.
(5): Excluding the parts of Jerusalem annexed by Israel in 1967.

Figure 18: Annual Abstraction Rates from the three Mountain Aquifer Subbasins in the West Bank in 2020

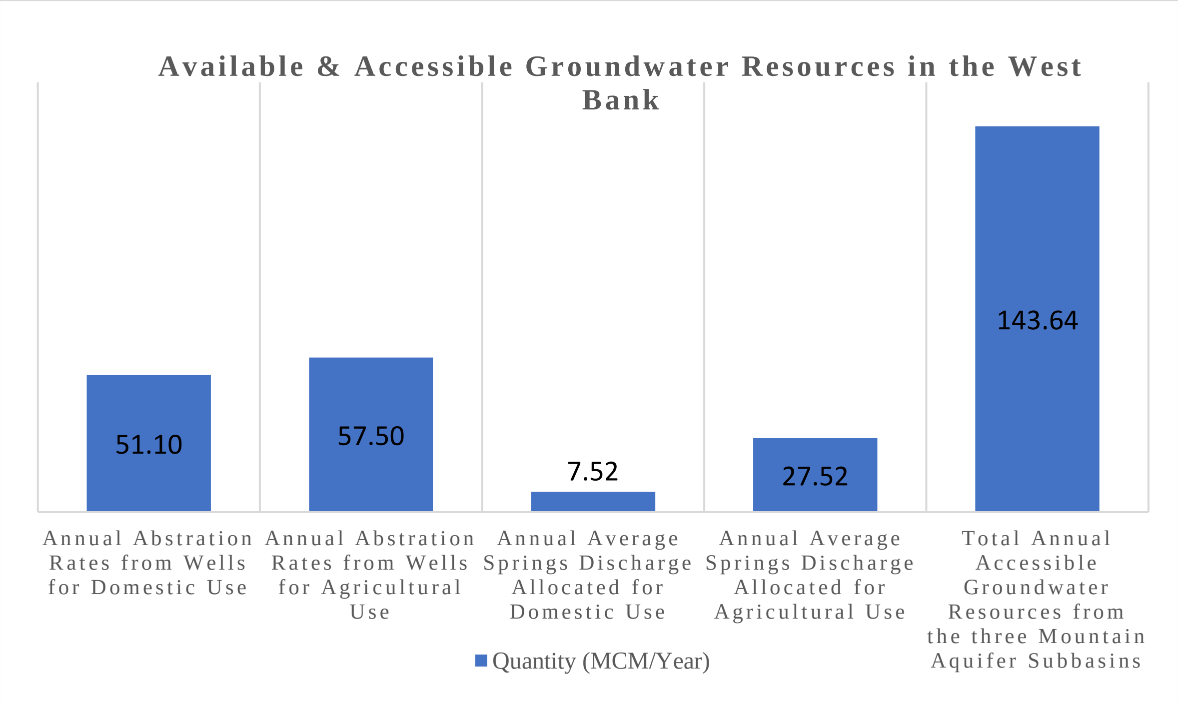


Table 16: Palestinian Allocation from three Mountain Aquifer Subbasins Per the 1995 Interim Agreement Versus Actual Abstraction Rates

Aquifer	Palestinian Allocation Per the 1995 Interim Agreement (MCM/year)	Actual Palestinian Allocation as of 2020 (MCM/year)
Eastern Mountain Aquifer Basin	54 (+78)	54.58
North-Eastern Mountain Aquifer Basin	42	46.85
Western Mountain Aquifer Basin	22	42.21
Totals	**196**	**143.64**
Groundwater Quantity Not Yet Exercised by Palestinians	**52.36 MCM/year**	

3.1.1.2 IMPORTED WATER FOR THE WEST BANK

The term imported water refers to water supplied to the West Bank by a party other than the Palestinian Authority. The water itself, however, is not imported because it includes water extracted by Israel from the West Bank's Mountain Aquifer and supplied to Palestinians on commercial terms. In other words, the water does not come from outside the West Bank's groundwater basins, but the authority extracting it is not the Palestinian Authority (PA), which is why it is referred to as imported water here.

The 1995 Israeli-Palestinian Interim Agreement was supposed to be a 5-year interim agreement until final negotiations could be completed, but in the face of stalled negotiations, it still mandates the current status quo, whereas the Palestinian population has nearly doubled since 1995 (PCBS, 2021b). To overcome the supply-demand gap, Palestinians have become more reliant on commercially purchased water from Israel through Mekorot, the National Water Company of Israel, making water access extremely vulnerable to Israeli-Palestinian political relations.

PWA purchased 77 MCM from Mekorot in 2020 for use in the West Bank, which were apportioned to the West Bank's governorates in the quantities specified in Table 17 (PWA, personal communication, January 20, 2022).

Table 17: Amount of Water Procured from Israel for the West Bank in 2020 in MCM/year

Governorate	Imported Water (MCM/year)
Jenin	2.49
Tubas and the Northern Valleys	6.53 (1)
Tulkarem	0.54
Nablus	4.65
Qalqilya	0.94
Salfit	3.24
Ramallah & Al-Bireh	18.19

Governorate	Imported Water (MCM/year)
Jericho & Al -Aghwar	2.58
Jerusalem (2)	6.41
Bethlehem	31.44
Hebron	
Total Annual Amount of Imported Water from Israel	**77.01**

Source: PWA, personal communication, January 20, 2022.

(1): Out of which 4.4 MCM/year are allocated for agricultural use in Bardalah and Kardalah PWA (personal communication, April 6, 2022).
(2): Excluding the parts of Jerusalem annexed by Israel in 1967.

3.1.1.3 TREATED WASTEWATER IN THE WEST BANK

Approximately 94 MCM/year of wastewater is generated annually in the West Bank (See Table 18). Out of which, only 11 MCM/year is treated in the 17 Palestinian wastewater treatment plants and 3 MCM/year are reused for agriculture (See Table 19) (PWA, personal communication, February 5, 2022), while the remaining treated wastewater is discharged in wadis where it gets mixed again with raw sewerage. The other 83 MCM/year of generated wastewater is either freely discharged to the environment or collected on site using cesspits and septic tanks. Table 20 shows the estimated quantity for each method of wastewater disposal.

Table 18: Annual Quantities of Wastewater Generated in the West Bank

Description	Quantity
Quantity of accessible groundwater resources allocated for domestic use	58.62 MCM/year
Amount of water procured from Israel excluding water procured for agricultural use	72.61 MCM/year
Total available water in the West Bank for domestic use	131.23 MCM
15.44% Real (physical) losses in the bulk and distribution water systems (1)	-20.3 MCM/year
Total domestic water consumption (MCM)	110.93 MCM/year
Percentage of wastewater generated to water consumption	85%
Total amount of wastewater generated in the West Bank in 2020	**94.3 MCM/year**

(1): Real Losses include leakage and overflows at utility's storage tanks and leakage on transmission mains and distribution pipes and service connections up to point of customer metering. This number reflects the average real losses derived using data from the Water Regulatory Information System of the Water Sector Regulatory Council of Palestine (WSRC, 2020a).

Particularly concerning is the 18.7 MCM/year of untreated wastewater flowing into Israel via six major transboundary streams (see figure 19). Israel treats this quantity and reuses it for agriculture in Israel, while unilaterally deducting the cost of treatment from collected Palestinian customs and value-added tax (VAT) revenues. In 2020, Israel withheld 110 million shekels for the treatment of Palestinian wastewater that flowed into Israel (World Bank Group, 2021, p. 29). Aside from the serious environmental concern that this freely discharged wastewater generates, the Palestinians are wasting a substantial amount of water that could otherwise be used for agriculture and are paying a significantly expensive cost for treatment in Israel of roughly 6 NIS per cubic meter.

Table 19: Existing Operational Wastewater Treatment Plants in the West Bank

No.	Description	Gov.	Year of Operation	Process Description	Capacity			Wastewater Reclaimed Reused	
				Technology	Design Flow m^3/day	Design Horizon	Current Flow m^3/day	Current Reuse m^3/day	Potential Reuse, m^3/day
1	Beit Dajan WWTP	Nablus	2014	Conventional Activated sludge	550	2022	150	100	0
2	Nablus West WWTP	Nablus	2013	A high rate activated sludge	14,000	2020	11,000	1,200	10,000
3	Sarra WWTP	Nablus	2014	Constructed wetland	460	2022	280	0	0
4	Hajja WWTP	Qalqilya	2014	Constructed wetland	100	2022	50	0	0
5	Anza WWTP	Jenin	2014	A conventional activated sludge	350	2022	100	80	350
6	Tayaseer WWTP	Tubas	2019	An activated sludge	4,400	2032	500	0	2,000
7	Jenin WWTP	Jenin	2013	Aerated lagoons	10,000	2030	4,000	4,000	10,000
8	Beit Hasan WWTP	Nablus	2013	Constructed wetland	200	2022	60	0	0
9	Misilyya WWTP	Jenin	2019	Constructed wetlands and storage pond	500	2020	200	0	700
10	Al-Tireh WWTP	Ramallah	2014	Membrane Bioreactor	2,000	2020	1,800	500	1,000
11	Al Bireh WWTP	Al Bireh	2000	Extended aeration/ activated sludge	5,750	2020	6,500	0	0
12	Jericho WWTP	Jericho	2014	Extended aeration/ activated sludge	9,800	2025	1,200	1,200	9,800
13	Taybeh - Rammun WWTP	Ramallah & Al Bireh	2014	Rotating biological contactors	450	2035	150	100	200
14	Rawabi WWTP	Ramallah & Al Bireh	2015	Moving Bed Biofilm Reactor	1,000	2035	500	0	0
15	Al Rehan WWTP	Ramallah & Al Bireh	2013	Membrane bioreactor	500	2030	100	0	0
16	Sa'ir Arrub WWTP	Hebron	2016	Activated sludge	1,500	2035	1,200	1,200	1,500
17	Salfit WWTP	Salfit	2022	Imhoff tank & trickling filter	2,400	2032	1,800	0	2,400
	Total quantity of wastewater treated/reused in the West Bank daily (m^3/day)						**29,590**	**8,380**	
	Total quantity of wastewater treated/reused in the West Bank annually (MCM/year)						**10.8**	**3.06**	

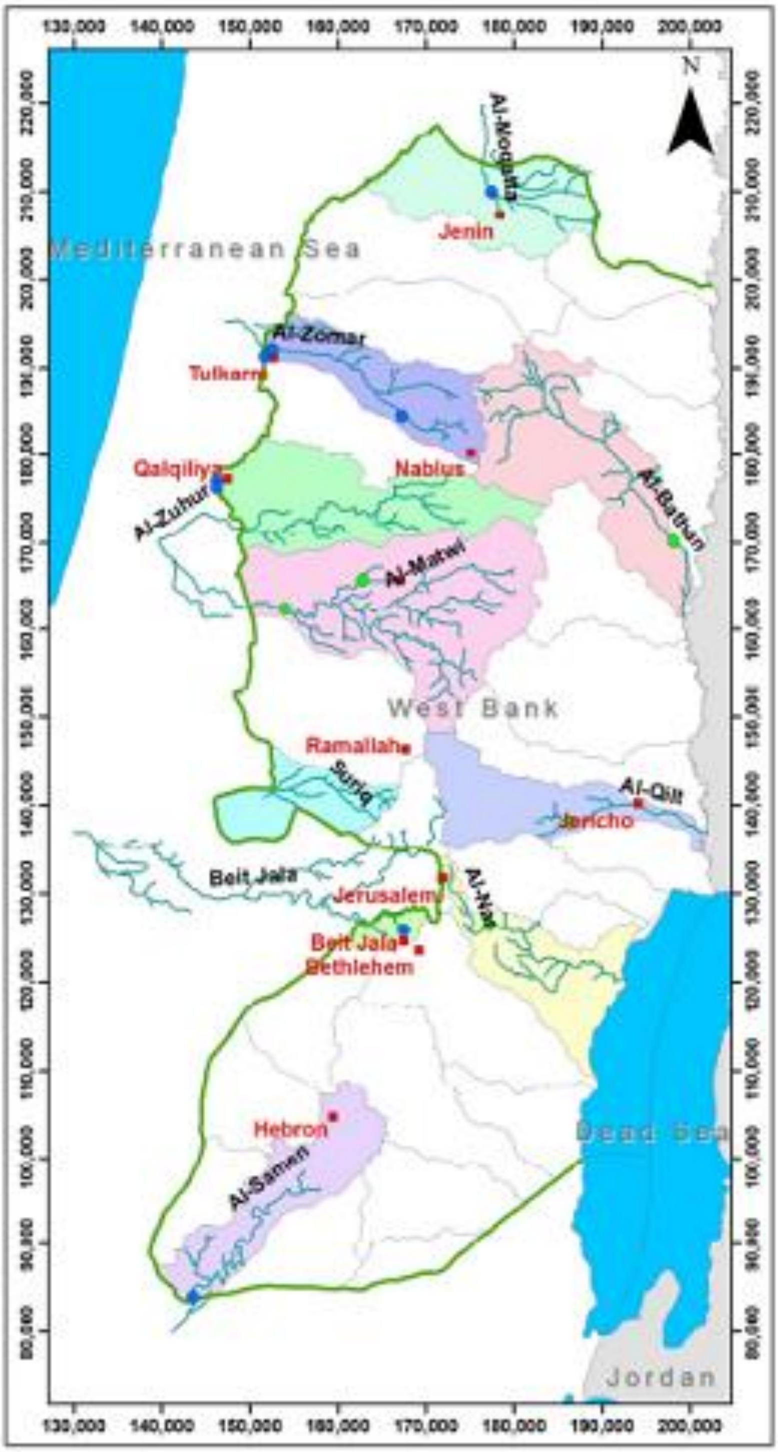
Source: PWA, personal communication, February 5, 2022

Table 20: Method of Disposal of Untreated Wastewater in the West Bank

Method of Wastewater Disposal	**Quantity (MCM/year)**
Collected and discharged in streams including treated wastewater	6.8
Collected and discharged untreated in transboundary streams flowing to Israel, including treated wastewater	18.7
On-site sanitation using cesspits and septic tanks	68.8

Source: PWA, personnel communication, April 6, 2022

Figure 19: Location Map of Transboundary Wastewater Streams in the West Bank



Source: HWE, 2012

3.1.1.4 WATER QUALITY IN THE WEST BANK

According to a recent study by Mahmoud et al. (2022, p. 13), "the majority of wells can be used for water supply after proper disinfection". The concentration of pollutants including total dissolved solids, chloride, sodium, fluoride, sulphate, heavy metals, calcium, magnesium, nitrate, and fecal coliform meet the Palestinian drinking water standards. Nevertheless, elevated ammonium concentrations were found in 50 percent of the tested wells (Mahmoud et al., 2022), which could be attributed to the free discharge of untreated wastewater into the environment, the use of porous cesspits, and leachate seepage from landfills.

The findings of Mahmoud et al. (2022), which targeted the groundwater wells are consistent with the findings of the Water Sector Regulatory Council (WSRC), which found that 92 percent of samples taken from different distribution networks in the West Bank were free of total coliform and fecal coliform. Total coliform was found in 88 percent and 33 percent of the samples obtained from the Yatta and Dhahiriyia networks, respectively (WSRC, 2020b), indicating wastewater contamination. Additionally, 100 percent of the samples taken from networks, including transmission mains, showed that the nitrate level was within the Palestinian Standards limits for drinking water, except in Zababdeh and the West Jenin Joint Service Council service area (WSRC, 2020c). The high nitrate concentration in Zababdeh and the West Jenin Joint Service Council service area requires investigation to determine the source of pollution.

3.1.1.5 SUMMARY OF ALL AVAILABLE AND ACCESSIBLE RESOURCES IN THE WEST BANK

Table 21 summarizes the annual quantities of water available in the West Bank as of 2020 for all water users. Because the quality of freshwater resources has been confirmed to meet Palestinian drinking water standards, all currently available and accessible resources are fully accounted for when determining the total quantity of available and accessible resources.

Table 21: Total Annual Quantities of Available and Accessible Water in the West Bank in 2020

Water Resource	**Annual Quantity Allocated for Domestic Use (MCM/Year)**	**Annual Quantity Allocated for Agricultural Use (MCM/Year)**
Groundwater Wells	51.10	57.50
Springs	7.52	27.52
Imported Water	72.61	4.4
Treated Wastewater	0.00	3.06
Annual Quantity per sector	**131.23**	**92.48**
Total annual quantity of available and accessible water in the West Bank	**223.71 MCM/year**	

3.1.1.6 PER CAPITA ALLOCATION FOR HOUSEHOLD USE IN THE WEST BANK

Although the average per capita allocation for household use in the West Bank is 94 l/c/day, there are considerable geographic discrepancies, with residents of Jenin receiving 54 l/c/day and residents of Bethlehem, Hebron, and Nablus governorates receiving roughly 80 l/c/day (See Table 12). The per capita allocation in these four governorates, which house over 60 percent of the population, is much below the recommended minimum allocation of 100 l/c/d of continuous supply to promote health (Howard & Bartram, 2003, p. i). These results of the per capita allocation analysis highlight the previously discussed shortcoming of this metric indicator in masking temporal and spatial differences. They also underline the importance of developing a more comprehensive water security index for Palestine that goes beyond this single metric indicator.

It should be noted that, despite common belief, the World Health Organization (WHO) has not released explicit recommendations on minimum per capita allocations (Howard & Bartram, 2003, p. 2). The WHO has published certain correlations between water allocations, water service types, and health and hygiene, such as the minimum 100 l/c/day to sustain good health.

The per capita allocation for household use is calculated based on the available and accessible water resources for domestic use after deducting the following:

1) Real losses in the water systems including leakage and overflows at utility's storage tanks as well as leakage on transmission mains, distribution pipes, and service connections up to point of customer metering. The average percentage of real losses is calculated using data from the Water Regulatory Information System of the Water Sector Regulatory Council of Palestine, which suggests that real losses in water systems account for 15.44 percent of total supply quantities (WSRC, 2020a) (WSRC, 2020d).

2) Commercial, industrial, and governmental water consumption. It is estimated that the commercial sector consumes 4.72 percent of total water sales (WSRC, 2020e); industrial sector consumes 3.42 percent of total water sales (WSRC, 2020f); and the governmental sector consumes 4.10 percent of total water sales (WSRC, 2020g), totaling 12.27 percent of total water supply.

3) Consumption in the touristic sector. The WSRC estimates that the touristic and recreational sector in Jericho consumed 21.25 percent of total water supply in 2020 (WSRC, 2020h). The touristic sector in Greater Bethlehem Area consumed 2.44 percent (WSRC, 2020i) of total

water supply, accounting for 0.6 percent of total water supply for Bethlehem and Hebron Governorates.

Table 22: Average Per Capita Allocation for Household Use in the West Bank per Governorate in 2020

Governorate Name	Population by end of 2020	Total Water Supplied (MCM/yr.)	Average Real Losses (%)	Total Water Consumed (MCM/yr.)	Commercial, Industrial, Touristic, and Governmental Use Percentage	Total Available Water for Household Use (MCM/yr.)	Daily Per Capita Allocation (l/c/day)
Jenin	335,485	8.95	15.44%	7.57	12.24%	6.64	54
Tubas and the Northern Valleys	65,211	3.73	15.44%	3.15	12.24%	2.77	116
Tulkarem	197,098	12.34	15.44%	10.43	12.24%	9.16	127
Nablus	411,680	16.44	15.44%	13.90	12.24%	12.20	81
Qalqilya	120,357	9.64	15.44%	8.15	12.24%	7.15	163
Salfit	81,162	3.72	15.44%	3.15	12.24%	2.76	93
Ramallah & Al-Bireh	351,510	20.19	15.44%	17.07	12.24%	14.98	117
Jericho & Al - Aghwar	52,836	6.68	15.44%	5.65	33.49%	3.76	195
Jerusalem (1)	165,587	7.50	15.44%	6.34	12.24%	5.57	92
Bethlehem	232,342	42.04	15.44%	35.55	12.84%	30.98	84
Hebron	772,384						
Totals	**2,785,652**	**131.23**		**110.96**		**95.97**	
Weighted average per capita allocation for household use in the West Bank (l/c/day)							**94**

(1): Excluding the parts of Jerusalem annexed by Israel in 1967.

3.1.2 AVAILABLE AND ACCESSIBLE RESOURCES WATER RESOURCES IN GAZA STRIP

3.1.2.1 RENEWABLE FRESHWATER RESOURCES IN GAZA STRIP

With Wadi Gaza becoming a wastewater stream, the Coastal Aquifer became the primary water source for the Gaza Strip, accounting for more than 90 percent of total accessible resources. Because of the sole reliance on the Coastal Aquifer, it has been overexploited and contaminated to the point where 97.5 percent of its water has become unsafe for human consumption (PCBS & PWA, 2022).

3.1.2.1.1 SURFACE FRESHWATER IN GAZA STRIP

Wadi Gaza is Palestine's only natural wetland ecosystem, designated as a natural reserve site by the Palestinian Ministry of Environmental Affairs in June 2000 (Yaghi, 2019). This 105-kilometer-long wadi has a catchment area of approximately 3,500 km^2 and originates in Naqab and the southern heights of Hebron (El-Hallaq, 2019, p. 1). As it enters the east borders of Gaza Strip, it bends and turns for 9 kilometers until draining into the Mediterranean Sea (Yaghi, 2019) (See Figure 20). This natural reserve, which UNESCO describes as, "a unique area characterized by a high degree of biological diversity, including globally threatened, endemic, and rare species" (Permanent Delegation of Palestine to UNESCO, 2012), has turned into a wastewater stream and illegal dump site, receiving tons of solid waste every day (GVC & MA'AN Development Center, 2018). Additionally, upstream dams and diversion schemes implemented by Israel have cut off Wadi Gaza's natural rainfall flow (GVC & MA'AN Development Center, 2018); (ESCWA & BGR, 2013, p. 495). This, together with Palestinian wastewater and solid waste discharge into the Wadi, resulted in the degradation and loss of a vital surface water resource capable of supplying 20 million cubic meters of water per year (PWA, 2013, p. 28); (GVC & MA'AN Development Center, 2018).

Figure 20: Geographic Location of Wadi Gaza

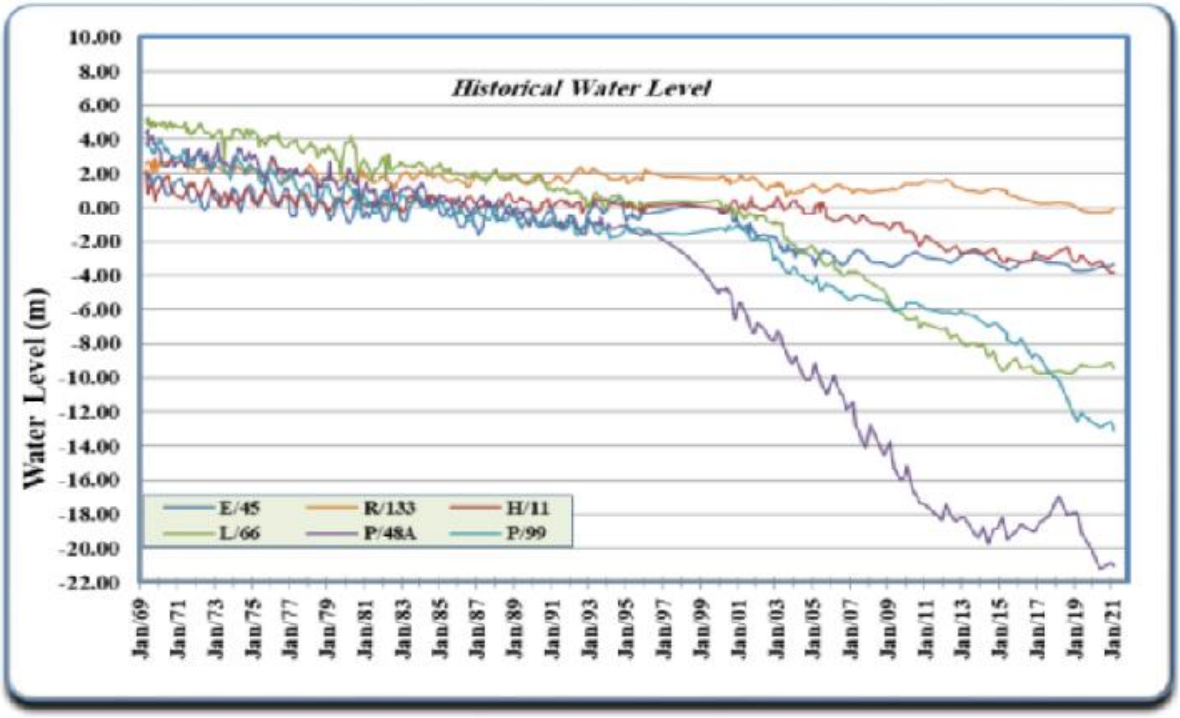
Source: El-Hallaq, 2019

3.1.2.1.2 GROUNDWATER IN GAZA STRIP

The Costal Aquifer Basin is Gaza Strip's only source of renewable freshwater water (Abu-alnaeem et al., 2018, p. 973). The Coastal Aquifer is mostly an unconfined transboundary aquifer shared by Palestine, Egypt, and Israel. It extends 390 kilometers along the eastern Mediterranean coast, from Israel's Mount Carmel to Egypt's northern Sinai Peninsula via the Gaza Strip, with a length of 40 kilometers and a width of 7-13 kilometers in Gaza (ESCWA & BGR, 2013, p. 490).

Studies suggest that the estimated sustainable yield of the Coastal Aquifer is 50-60 MCM (ESCWA & BGR, 2013, p. 495); (PCBS & PWA, 2022). However, the Coastal Aquifer has been overexploited to more than three times its sustainable safe yield, with PWA records indicating that abstraction from the Coastal amounted to 190.5 MCM in 2020 (See Table 23). The overexploitation of this aquifer resulted in a decline in groundwater water level. The water level decline began to take a steeper turn in 1995, according to PWA statistics (See Figure 21), with the western section of the Rafah area having the largest decline of 21 m since 1995 (PWA, 2021, p. 4).

Figure 21: Historical Water Level in Selected Wells in Gaza Strip Showing Water Levels Decline Trends



Source: PWA, 2021

There are 290 PWA/CMWU-owned domestic wells in Gaza Strip, in addition to 9 wells owned by UNRWA. However, there are no reliable data on the number of agricultural wells in Gaza Strip, nor their geographical location. As shown in the Table 23, total abstraction from the Coastal Aquifer in 2020 was 190.5 MCM/year.

Table 23: Abstraction Rates from the Coastal Aquifer for All Users in 2020

Governorate Name	**Annual Abstraction Rate from Groundwater Wells Owned by PWA/CMWU (m^3/year)**	**Annual Abstraction Rate from Groundwater Wells Owned by UNRWA (m^3/year)**	**Total Annual Abstraction Rate from the Coastal Aquifer (m^3/year)**
Domestic Use [(1)]			
North Gaza	25,002,853.0	2,113,148	27,116,001
Gaza	28,933,087.0		28,933,087
Dier al Balah	13,462,008.0		13,462,008
Khan Yunis	13,111,423.0	149,053	13,260,476
Rafah	10,578,072.0	190,833	10,768,905
Total Abstraction Rate for Domestic Use	91,087,443.0	2,453,034	93,540,477
Agricultural Use			
Total Abstraction Rate for Agricultural Use			97,000,000.0
Total Annual Abstraction Rate from the Coastal Aquifer in 2020 (m^3/year)			190,540,477.0

Source: PWA, 2021

(1): Domestic use includes household, commercial, institutional, recreational, touristic, and industrial uses.

Several factors contributed to the over-exploitation of the Coastal Aquifer, including poor management, rapid population growth, frequent wars on Gaza Strip, which caused international donors to reconsider funding large-scale projects in Gaza Strip, as well as Palestinian Authority fiscal constraints and siege imposed on Gaza Strip, which hampered the development of additional non-conventional resources.

3.1.2.2 IMPORTED WATER FOR GAZA STRIP

The term imported water refers to water brought into Gaza by Mekorot from outside the Gaza Strip. The Palestinian Water Authority receives water at two main connection points along Gaza's borders, one in the north and one in the middle, and distributes it to the people of Gaza.

In 2020, PWA purchased a total of 13.2 MCM/year from Israel through Mekorot for use in Gaza Strip, which was divided among four of the five governorates as illustrated in Table 24 (PWA, 2021, p. 1).

Table 24: Quantity of Water Procured from Israel for Gaza Strip in 2020

Governorate	Imported Water (m^3/year)
North Gaza	0.0
Gaza	7,956,900
Dier al Balah	2,047,342
Khan Yunis	3,218,400
Rafah	0.0
Total Annual Quantity of Imported Water from Israel (m^3/year)	13,222,642

Source: PWA, 2021

3.1.2.3 DESALINATED WATER PRODUCED VIA PWA OWNED, CMWU OPERATED SHORT TERM LOW VOLUME (STLV) SEA WATER DESALINATION PLANTS

There are three PWA owned, CMWU-operated Short Term Low Volume (STLV) sea water desalination plants currently operational in Gaza Strip: Gaza Desalination Plant, Middle Area Desalination Plant, and Khan Younis Desalination Plant. The overall design production capacity of these three STLVs is approximately 13 MCM/year (PWA - GPCU, 2021, pp. 21-22), as indicated in Table 25. However, due to Gaza's electricity crisis, the three plants' combined production capacity is one-fourth their total design capacity (PWA - GPCU, 2021, pp. 32-33) , or 3.3 MCM/year. These three desalination plants supply water to four of the five governorates, as shown in Table 26.

The Gaza Strip has a chronic electricity deficit, which averaged 220 MW/day in 2021 and 280 MW/day in the first quarter of 2022 (OCHA, 2022), limiting the capacity to operate the desalination facilities around the clock as planned, especially since running these facilities on diesel generators is very expensive, and diesel continuous supply is dependent on a volatile political situation (Al Mezan Center for Human Rights, 2021).

Table 25: Design and Current Production Rates of Existing STLVs in Gaza Strip by mid-2021

Desalination Plant Name	Design Production Capacity (m^3/day)	Design Production Capacity (m^3/year)	Actual Production Rate by mid- 2021 (m^3/year) (1)	Service Area
Gaza Desalination Plant	10,000	3,650,000	2,040,000	Gaza Governorate
Middle Area Desalination Plant	6,000	2,190,000	342,000.00	Dier al Balah
Khan Younis Desalination Plant	20,000	7,300,000	960,000.00	Khan Yunis and Rafah
Totals		13,140,000	3,342,000	

Source: PWA - GPCU, 2021, pp. 31-32

(1): Based on the average production rates during the month of June 2021

Table 26: Quantities of Desalinated Water Produced by PWA-Owned STLVs per Governorate by mid- 2021

Governorate	**Water Supplied from PWA-Owned STLVs (m^3/year)**
North Gaza	0.0
Gaza	2,040,000
Dier al Balah	342,000
Khan Yunis	480,000
Rafah	480,000
Total Quantity of Desalinated Water Produced by PWA-Owned STLVs by mid-2021	**3,342,000**

3.1.2.4 DESALINATED WATER PROVIDED BY PRIVATE DESALINATION PLANTS IN GAZA STRIP

There are about 155 private brackish water desalination plants that produce approximately 3.9 MCM/year (PWA, 2021, pp. 1-3) and distribute it across Gaza Strip, as indicated in Table 27. Private desalination plants sell water for 20-30 times the price of piped water (Hilles, 2021). These private desalination facilities are mostly unregulated and poorly monitored, with 68 percent of them operating without a license and 40 percent relying on illegal wells for its water (World Bank, 2018b, p. 8). The poor monitoring of privately generated and distributed desalinated water incentivized poor production, transportation, and storage practices that impacted water quality, as discussed in Section 3.1.2.6 below.

Table 27: Quantity of Water Provided by private Desalination Plants in Gaza Strip in 2020

Governorate	**Water Provided by Private Desalination Plants (m^3/year)**
North Gaza	632,910
Gaza	1,070,947
Dier al Balah	1,046,747
Khan Yunis	450,957
Rafah	717,590
Total Water Provided by Private Desalination Plants	**3,919,151**

Source: PWA, 2021, pp. 2-3

3.1.2.5 TREATED WASTEWATER IN GAZA STRIP

Approximately 94 million cubic meters (MCM) of wastewater is generated annually in Gaza Strip (see Table 28), of which 73 MCM/year is collected by sewer collection systems (WSRC, 2020p) and 21 MCM/year is collected on site using cesspits, posing a serious threat to groundwater. Approximately 61 MCM/year of the collected wastewater are treated in six wastewater treatment plants with varying degrees of treatment (see Table 29). Because the wastewater collection rate exceeds the treatment capacity of the existing plants, the excess wastewater is discharged to the environment via the plants' bypass. Table 30 shows the estimated quantity for each method of wastewater disposal.

Table 28: Annual Quantities of Wastewater Generated in Gaza Strip by mid-2020

Description	Quantity
Quantity of water abstracted from groundwater and allocated for domestic use	93,540,477 m^3/year
Amount of water procured from Israel	13,222,642 m^3/year
Quantity of desalinated water produced by PWA-owned STLVs	3,342,000 m^3/year
Quantity of desalinated water provided by private desalination plants	3,919,151 m^3/year
Total available water in Gaza Strip for domestic use (1)	114,024,270 m^3/year
3.32% Real (Physical) losses in the bulk and distribution water systems (2)	3,785,606 m^3/year
Total domestic water consumption (MCM)	110,238,664 m^3/year
Percentage of wastewater generated to water consumption	85%
Total amount of wastewater generated in the Gaza Strip	**93,702,864 m^3/year**

(1): Domestic use includes household, commercial, institutional, touristic, recreational, and industrial water uses.
(2): Source: (WSRC, 2020k). Real Losses include leakage and overflows at utility's storage tanks and leakage on transmission mains and distribution pipes and service connections up to point of customer metering. This number reflects the average real losses derived using data from the Water Regulatory Information System of the Water Sector Regulatory Council of Palestine.

Table 29: Existing Wastewater Treatment Plants in Gaza Strip, their Treated Water Quality, and Reuse Quantities by mid-2021

WWTP Name	Design Treatment Capacity MCM/year	Annual Treatment Capacity (MCM)/year	Treated Water Quality	Reuse Quantity in Agriculture (MCM/year)	Recharge to Groundwater (MCM/year)	Notes
North Gaza Wastewater Treatment Plant (NGEST)	12.99	14.89	BOD_5: 10 mg/l	0	14.89	WWTP is operating above its design capacity
Gaza Central Wastewater Treatment Plant (GCWWTP)	21.90	22.00	BOD_5: 40 mg/l COD: 100 mg/l TSS: 60 mg/l	0	0	The treated wastewater is discharged to Gaza Wadi
Khan Younis WWTP	9.71	5.48	BOD_5: 3.3 mg/l TKN: 17 mg/l NH_3: 6 mg/l NO_3-N: 31 mg/l TSS: 7 mg/l (1)	0	5.48	The plant is not yet fully operational as the main sewage pumping station requires upgrading, and the sewer collection system requires expansion
Gaza Sheikh Ejleen WWTP	10.95 (2)	10.95 (2)	BoD_5: 200 mg/l	0	0	Treated wastewater quality does not meet the Palestinian Standards for Reuse. Reuse project was suspended

WWTP Name	Design Treatment Capacity MCM/year	Annual Treatment Capacity (MCM)/year	Treated Water Quality	Reuse Quantity in Agriculture (MCM/year)	Recharge to Groundwater (MCM/year)	Notes
Rafah WWTP	7.30 (2)	7.30 (2)	BoD_5: 90 mg/l FC: 5000/ml	0	0	Treated wastewater quality does not meet the Palestinian Standards for Reuse. Reuse project was suspended
Totals	**62.85**	**60.61**			**20.36**	

Source: PWA - GPCU, 2021, except otherwise noted.

(1): Source: CMWU, 2022
(2): Masoud and Ali Contracting Company, personal communication, April 19, 2022.

As indicated in Table 29, the treated water quality of three of the five operational facilities do not meet the Palestinian standards for agricultural use. Attempts have previously been made to reuse treated water from Gaza's Sheikh Ejleen WWTP and Rahah WWTP, but the initiatives were halted due to the poor quality of treated wastewater from these two facilities (PWA - GPCU, 2021, p. 35). Plans are underway to expand reuse of treated water from the North Gaza Wastewater Treatment Plant (PWA - GPCU, 2021, p. 34) to include agricultural reuse in addition to aquifer recharge, however these plans have not yet been completely realized. Currently, approximately 20 MCM/year of treated wastewater from the North Gaza Wastewater Treatment Plant and the Khan Younis WWTP is recharged to the aquifer.

Table 30: Method of Disposal of Untreated/Partially Treated Wastewater in Gaza Strip in 2021

Method of Wastewater Disposal	Quantity (MCM/year)
Collected and discharged untreated to the environment	12.5
Partially treated and discharged to Wadi Gaza and the sea	40.25
On-site sanitation using cesspits and septic tanks	20.6

3.1.2.6 WATER QUALITY IN GAZA STRIP

The PWA water quality testing revealed that only 9 of the 290 PWA-owned wells' water quality met the WHO upper limits for chloride and nitrate. These 9 wells generate 2.3 MCM/year, or around 2.5 percent of the entire amount extracted from PWA's wells in Gaza Strip (PWA, 2021, p. 7), whereas the remaining 97.5 percent do not meet either the WHO chloride limit or the WHO nitrate limit, or both. This means that only 18.7 percent of the total piped water for domestic use from all sources in Gaza Strip meets WHO drinking water standards, leaving the remaining 81.3 percent unfit for human consumption, as shown in Table 31.

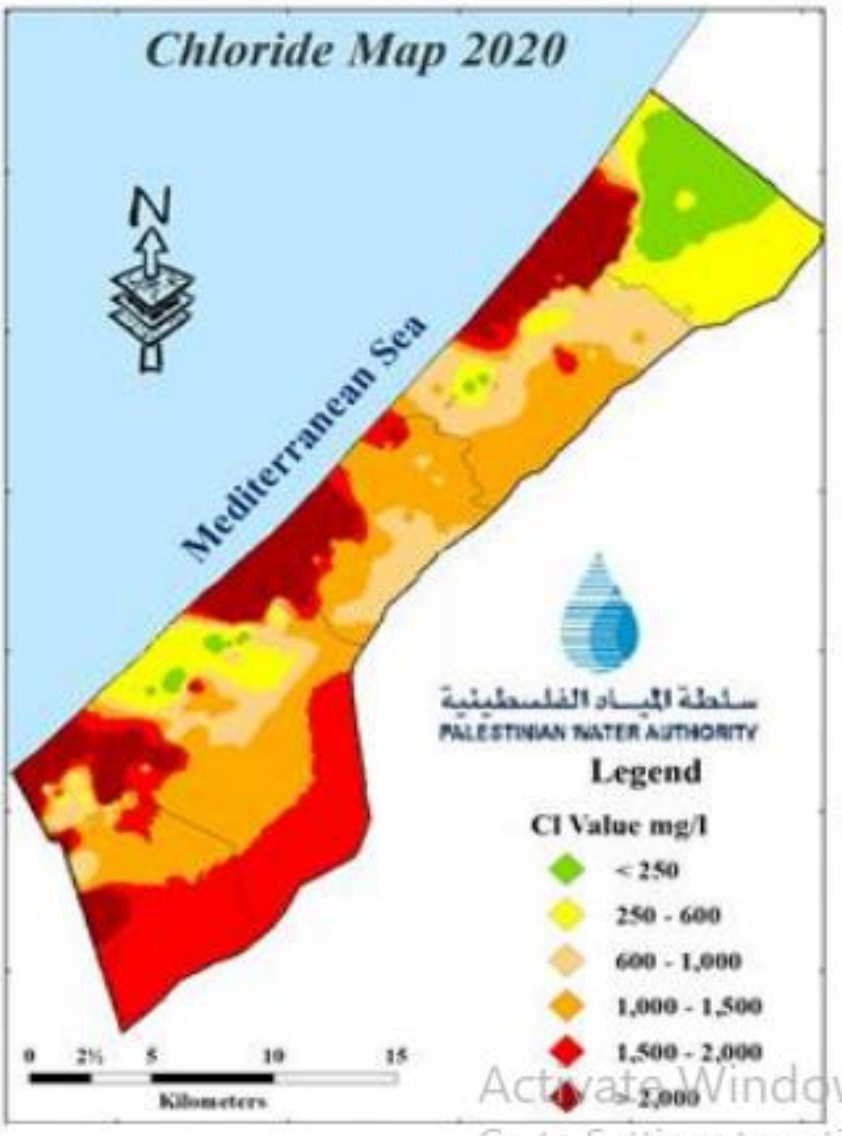
Table 31: Percentage of Domestic Water Supply Meeting the WHO Drinking Water Standards in Gaza Strip

Description	**Quantity of Drinking Water Meeting WHO Drinking Water Standards**	**The percentage meeting the WHO Drinking Water Standards from Total Available Quantity**
Groundwater that meets WHO drinking water standards for chloride and nitrate concentrations(1)	2,285,493 m^3/year	2.5%
Desalinated water	3,342,000 m^3/year	100%
Imported Water	13,222,642 m^3/year	100%
Desalinated water provided by private desalinated plants that meets WHO drinking for total coliform	2,429,874 m3/year	62%
Total amount of domestic water available that meets WHO water quality standards	21,280,009 m^3/year	18.7%

(1): PWA, 2021, p. 7

Human activities such as overexploitation of the Coastal Aquifer, misuse and excessive use of fertilizers and pesticides, wastewater infiltration from leaky sewer systems and porous cesspits, and leachate infiltration from random dumpsites and non-engineered landfills are all contributing to the degradation of groundwater quality (Hilles, 2021, p. 11). Overexploitation of the Coastal Aquifer, driven by population growth and the absence of other resources, led to the decline of the water level by 6.5 to 21 m below sea level in the central part of the northern area and the Western part of Rafah respectively (PWA, 2021, p. 4). The chloride concentration grew as the water level declined and seawater intrusion increased. The chloride concentration increase followed an anticipated positive trend across the 290 wells, except for a few wells along the shoreline that exhibited a significant increase. As illustrated in Figure 22, the PWA's analysis also revealed that, except for the central area of northern Gaza, the concentration of chloride in groundwater surpasses 250 mg/l (PWA, 2021, p. 5), the limit set by the World Health Organization (WHO) as the concentration above which a rise in detectable taste in water occurs (WHO, 2022, p. 361).

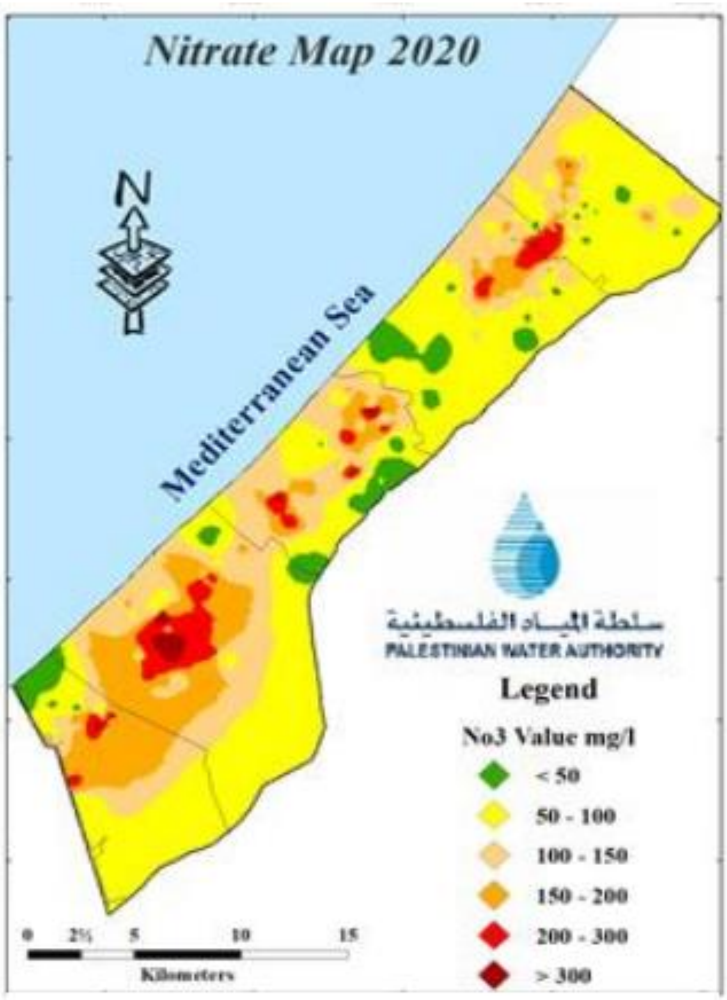
Figure 22: Gaza Strip Groundwater Chloride Map



Source: PWA, 2021, p. 5

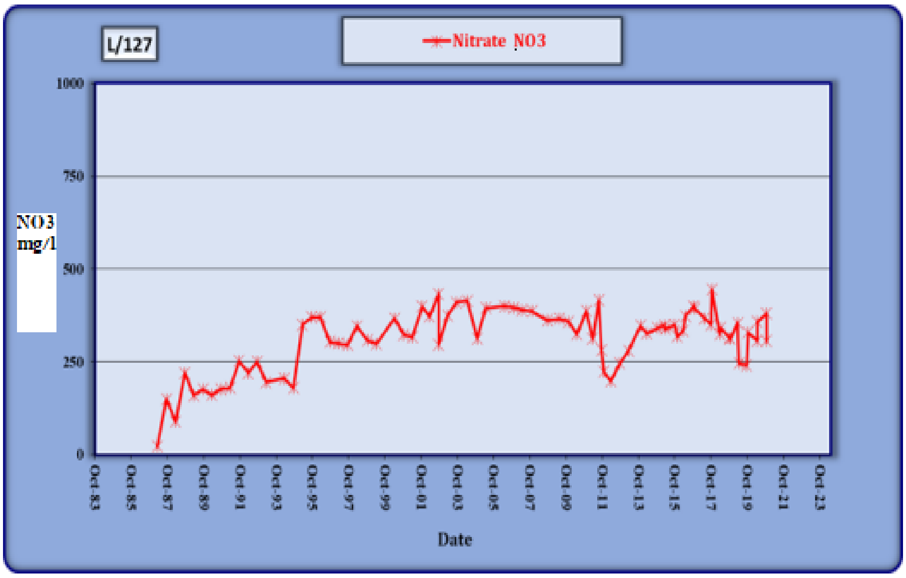
In terms of nitrate concentration, PWA's analysis indicated that the nitrate concentration over the Coastal Aquifer surpasses the WHO nitrate guideline value of 50 mg/l (WHO, 2022, p. 211). The Nitrate Map (See Figure 23) shows that nitrate concentrations ranged from 100 to 200 mg/l, with most of the pollution attributed to leaking sewer systems, use of cesspits, and agricultural practices. Though the nitrate concentration did not follow a specific trend (See Figure 24), a reduction in nitrate concentration in Gaza City center over the years was noted as a result of improving the efficiency of the sewer collection system. This emphasizes the direct relationship between untreated wastewater and nitrate concentration in Gaza Strip (PWA, 2021, pp. 5-6).

Figure 23: Gaza Strip Groundwater Nitrate Map



Source: PWA, 2021, p. 6

Figure 24: Nitrate Concentration Increase Trend in Gaza Strip



Source: PWA, 2021, p. 5

Furthermore, a study conducted in 2018 to assess the quality of desalinated water provided by private desalination plants found that 30 percent of the samples taken from these plants were contaminated with fecal coliform and 38 percent were contaminated with total coliform (Hilles, 2021, p. 12), highlighting the fact that private desalination facilities are unregulated and poorly monitored, entailing additional control and monitoring by relevant authorities such as the Ministry of Health and the Palestinian Water Authority.

3.1.2.7 SUMMARY OF ALL AVAILABLE AND ACCESSIBLE RESOURCES IN GAZA STRIP

Table 32 summarizes the annual quantities of water available in Gaza Strip by mid- 2021 for all water users, noting that groundwater, imported water, and privately produced desalinated water volumes were constant between the end of 2020 and the middle of 2021.

Table 32: Total Annual Quantities of Water Available in Gaza Strip by mid-2021

Water Resource	Annual Quantity Allocated for Domestic Use (MCM/year) (1)	Annual Quantity Allocated for Agricultural Use (MCM/year)
Groundwater	93.54	97.00
Imported Water	13.22	0.00
Treated Wastewater (2)	0.00	0.00
Desalinated water from PWA-owned STLVs	3.34	0.00
Desalinated water provided by private desalinated plants	3.92	0.00
Annual Quantity of Water Available in Gaza Strip per Sector in MCM/year	**114.02**	**97.00**
Total Annual Quantity of Water Available in Gaza Strip by mid-2021 MCM/year	**211.02**	

(1): Domestic use includes household, commercial, institutional, recreational, touristic, and industrial uses.

(2): Currently all the treated wastewater that meets the Palestinian standards for irrigation is recharged to the aquifer. The use of treated wastewater in agriculture is still being explored as pilot projects.

However, since only 18.7 percent of the total quantity allocated for domestic use meets the WHO guideline for drinking water, only 21.28 MCM/year out of the total 114.02 MCM/year are considered in the calculations of the per capita allocation in Gaza Strip, as shown in Table 33.

Table 33: Total Annual Quantity of Domestic Water that is Fit for Human Consumption in Gaza Strip by mid-2021

Water Resource	Quantity Fit for Human Consumption (MCM/year)
Groundwater Wells	2.29
Imported Water	13.22
Treated Wastewater	0.00
Desalinated water from PWA-owned SSTLSs	3.34
Desalinated water provided by private desalinated plants that is fit for human consumption	2.43
Total Annual Quantity of Domestic Water that is Fit for Human Consumption in Gaza Strip by mid- 2021	21.28

3.1.2.8 PER CAPITA ALLOCATION FOR HOUSEHOLD USE IN IN GAZA STRIP

The per capita allocation computed based on total quantity of water available for domestic water is 136 l/c/day (See Table 34); however, this figure is misleading because only 18.7 percent of the total quantity allocated for domestic use is fit for human consumption. Therefore, when only the amount of water that is fit for human consumption is considered, the per capita allocation in Gaza Strip drops to 25.4 l/c/day (See Table 35). The considerable difference between these two values demonstrates that ignoring water quality while assessing this indicator yields inaccurate and misleading results, and further emphasizes the need to develop a more comprehensive water security index that goes beyond this single metric indicator. The analysis of the per capita allocation is based on the following:

- Real losses in the water systems includes leakage and overflows at utility's storage tanks as well as leakage on transmission mains, distribution pipes, and service connections up to point of customer metering. The percentage of real losses is calculated using data from the Water Regulatory Information System of the Water Sector Regulatory Council of Palestine, which suggests that real losses in water systems account for 3.32 percent of total supply quantities (WSRC, 2020k).
- It is estimated that the commercial sector consumes 1 percent of total water sales (WSRC, 2020n); industrial sector consumes 1 percent of total water sales (WSRC, 2020m); and the governmental sector consumes 3 percent of total water sales (WSRC, 2020n), totaling 5 percent of total water supply.
- Given the siege on Gaza Strip, there is essentially no tourist flow to Gaza Strip since 2005, and thus this sector is currently considered a non-water consuming sector.

Table 34: Per Capita Allocation in Gaza Strip for Household Use Based on the Quantity of Water Available for Domestic Use by mid-2021

Governorate	Population by mid-2021	Total Water Supplied per Governorate (MCM/year)	Average Real Losses Percentage	Total Water Consumed (MCM/year)	Commercial, Industrial, & Governmental Use Percentage	Total Available Water for Household Use (MCM/year)	Daily Per Capita Allocation (l/c/day)
North Gaza	416,906	27.75	3.32%	26.83	5.00%	25.49	167.48
Gaza	713,488	40.00	3.32%	38.67	5.00%	36.74	141.08
Dier al Balah	302,507	16.90	3.32%	16.34	5.00%	15.52	140.56
Khan Yunis	413,727	17.41	3.32%	16.83	5.00%	15.99	105.89
Rafah	260,117	11.97	3.32%	11.57	5.00%	10.99	115.76
Totals	**2,106,745**	**114.02**		**110.24**		**104.73**	
Weighted Average Per Capita Allocation for Household Use in Gaza Strip Based on Total Available Quantity (l/c/day) in 2021							**136.19**

Table 35: Per Capita Allocation in Gaza Strip for Household Use Based on Quantity of Domestic Water that is Fit for Human Consumption by mid-2021

Governorate	Population by mid-2021	Total Water Supplied per Governorate (MCM/year)	Average Real Losses Percentage	Total Water Consumed (MCM/year)	Commercial, Industrial, & Governmental Use Percentage	Total Available Water for Household Use	Daily Per Capita Allocation (l/c/day)
North Gaza	416,906	1.06	3.32%	1.02	5.00%	0.97	6.38
Gaza	713,488	11.37	3.32%	10.99	5.00%	10.44	40.10
Dier al Balah	302,507	3.37	3.32%	3.26	5.00%	3.09	28.02
Khan Yunis	413,727	4.30	3.32%	4.16	5.00%	3.95	26.17
Rafah	260,117	1.18	3.32%	1.14	5.00%	1.09	11.45
Totals	**2,106,745**	**21.28**		**20.57**		**19.55**	
Weighted Average Per Capita Allocation for Household Use in Gaza Strip Based on Quantity of Domestic Water that is Fit for Human Consumption (l/c/day) in 2021							**25.42**

3.1.3 PALESTINE'S SERVICE DELIVERY INDICATORS

In Palestine, a near universal access to water has been accomplished, with 96 percent of the population in the West Bank and 90 percent in Gaza Strip connected to public mains (See Table 36). In terms of wastewater collection and treatment, the West Bank has poor wastewater management, with sewer collection pipelines serving only 27 percent of the West Bank's population (WSRC, 2020o) and only 10 percent of the population connected to wastewater treatment facilities (See Table 17). In contrast, 78 percent of Gaza Strip's population is served by sewer collection pipelines (WSRC, 2020p) and 64 percent is served by wastewater treatment facilities.

In 2020 (the most recent published data), non-revenue water (NRW) remained very high in both the West Bank and Gaza Strip at 34 percent and 36 percent, respectively (WSRC, 2021, p. 10). In the West Bank, 45 percent of NRW is physically lost due to leakages in main transmission pipelines and distribution networks, as well as leakage and overflows at storage reservoirs (WSRC, 2020a). Whereas in Gaza Strip, real or physical losses account for only 10 percent of total NRW (WSRC, 2020k).

To address the high non-revenue water and low collection efficiency, the water sector's financial viability and sustainability must be strengthened. Several steps must be taken to improve financial viability, including infrastructural improvements, the development of a sound tariff structure, revisiting the policies and regulations, and, most crucially, the enforcement of the law. Even if the other three measures are achieved, financial viability will not improve unless laws and regulations are strictly enforced, particularly in terms of eliminating illegal connections and enacting a deterrent polluter pays principle.

Table 36: Indicators' Values of Service Delivery in the West Bank and Gaza Strip in 2020

Indicator	**West Bank**	**Gaza Strip**
Percentage of population served with water network	96%	89%
Percentage of population served with wastewater collection system	27%	78%
Percentage of Non-revenue Water	34%	36%
Collection Efficiency	64%	40%

In terms of service reliability, the access to public main water remains intermittent with some villages and neighborhoods receiving water for a few hours every week or few weeks (World Bank, 2017, p. 27); (EcoPeace Middle East, 2018, p. 12); (B'Tselem, 2020). To cope with the intermittent nature of water service delivery, Palestinians rely on roof water tanks, which continue to be a prominent element of Palestinian homes.

3.1.4 CURRENT AND FUTURE WATER DEMAND IN PALESTINE

3.1.4.1 PROJECTED PALESTINIAN POPULATION BY 2032

The population of the West Bank and Gaza Strip is expected to reach 6,818,935 in 2032 (See Table 37), assuming a 2.2 percent growth rate in the West Bank and a 2.8 percent growth rate in Gaza Strip, as discussed in section 1.4.1.3.

Table 37: Current and Projected Population of the West Bank and Gaza Strip in 2032

Governorate Name	Estimated Population in 2021	Population Projection by 2032
West Bank		
Jenin	338,919	430,582
Tubas and the Northern Valleys	65,915	83,742
Tulkarem	198,856	252,638
Nablus	415,606	528,009
Qalqilya	121,671	154,578
Salfit	82,099	104,303
Ramallah & Al-Bireh	355,202	451,269
Jericho & Al -Aghwar	53,317	67,737
Jerusalem(1)	471,834	599,445
Bethlehem	234,802	298,306
Hebron	782,227	993,786
Total Population in West Bank	**3,120,448**	**3,964,394**
Gaza Strip		
North Gaza	416,906	564,888
Gaza	713,488	966,743
Dier al Balah	302,507	409,883
Khan Yunis	413,727	560,581
Rafah	260,117	352,446
Total Population in Gaza Strip	**2,106,745**	**2,854,541**
Total Population of West Bank and Gaza Strip	**5,227,193**	**6,818,935**

(1): Including East Jerusalem localities

3.1.4.2 CURRENT AND PROJECTED DOMESTIC WATER DEMAND BY 2032

The current and projected domestic and industrial water demand are calculated based on the following targets and assumptions:

1. Current and projected household water demand of 120 l/c/day based on the Palestinian Water Authority's National Water Strategy for Palestine (2013), which established a national average target of 120 l/c/day for household use with a minimum average per governorate of 84 l/c/day (PWA, 2013, p. 56). The set target is also consistent with the WHO's published level of water service required to improve public health, which is 100 l/c/day or higher in the case of continuous supply (Howard & Bartram, 2003, p. 2).
2. Available water quantities in the West Bank and Gaza Strip remained constant between the end of 2020 and the middle of 2021.

3. Current industrial water consumption in the West Bank and Gaza Strip remains unchanged at 3.42 percent and 1 percent of total domestic supply, respectively.
4. Industrial water demand will increase to 7% of total domestic supply by 2032. This percentage is based on the National Water Strategy for Palestine (2013), which aims to allocate a volume of water equivalent to 7 percent of domestic water supply for industrial use to promote economic growth (PWA, 2013, p. 56).
5. Projected commercial and governmental water demand for the West Bank will remain unchanged at 4.72 percent and 4.11 percent of the total domestic supply through 2032.
6. Even though commercial, industrial, and governmental water consumption in Gaza Strip accounts for only 5% of total domestic supply, Gaza Strip's projected commercial, industrial, and governmental water demand by 2032 is expected to be comparable to that of the West Bank, assuming the siege will be lifted, and that Gaza Strip will experience the same level of economic growth and prosperity as the West Bank.
7. The East Jerusalem localities are not included in the calculation of Jerusalem's current water demand. East Jerusalem localities, however, are included in the calculation of the projected demand for Jerusalem by 2032 since, from the Palestinian perspective, negotiations with Israel are only viable if Palestinian sovereignty in East Jerusalem is recognized (Dumper, 2000).
8. It is estimated that touristic water demand in Bethlehem will almost double from 2.44 percent to about 5 percent, corresponding to 2 percent of total domestic demand in Bethlehem and Hebron. This assumption is based on the historical trend of the last ten years (2009-2019), which showed that the number of guest nights nearly doubled during that time (PCBS, 2020b). Due to the COVID-19 outbreak and the associated travel restrictions and closures, years 2020 and 2021 were excluded.
9. Touristic water demand in Jericho will remain unchanged at around 21% of total domestic supply.
10. The current percentage of real losses in water systems will remain steady.
11. Illegal connections will be drastically eliminated to ensure fair and equal distribution of water resources within each locality.

According to the water deficit analysis shown in Table 38, the current water deficit in the West Bank and Gaza Strip is 31 and 77 MCM/year, respectively, totaling 107 MCM/year in 2021. In the absence of new resources, the gap between domestic water supply and demand in the West Bank and Gaza Strip will reach 99 MCM/year and 128 MCM/year, respectively, by 2032. Because of the deadlocked Israeli-Palestinian water-rights negotiations, reliance primarily on conventional water resources will result in increased degradation of water quality and quantity. Therefore, developing additional non-conventional water resources is critical to avert a water crisis that will impair human health and lead to economic loss, food insecurity, and poverty increase.

Table 38: Current and Projected Domestic Water Demands and Deficits in the West Bank and Gaza Strip by 2032

Governorate Name	Current Household Water Demand (1)	Projected Household Water Demand by 2032 (MCM/yr.)	Current Domestic Water Demand including Household, Industrial, Commercial, Touristic, and Governmental Uses (MCM/year)	Projected Water Demand including Household, Industrial, Commercial, Touristic, and Governmental Uses by 2032 (MCM/year)	Total Available Water for Domestic (reduced by real losses)	Current Domestic Water Deficit (MCM/yr)	Projected Domestic Water Deficit by 2032 (MCM/yr.)
West Bank							
Jenin	14.84	18.86	16.92	22.45	7.57	9.35	14.88
Tubas and the Northern Valleys	2.89	3.67	3.29	4.37	3.15	0.14	1.22
Tulkarem	8.71	11.07	9.92	13.17	10.43	-0.51	2.74
Nablus	18.20	23.13	20.74	27.53	13.90	6.84	13.63
Qalqilya	5.33	6.77	6.07	8.06	8.15	-2.08	-0.09
Salfit	3.60	4.57	4.10	5.44	3.15	0.95	2.29
Ramallah & Al-Bireh	15.56	19.77	17.73	23.53	17.07	0.66	6.46
Jericho & Al - Aghwar	2.34	2.97	3.51	4.71	5.65	-2.14	-0.94
Jerusalem	7.33	26.26	8.35	31.26	6.34	2.01	24.92
Bethlehem	10.28	13.07	11.80	15.93	35.55	15.56	33.47
Hebron	34.26	43.53	39.31	53.08			
Totals for West Bank	**123.34**	**173.64**	**141.74**	**209.54**	**110.96**	**30.78**	**98.58**
Gaza Strip							
North Gaza	18.26	24.74	19.22	29.45	1.02	18.20	28.43
Gaza	31.25	42.34	32.90	50.41	10.99	21.90	39.42
Dier al Balah	13.25	17.95	13.95	21.37	3.26	10.69	18.12
Khan Yunis	18.12	24.55	19.07	29.23	4.16	14.91	25.07
Rafah	11.39	15.44	11.99	18.38	1.14	10.85	17.23
Total for Gaza Strip	**92.28**	**125.03**	**97.13**	**148.84**	**20.57**	**76.56**	**128.27**
Totals for Palestine	**215.62**	**298.67**	**238.88**	**358.38**	**131.53**	**107.34**	**226.85**

(1): Current demand= demand in year 2021

3.1.4.3 Current Agricultural Water Demand

According to the Ministry of Agriculture (MoA), there are 1,579,801 dunums of cultivated area in Palestine of which 358,628 dunums are irrigated versus 1,221,173 dunums of rainfed areas as detailed in Table 39. In terms of livestock, there are currently 64,426 cattle, 671,615 sheep, 230,893 goats, 80,664 beehives, and 79,163 poultry (in 1000) (See Tables 40 and Table 41) (MoA, personal communication, Feb 6, 2022).

Table 39: Cultivated Area of Fruit Trees, Vegetables, and Field Crops in the West Bank and Gaza Strip in Dunums in 2021

Governorate Name	Fruit Trees				Vegetables			Field crops		Totals
	Bearing		Unbearing		Rainfed	Open Irrigated	Protected Irrigated	Rainfed	Irrigated	
	Rainfed	Irrigated	Rainfed	Irrigated						
Palestine	**722,347**	**101,109**	**160,339**	**34,027**	**19,721**	**128,514**	**57,427**	**318,766**	**37,551**	**1,579,801**
West Bank	**722,347**	**34,595**	**160,339**	**12,937**	**19,721**	**81,520**	**45,989**	**291,881**	**20,179**	**1,389,508**
Jenin	143,819	1,269	21,120	302	6,313	23,836	6,861	90,726	7,578	**301,824**
Tubas	18,490	1,776	3,630	355	1,970	15,100	10,123	33,250	6,115	**90,809**
Tulkarem	80,651	3,188	9,074	488	299	4,370	6,009	2,178	1,360	**107,617**
Nablus	124,780	1,924	17,505	1,604	358	7,006	3,227	26,160	3,827	**186,391**
Qalqilya	44,053	7,755	7,016	2,039	371	961	1,561	2,318	1,080	**67,154**
Salfit	54,321	105	8,182	0	1,208	774	24	2,402	54	**67,070**
Ramallah and Al-Bireh	93,159	467	32,600	96	2,645	1,253	121	17,816	0	**148,157**
Jericho and Al-Aghwar	0	16,619	0	7,359	0	13,779	12,291	2,164	30	**52,242**
Jerusalem	17,897	0	5,777	2	710	300	32	5,211	2	**29,931**
Bethlehem	37,654	302	13,191	0	496	4,278	432	5,600	0	**61,953**
Hebron	107,523	1,190	42,244	692	5,351	9,863	5,308	104,056	133	**276,360**
Gaza Strip	**0**	**66,514**	**0**	**21,090**	**0**	**46,994**	**11,438**	**26,885**	**17,372**	**190,293**
North Gaza	**0**	7,518	0	5,730	**0**	14,593	587	11,410	0	**39,838**
Gaza	**0**	16,968	0	5,591	**0**	11,137	862	3,100	1,475	**39,133**
Deir Al-Balah	**0**	14,998	0	3,613	**0**	7,011	2,061	6,000	1,220	**34,903**
Khan Yunis	**0**	18,477	0	3,825	**0**	9,367	4,601	4,920	8,395	**49,585**
Rafah	**0**	8,553	0	2,331	**0**	4,886	3,327	1,455	6,282	**26,834**

Table 40: Number of Cattle in the West Bank and Gaza Strip in 2021

Governorate Name	No. of Bull Calves	No. of Heifer Calves	No. of Bulls	Grand Total
Palestine	**25,680**	**7,302**	**666**	**64,426**
West Bank	**16,180**	**6,342**	**666**	**51,704**
Jenin	3,821	1,324	127	9,626
Tubas	250	233	91	2,109
Tulkarem	898	172	3	2,045
Nablus	1,043	633	246	5,888
Qalqilya	1,119	398	49	3,078
Salfit	258	52	14	858
Ramallah and Al-Bireh	32	44	6	280
Jericho and Al-Aghwar	840	504	23	2,924
Jerusalem	335	45	12	645
Bethlehem	54	32	3	153
Hebron	7,530	2,905	92	24,098
Gaza Strip	**9,500**	**960**	**-**	**12,722**
North Gaza	3,000	400	-	4,365
Gaza	1,300	200	-	1,963
Deir Al-Balah	800	160	-	1,352
Khan Yunis	1,200	150	-	1,659
Rafah	3,200	50	-	3,383

Table 41: Number of Sheep, Goats, Beehives, Broilers and Layers in the West Bank and Gaza Strip in 2021

Governorate	No. of Sheep	No. of Goats	No. of Beehives	Poultry (1000)	
				Broilers	Layers
Palestine	**671,615**	**230,893**	**80,664**	**76,355**	**2,828**
West Bank	**608,315**	**221,643**	**65,777**	**53,355**	**2,114**
Jenin	83,420	29,722	13,493	10,722	210
Tubas	49,725	6,380	4,786	1,638	25
Tulkarem	18,851	2,262	6,500	2,732	164
Nablus	81,561	15,928	7,335	3,791	27
Qalqilya	21,190	3,235	5,313	4,697	282
Salfit	12,148	6,722	3,295	464	33
Ramallah and Al-Bireh	42,179	30,881	4,704	10,661	759
Jericho and Al-Aghwar	34,319	25,802	5,564	1,846	20
Jerusalem	36,822	24,018	3,136	3,581	124
Bethlehem	44,428	34,783	2,086	1,531	46
Hebron	183,672	41,910	9,565	11,692	425
Gaza Strip	**63,300**	**9,250**	**14,887**	**23,000**	**714**
North Gaza	22,000	1,650	5,008	1,746	238
Gaza	10,500	2,200	1,630	2,620	181
Deir Al-Balah	8,500	800	3,432	5,823	100
Khan Yunis	12,700	2,500	3,370	6,987	50
Rafah	9,600	2,100	1,447	5,823	144

Source: MoA, personal communication, February 6, 2022

The estimated current irrigation water demand is 149 MCM/year in the West Bank and 192 MCM/year in Gaza Strip, for a total of around 341 MCM/year (See Table 42). The calculation is based on the MoA's estimated demand for each type of cultivated area in the West Bank, which is 1200 m^3/dunum/year for fruits, 500 m^3/dunum/year for vegetables, 900 m^3/dunum/year for vegetables planted in greenhouses, and 500 m^3/dunum/year for field crops, with needs in Gaza Strip being 130 percent higher than those in the West Bank due to higher evapotranspiration rates (MoA, personal communication, February 6, 2022). In addition, the current water demand for livestock is estimated at 12.6 MCM/year for the West Bank and 4.1 MCM/year for Gaza Strip as shown in Table 43, based on an animal's water demand of 100 l/cattle/day, 9 l/sheep/day, 9 l/goat/day, 400 l/1000 broilers/day, and 250 l/1000 layers/day (MoA, personal communication, February 6, 2022).

Table 42: Current Water Demands for Irrigation in the West Bank and Gaza Strip in 2021

Governorate	Fruits		Vegetables				Field crops		
	Total Irrigated Land (Dunum)	Water Needs (MCM/yr.)	Open Irrigated Land (Dunum)	Water Needs (MCM/yr.)	Protected Irrigated Land (Dunum)	Water Needs (MCM/yr.)	Irrigated field Crops Land (Dunum)	Water Needs (MCM/yr.)	Total Water Needs for Irrigation (MCM/yr.)
Palestine	**135,136**	**193.70**	**128,514**	71.31	**57,427**	**55.12**	**37,551**	**21.38**	**341.50**
West Bank	**47,532**	**57.04**	**81,520**	**40.76**	**45,989**	**41.39**	**20,179**	**10.09**	**149.28**
Jenin	1,571	1.89	23,836	**11.92**	6,861	6.17	7,578	3.79	23.77
Tubas	2,131	2.56	15,100	7.55	10,123	9.11	6,115	3.06	22.28
Tulkarem	3,676	4.41	4,370	2.19	6,009	5.41	1,360	0.68	12.68
Nablus	3,528	4.23	7,006	3.50	3,227	2.90	3,827	1.91	12.55
Qalqilya	9,794	11.75	961	0.48	1,561	1.40	1,080	0.54	14.18
Salfit	105	0.13	774	0.39	24	0.02	54	0.03	0.56
Ramallah and Al-Bireh	563	0.68	1,253	0.63	121	0.11	0	0.00	1.41
Jericho and Al-Aghwar	23,978	28.77	13,779	6.89	12,291	11.06	30	0.02	46.74
Jerusalem	2	0.00	300	0.15	32	0.03	2	0.00	0.18
Bethlehem	302	0.36	4,278	2.14	432	0.39	0	0.00	2.89
Hebron	1,882	2.26	9,863	4.93	5,308	4.78	133	0.07	12.03
Gaza Strip	**87,604**	**136.66**	**46,994**	30.55	**11,438**	**13.73**	**17,372**	**11.29**	**192.23**
North Gaza	13,248	20.67	14,593	9.49	587	0.70	0	0.00	30.86
Gaza	22,559	35.19	11,137	7.24	862	1.03	1,475	0.96	44.42
Deir Al-Balah	18,611	29.03	7,011	4.56	2,061	2.47	1,220	0.79	36.86
Khan Yunis	22,302	34.79	9,367	6.09	4,601	5.52	8,395	5.46	51.86
Rafah	10,884	16.98	4,886	3.18	3,327	3.99	6,282	4.08	28.23

Table 43: Current Water Demands for Livestock in the West Bank and Gaza Strip in MCM/year in 2021

Gov.	No. of Cattle	Cattle Water Demand	No. of Sheep	Sheep Water Demand	No. of Goats	Goats Water Demand	Poultry (1000)				Total Animal Water Demand
							No. of Broilers	Broilers Water Demand	No. of Layers	Layers Water Demand	
Palestine	**64,426**	**2.35**	**671,615**	**2.21**	**230,893**	**0.76**	**76,355**	**11.15**	**2,828**	**0.26**	**16.72**
West Bank	**51,704**	**1.89**	**608,315**	**2.00**	**221,643**	**0.73**	**53,355**	**7.79**	**2,114**	**0.19**	**12.60**
Jenin	9,626	0.35	83,420	0.27	29,722	0.10	10,722	1.57	210	0.02	2.31
Tubas	2,109	0.08	49,725	0.16	6,380	0.02	1,638	0.24	25	0.00	0.50
Tulkarem	2,045	0.07	18,851	0.06	2,262	0.01	2,732	0.40	164	0.01	0.56
Nablus	5,888	0.21	81,561	0.27	15,928	0.05	3,791	0.55	27	0.00	1.09
Qalqilya	3,078	0.11	21,190	0.07	3,235	0.01	4,697	0.69	282	0.03	0.90
Salfit	858	0.03	12,148	0.04	6,722	0.02	464	0.07	33	0.00	0.16
Ramallah & Al-Bireh	280	0.01	42,179	0.14	30,881	0.10	10,661	1.56	759	0.07	1.88
Jericho and Al-Aghwar	2,924	0.11	34,319	0.11	25,802	0.08	1,846	0.27	20	0.00	0.58
Jerusalem	645	0.02	36,822	0.12	24,018	0.08	3,581	0.52	124	0.01	0.76
Bethlehem	153	0.01	44,428	0.15	34,783	0.11	1,531	0.22	46	0.00	0.49
Hebron	24,098	0.88	183,672	0.60	41,910	0.14	11,692	1.71	425	0.04	3.37
Gaza Strip	**12,722**	**0.46**	**63,300**	**0.21**	**9,250**	**0.03**	**23,000**	**3.36**	**714**	**0.07**	**4.13**
North Gaza	4,365	0.16	22,000	0.07	1,650	0.01	1,746	0.25	238	0.02	0.51
Gaza	1,963	0.07	10,500	0.03	2,200	0.01	2,620	0.38	181	0.02	0.51
Deir Al Balah	1,352	0.05	8,500	0.03	800	0.00	5,823	0.85	100	0.01	0.94
Khan Yunis	1,659	0.06	12,700	0.04	2,500	0.01	6,987	1.02	50	0.00	1.14
Rafah	3,383	0.12	9,600	0.03	2,100	0.01	5,823	0.85	144	0.01	1.03

3.1.4.4 PROJECTED AGRICULTURAL WATER DEMAND BY 2032

As shown in Table 44, the projected agricultural water demand in the West Bank and Gaza Strip is 190 MCM/year and 192 MCM/year, respectively, while the projected livestock water demand is 16 MCM/year and 5.6 MCM/year, respectively, assuming the following:

1. The entire arable land of the West Bank, totaling 1,861.6 km^2, will be rehabilitated and cultivated, representing an increase of 472 km^2 above the currently cultivated rea, with 66 km^2 irrigated (based on current proportion of irrigated fields from total agricultural land). However, because new roads must be built to serve the expanded land area, the expected additional irrigated land is 53 km^2, indicating a 27 percent increase in cultivated irrigated land.
2. As Gaza Strip's population and economy grow, there will be a need to extend the urban area at the expense of agricultural land, resulting in a decline in agricultural land. However, it is expected that the fertile land in the Access Restricted Area, which accounts for 15 percent of Gaza Strip's total area (Abo Rezeg, 2019), will be recovered, and repurposed for agriculture, offsetting the loss of other agricultural land for urban expansion. As a result, it is predicted that total agricultural land would remain constant between now and 2032.
3. To meet the demands of the people while maintaining the same consumption rate, the number of livestock will increase at the same pace as the population growth rate; 2.2 percent in the West Bank and 2.8 percent in Gaza Strip.

Table 44: Projected Agricultural Water Demands in the West Bank and Gaza Strip by 2032

Water Use	West Bank Current Water Demand (MCM/year)	Gaza Strip Current Water Demand (MCM/year)	West Bank Projected Water Demand by 2032 (MCM/year)	Gaza Strip Projected Water Demand by 2032 (MCM/year)
Irrigation	149.28	192.23	190	192.23
Livestock	12.6	4.13	16	5.6

3.1.4.5 CURRENT AND PROJECTED AGRICULTURAL WATER DEFICIT IN THE WEST BANK AND GAZA STRIP

The West Bank and Gaza Strip have a severe water agricultural water deficit of 57 MCM/year and 95 MCM/year, respectively, which threatens food security and economic growth. Unless new resources, specifically treated wastewater, are developed and there is widespread social acceptance to use it for irrigation, this deficit is expected to reach 97 MCM/year in the West Bank and 95 MCM/year in Gaza by 2032 (See Tables 45 and 46), indicating that domestic agricultural productivity will not be able to keep pace with population growth, leaving people with insufficient food, particularly the poor and marginalized communities who are unable to cope with price surges. The agricultural water deficit will also have a negative impact on Palestinian economy, resulting in a decrease in GDP and an increase in unemployment, especially since the agriculture sector's value added exceeded $1.0 billion per year in the last 8 years (2013-2020), accounting for 7 percent of GDP over the same period (PCBS, 2021c) (GlobalEconomy, 2022), and employs 6.4 percent of the Palestinian workforce (PCBS, 2021d).

Table 45: Current and Projected Agricultural Water Deficits in the West Bank by 2032

Agricultural Water Use	West Bank Current Water Demand (MCM/year)	West Bank Projected Water Demand by 2032 (MCM/year)	Annual Quantity Allocated for Agricultural Use in the West Bank (MCM/year)	Current Agricultural Water Deficit in the West Bank (MCM/year)	Projected Agricultural Water Deficit in the West Bank by 2023 (MCM/year)
Irrigation	149.28	190	92.48	56.8	97.52
Livestock	12.6	16	0	12.6	16

Table 46: Current and Projected Agricultural Water Deficits in Gaza Strip by 2032

Agricultural Water Use	Gaza Strip Current Water Demand (MCM/year)	Gaza Strip Projected Water Demand by 2032 (MCM/year)	Annual Quantity Allocated for Agricultural Use in Gaza Strip (MCM/year)	Current Agricultural Water Deficit in Gaza Strip (MCM/year)	Projected Agricultural Water Deficit in Gaza Strip by 2032 (MCM/year)
Irrigation	192.23	192.23	97	95.23	95.23
Livestock	4.13	5.6	0	4.13	5.6

3.1.5 HOUSEHOLD WATER INSECURITY SCALE RESULTS FOR PALESTINE

The results of the HWISE Scale revealed that 43.1 percent of West Bank's households are water insecure, compared to 47.8 percent in Gaza Strip, implying that 45 percent of Palestinian households are water insecure, as shown in Table 47. Tables 48 and 49 provide the detailed HWISE Scale results by cluster and by governorate respectively.

Table 47: Percentage of the Water Insecure Households in Palestine Based on the HWISE Scale Score

Region	Percentage of Water Secure Households (HWISE Scale Score <12)	Percentage of Water Insecure Households (HWISE Scale Score ≥12)
West Bank	56.9%	43.1%
Gaza Strip	52.2%	47.8%
Palestine	**55.0%**	**45.0%**

Table 48: Results of the HWISE Scale Survey Per Cluster

Serial No.	Governorate	Locality Name	Number of Households	
			HWISE Scale Score <12	HWISE Scale Score ≥12
West Bank				
1	Jenin	Jenin	20	0
2	Jenin	A’nin	19	1
3	Tulkarem	Tulkarem	20	0
4	Nablus	Nablus	37	3
5	Nablus	Beit Imrin	8	12
6	Nablus	Balata Camp	4	16
7	Qalqilya	Qalqilya	20	0
8	Salfit	Salfit	19	1
9	Ramallah & Al-Bireh	Al-Bireh	0	20
10	Ramallah & Al-Bireh	A’rura	0	20
11	Jerusalem J2	Ar Ram	2	18
12	Jerusalem J1	Jerusalem	7	13
13	Bethlehem	Bethlehem	0	20
14	Bethlehem	Dar Salah	20	0
15	Hebron	Hebron	42	18
16	Hebron	Adh Dhahiriya	9	11
17	Hebron	Beit A’mra	16	4
Gaza Strip				
1	North Gaza	Beit Lahia	6	14
2	North Gaza	Jabalya	7	33
3	North Gaza	Jabalya Camp	2	18
4	Gaza	Gaza	66	54
5	Gaza	Ash Shati' Camp	9	11
6	Dier al Balah	Beir al Balah	35	5
7	Dier al Balah	An Nuseirat Camp	18	2
8	Khan Yunis	Khan Yunis	24	16
9	Khan Yunis	Bani Suheila	15	5
10	Khan Yunis	Khan Yunis Camp	10	10
11	Rafah	Rafah	16	24

Table 49: Results of the HWISE Scale Survey Per Governorate

Governorate	Number of Households		Total No. of Surveyed Households	Percentage of Water Insecure Households
	HWISE Scale Score <12	HWISE Scale Score ≥12		
West Bank				
Jenin	39	1	40	2.5%
Tulkarem	20	0	20	0%
Nablus	49	31	80	39%
Qalqilya	20	0	20	0%
Salfit	19	1	20	5%
Ramallah	0	40	40	100%
Jerusalem	9	31	40	77.5%
Bethlehem	20	20	40	50%
Hebron	67	33	100	33%
Gaza Strip				
North Gaza	15	65	80	81%
Gaza	75	65	140	46%
Deir al Balah	53	7	60	12%
Khan Yunis	49	31	80	39%
Rafah	16	24	40	60%

With roughly half of Palestinian households experiencing water insecurity, the HWISE scale results are very alarming and call for immediate action. The HWISE Scale results clearly demonstrate that the metric indicator of per capita allocation obscures geographic differences and ignores quality issues, as evidenced by the lack of correlation between average per capita allocations in the West Bank and Gaza Strip of 94 l/c/day and 136 l/c/day respectively, and the HWISE Scale results.

3.1.6 CURRENT WATER SECURITY LEVEL IN PALESTINE

3.1.6.1 CURRENT WATER SECURITY INDICATOR SCORE FOR THE WEST BANK

The West Bank received a score of 2.22 out of 5 on the Babel Water Security Index for the year 2021, as shown in Table 50, indicating a 'fair' water security state. According to this result, the West Bank is water insecure in a variety of ways and has specific water-related challenges, necessitating improved institutional management and strengthened planning for future water challenges, as evidenced by the scores of the various variables in Table 51.

Table 50: Water Security Index Score for the West Bank in 2021

Dimension	**Average Score out of 5**
Water Supply and Sanitation	3
Water Productivity	3
Water-Related Disasters	1.5
Water Environment	1
Water Governance	2.62
Water Security Index for the West Bank in 2021	**2.22**

Table 51: Results of the Water Security Assessment for the West Bank in 2021

Dimension	**Indicators**	**Variables**	**Reference values**					**Notes**
			1	**2**	**3**	**4**	**5**	
Water supply and sanitation	Water Availability	Per capita water use (l/c/d)				4		See Section 3.1.1.6: 94 l/c/day
		Percentage of imported water (%)	1					See Section 3.1.1.2: 77.01/131.23=55%
	Accessibility	Population access to piped water supply (%)					5	See Section 3.1.3: 96%
	Quality of water supplied	Percentage of piped water that meet WHO drinking water standards				4		See Section 3.1.1.4: 92%
	Hygiene and Sanitation	Percentage of people using improved sanitation facilities (i.e., connected to public sewer lines)	1					See Section 3.1.3: 27%
Water Productivity	Economic value of water	Agricultural water productivity ($/m3)			3			See Section 3.1.1.5 and PCBS, 2021c: $765.6 million / 92.4 MCM/year= $8.2/m^3
Water-related disasters	Disaster mitigation	Disaster budget factor (Percentage Investment in disaster response mechanism/total budget)	1					Given the PA fiscal constraints the disaster budget is almost nil
	Disaster preparedness	Flood hazard areas (%)		2				Source: (Shadeed, 2019, p. 15): 36% of the total West Bank area are highly vulnerable for flood hazard
Water Environment	Effect of polluting factors	Wastewater treatment factor (%)	1					See Section 3.1.1.3: 11.4%
Water Governance	Overall management of water sector	Institution factor questionnaire			3.27			Average of the response to Institution questionnaire (see Table 52)
	Potential to adapt to future changes	Adaptability factor questionnaire			3.60			Average of the responses to Adaptability questionnaire (see Table 52)
	Public satisfaction with the level of water security	The proportion of water-insecure households in West Bank (%) measured using (HWISE) Scale	1					See Section 3.1.5: 43.1%

Table 52: Average Values of the Responses Received for the Institution and Adaptability Factors

Factor	Average Score
Institution Factor	
1. Is public opinion sought when developing water-related plans?	3.67
2. Is there an official mechanism to monitor Non-Revenue Water (NRW)?	3.83
3. To what extent does the tariff structure consider the full cost recovery of the service provision?	2.50
4. To what extent the current revenue collection system and/or adopted financial system support self-sustainability of the water sector?	2.67
5. Is there a provision to incentivize water conservation?	3.67
Average score for the institution factor	**3.27**
Adaptability Factor	
1. To what extent do existing policies incentivize or support reuse of treated wastewater?	3.00
2. Is there a centralized database for water related information at national and local levels?	4.50
3. Is climate change taken in consideration when developing long-term water-related plans?	2.67
4. Is there a system to forecast water availability?	3.67
5. Is there a system to forecast water quality?	4.17
Average score for the adaptability factor	**3.60**

3.1.6.2 Water Security Indicator Score for Gaza Strip in 2021

Gaza Strip received a score of 2.26 out of 5 on the Babel Water Security Index, as shown in Table 53, indicating a 'fair' water security state. According to this result, Gaza Strip, like the West Bank, is water insecure in various ways. As demonstrated by the scores of the various variables in Table 54, Gaza Strip is experiencing certain water-related issues and needs to enhance both institutional management and preparedness for future water challenges.

Table 53: Current Water Security Index for Gaza Strip in 2021

Dimension	Average Score out of 5
Water Supply and Sanitation	3.2
Water Productivity	2
Water-Related Disasters	2.5
Water Environment	1
Water Governance	2.62
Water Security Index for Gaza Strip in 2021	**2.26**

Table 54: Results of the Water Security Assessment for Gaza Strip in 2021

Dimension	Indicators	Variables	Reference values					Notes
			1	2	3	4	5	
Water supply and sanitation	Water Availability	Per capita water use (l/c/d)					5	See Section 3.1.2.8: 136 l/c/day
		Percentage of Imported water (%)			3			See Section 3.1.2.2: 13.02/114.02=11.6%
	Accessibility	Population access to piped water supply (%)				4		See Section 3.1.3: 89%
	Quality of water supplied	Percentage of piped water that meet WHO drinking water standards	1					See Section 3.1.2.6: 18.7%
	Hygiene and Sanitation	Percentage of people using improved sanitation facilities (i.e., connected to public sewer lines)			3			See Section 3.1.3: 78%
Water Productivity	Economic value of water	Agricultural water productivity ($/m3)		2				See Section 3.1.2.7 and PCBS, 2021c: $337.6 million / 97 MCM/year= $3.4/m^3
Water-related disasters	Disaster mitigation	Disaster budget factor (Percentage Investment in disaster response mechanism/total budget)	1					Given the PA fiscal constraints the disaster budget is almost nil
	Disaster preparedness	Flood hazard areas (%)				4		Based on the number of Gazans living in flood area per the WASH Cluster, 2021, p. 1: 13.2%
Water Environment	Effect of polluting factors	Wastewater treatment factor (%)	1					See Section 3.1.2.5: 20.37/93.7=21.7%. Including only the quantity of treated wastewater that meets PWA standard for discharge to environment
Water Governance	Overall management of water sector	Institution factor questionnaire			3.27			Average of the response to Institution questionnaire (see Table 52)
	Potential to adapt to future changes	Adaptability factor questionnaire			3.60			Average of the responses to Adaptability questionnaire (see Table 52)
	Public satisfaction with the level of water security	The proportion of water-insecure households in West Bank (%) measured using (HWISE) Scale	1					See section 5.11: 47.8%

3.1.6.3 CURRENT WATER SECURITY INDEX FOR PALESTINE

Palestine has a weighted average Water Security Index score of 2.24, indicating that it is in a 'fair' water security state. The results demonstrate that Palestine is water insecure, and it is confronted with some water challenges that call for improved water resource management to address the water aspects where Palestine received a low score, mainly imported water, wastewater collection and treatment, water quality in Gaza Strip, agricultural productivity, as well as disaster mitigation and preparedness.

3.1.7 THE UNTAPPED POTENTIAL RESOURCES IN PALESTINE

3.1.7.1 SCENARIO SETTING

Given the current political situation and the failure to initiate realistic permanent status negotiations for more than two decades, this section examines the untapped potential resources in the West Bank and Gaza Strip that could be developed within the next ten years under the “most likely water scenario for 2032”. This "most likely water scenario for 2023" is based on the following assumptions:

1) Palestinians will take reasonable efforts to develop additional resources to improve the water security in Palestine until final negotiations are concluded.
2) International donors will continue to support the water sector.
3) Prospects for advancement in the permanent status negotiations are low.

This scenario should not be interpreted as an alternative to Palestinians achieving complete sovereignty over their resources, but rather as a stopgap measure to avert further deterioration in Palestine's social, economic, and environmental situation owing to water insecurity.

3.1.7.2 POTENTIAL UNTAPPED RESOURCES IN THE WEST BANK BY 2032

The untapped resources in the West Bank include expanding wastewater treatment and reuse for agriculture, developing additional groundwater wells for domestic use, reducing non-revenue water, improving the agricultural water productivity, as well as increasing water importation on the basis of right to water rather than commercial terms. The following untapped potentials are recommend based on donors’ funding level to the water sector, the PA’s fiscal capacity, and a realistic design, permitting, and construction timeframe.

3.1.7.2.1 EXPANDING WASTEWATER TREATMENT AND REUSE

The most significant untapped potential resource in the West Bank is reclaimed treated wastewater. Only 11 MCM of total wastewater generated in the West Bank is treated each year, and only 3 MCM is reuse for agriculture (see section 3.1.1.3), resulting in severe water losses. Based on donor funding levels, the Palestinian Authority fiscal budget, and the high capital cost of wastewater treatment plants, it is recommended that the PA prioritize the intervention shown in Table 55 over the next ten years, which would provide an additional quantity of 42.9 MCM/year of treated wastewater for agricultural use in the West Bank by 2032 at a capital cost of $254 million.

Table 55: Additional Reclaimed Wastewater by 2032 from the Proposed Expansion of Wastewater Treatment and Reuse in the West Bank

No.	WWTP Name	Government	Potential Additional Water for Reuse by 2032 (MCM/year)	Rough Estimated Capital Cost (million USD)	Notes
	Operational WWTP				
1	Nablus West WWTP	Nablus	4.7	$7	Capital cost includes the estimated cost of expanding the wastewater collection system to allow for plant operation at full capacity. Analogous estimating method is used to develop the cost. Reuse scheme cost is included within the centralized conveyance system cost of Tulkarem WWTP.
2	Tayaseer WWTP	Tubas	1.6	$11	Capital cost includes the estimated cost of expanding the wastewater collection system to allow for plant operation at full capacity, as well as developing a sustainable reuse scheme. Analogous estimating method is used to develop the cost.
3	Jenin WWTP	Jenin	2.2	$25	Capital cost includes the estimated cost of expanding the wastewater collection system to allow for plant operation at full capacity, upgrading the treatment plant, as well as developing a sustainable reuse scheme. Analogous estimating method is used to develop the cost.
4	Al Bireh WWTP	Al Bireh	2.4	$15	Capital cost represents the cost of the reuse scheme from Al Bireh to Al Auja based on PWA estimate.
5	Jericho WWTP	Jericho	3.1	$7	Capital cost includes the estimated cost of expanding the wastewater collection to cover the entire city; currently only 70% of the city is connected to the collection system. Analogous estimating method is used to develop the cost.
6	Upgrade Salfit WWTP to include tertiary treatment	Salfit	0.9	$10	Capital cost includes the cost of upgrading the plant to tertiary treatment, as well as developing a sustainable reuse scheme. Analogous estimating method is used to develop the cost.
7	Al Tireh WWTP	Ramallah	0.6	1.0	Localized reuse

No.	WWTP Name	Government	Potential Additional Water for Reuse by 2032 (MCM/year)	Rough Estimated Capital Cost (million USD)	Notes
	Under Construction WWTP				
8	Hebron WWTP	Hebron	8.4	13	Capital cost include the estimated cost of the reuse scheme based on PWA estimate.
	Planned WWTPs				
9	Ramallah-Betounyia-Ein Areek	Ramallah	2.9	30	Capital cost is based on PWA estimate.
10	Nablus East WWTP	Nablus	8.4	35	Analogous estimating method - similar to the cost of Hebron WWTP, and excluding reuse scheme cost, which is included within the centralized conveyance system cost of Tulkarem WWTP.
	Priority WWTP and Reuse Scheme Projects				
11	Tulkarem WWTP	Tulkarem	7.7	100	Capital cost includes the cost of the WWTP, expanding the collection system for Tulkarem, and a centralized reuse scheme from Nablus East, Nablus West, and Tulkarem WWTPs. Cost also includes $22 million for upgrading the plant in 2032 to include tertiary treatment. Cost is based on PWA estimates.
		Totals	**42.9**	**254**	

It is also advised that the reclaimed effluent of the Nablus East, Nablus West, and Tulkarem WWTPs be combined into a single centralized treated wastewater conveyance system that allows for localized reuse within these governorates while transporting excess effluent to the Jordan Valley for reuse during wet seasons.

Upon constructing these wastewater treatment plants and their associated reuse systems, transboundary wastewater flow will be significantly reduced, saving the PA approximately 6 NIS per cubic meter treated in the West Bank, which may be used to construct new WWTPs in the West Bank. In the meantime, the PWA should enter into negotiations with Israel to exchange the amount of wastewater treated in Israel, which is estimated at 18.7 MCM/year, for freshwater or treated water for the West Bank, especially since the PA is already paying for the cost of treatment.

On the governance level, the development of these wastewater treatment plants should be accompanied by sector reform, including the establishment of water users' associations and regional service providers, as well as revisiting the agricultural water tariff and the wastewater tariff to ensure the financial sustainability of these WWTPs and reuse facilities.

3.1.7.2.2 DEVELOPMENT OF ADDITIONAL GROUNDWATER WELLS

The Palestinians are still unable to access the remaining 52 MCM/year from the Oslo Agreement interim allocated share of the groundwater resources (See Table 16, Section 3.1.1.1.2), due to Israel's continued denial to approve the drilling or development of new wells in the West Bank. However, recently a major breakthrough has been achieved during the January 10, 2021, Joint Water Committee meeting, when it was agreed to consider the PWA's request of drilling and developing new wells with a total capacity of 20-30 MCM/year (Office of the Quartet, 2022, p. 12). The estimated cost of developing additional groundwater wells with a total abstraction rate of 30 MCM/year is $150 million, assuming that drilling, equipping, and connecting new wells to the transmission system costs $5-10 million per well (depending on whether rehabilitation or new) and that twenty wells with an average production rate of 1.5 MCM/year will be developed in the course of the upcoming ten years.

Prior to developing additional wells, it is strongly recommended to do groundwater resource mapping to determine the actual safe yield, or more precisely, the managed yield of the Mountain Aquifer Basins to ensure the long-term sustainability of this primary source of water and any investment. To that end, and in order to help replenish the Mountain Aquifer, the PWA should seriously consider establishing Managed Aquifer Recharge (MAR) projects that would capture and store millions of cubic meters of water for future use. Based on a recent study conducted by the U.S. Geological Survey (USGS) for the eastern side of the Jordan Valley (Goode, 2021), which suggest that the Jordan Valley offers a great potential for the implementation of MAR projects, it is recommended that the PWA undertakes a similar study for the Palestinian side of the Jordan Valley.

3.1.7.2.3 WATER IMPORTED FROM ISRAEL

Though imported water threatens water insecurity, it can be transformed from a risk to an opportunity if the terms of these agreements are modified from commercial to right to water terms. PWA has a great opportunity to increase water availability in the West Bank and stress its right to water by insisting that the provisions of the water sales agreement are based on the Palestinian water rights. This applies to both the 2017 sales agreement described below and any new agreements.

Under the auspices of the Israel-Jordan Read Sea-Dead Sea Arrangement, the Israelis and Palestinians agreed on a new bulk sales agreement in July 2017 for an additional 32 MCM/year; 22 MCM/year for the West Bank and 10 MCM/year for Gaza Strip (Ahren & Lidman, 2017). According to the 2017 bulk sales agreement, the Palestinians will receive additional 3.3 MCM/year for the middle area at the Aboud Connection Point, 4 MCM/year for the northern area at the Jalalmeh Connection Point, and 12.78 MCM/year for the southern area at the Deir Sha'ar Connection Point. To date, the Palestinians have only received 7.7 MCM/year at Deir Sha'ar Connection Point, out of a total of 22 MCM/year allocated for the West Bank. The PWA is unable to receive the additional supply for the middle and northern districts due to inadequate infrastructure on the Palestinian side.

In addition, at the Joint Water Committee meeting on January 10, 2021, both sides agreed to deliver an additional 18-25 MCM/year by 2027 through Al Samou's Connection Point for the southern area of West Bank (Office of the Quartet, 2022, p. 5). To receive this quantity, the PWA must upgrade the Samou's transmission and distribution systems.

As shown in Table 56, the expected increase in domestic water quantity as a result of increasing the quantity of water imported from Israel is 37.4 MCM/year at a capital cost of $67 million.

Table 56: Additional Quantity Imported from Israel by 2032 and Required Infrastructure Capital Cost

Connection Point	**Additional Quantity Imported from Israel by 2032 (MCM/year)**	**Estimated Capital Cost for Infrastructure Upgrade (million USD)**	**Notes**
Deir Sha’ar	5.1	0	Deir Sha’ar pipeline has the capacity to transmit the additional quantity.
Aboud	3.3	0	Donor funding has already been secured (Office of the Quartet, 2022, p. 11)
Jenin Jalameh	4	25	Based on OQ estimates (Office of the Quartet, 2022, p. 11)
Samou’	25	42	The cost is based on PWA estimates and includes a regional reservoir in Dura and reconfiguration of the distribution system.
Totals	**37.4**	**67**	

Increasing the amount of imported water will not improve Palestine’s water security index’s score because Palestine will continue to rely on imported resources, making water accessibility extremely vulnerable to the geopolitical climate and limiting Palestine’s sovereignty over its water resources. Because importing water is unavoidable in the medium term to avoid public health risks and social unrest, the terms of these agreements must be modified from commercial to right to water terms. This approach will allow PWA to not only increase water supply in the West Bank, but also to emphasize the Palestinian right to water until the final status negotiations are concluded.

3.1.7.2.4 REDUCTION OF NON-REVENUE WATER

The percentage of non-revenue water in the West Bank is 34 percent, with 15.44 percent representing real losses and the remaining 18.56 percent representing unbilled authorized consumption, unauthorized consumption (illegal connections), metering inaccuracies, and data handling error. Reducing real losses is vital to protecting the limited resources, while reducing unauthorized consumption is critical to ensuring equity in resource distribution and tackling both contributes to strengthening the financial sustainability of the service providers.

The length of Palestine's water network is estimated to be 16,458.00 km (WSRC, 2020q), and it would be impossible to replace all of the pipelines; however, using the district metered area and water audit concepts, the service providers can identify the sections with the highest percentage of real losses and implement strategic high priority low-cost infrastructure repair works to reduce real losses. Reducing the real losses from 15.44 percent to 3 percent would result in saving 16 MCM/year of freshwater. Based on the recently completed WADA Tajdid project in Iraq, which used the DMA concept, a total of 408,000 m^3/year was saved at a cost of $1,428,372.00 (WADA, 2021) equating to $3.5 per saved cubic meter. After accounting for the fact that the cost of living in Palestine is 132 percent higher than in Iraq (Livingcost, 2021), the anticipated cost per saved cubic meter in Palestine is $4.6 per saved cubic meter. As a result, reducing current real losses by 16 MCM per year will requires a capital investment of $74 million.

3.1.7.2.5 IMPROVING AGRICULTURAL WATER PRODUCTIVITY IN THE WEST BANK

Studies and field observations suggest that water savings from replacing conventional irrigation by smart irrigation range from 20 to 30 percent (Arad Group, 2017); (Cleary, 2017); (Grolms, 2019). In 2032, the projected agricultural water demand is 190 MCM/year, which will be used to irrigate 248,000 dunums of irrigated land. According to market research, smart drip irrigation costs $1,000 per dunum on average for holdings larger than 80 dunums (Grupa et al., 2021); (Let's Nurture, 2022). If all irrigated land holdings larger than 80 dunums, which account for 29.5 percent of total agricultural land holdings (MoA, 2016, p. 10), are converted to smart drip irrigation, approximately $74 million will be required over the next ten years to save 14.25 MCM/year.

3.1.7.2.6 SUMMARY OF ADDITIONAL POTENTIAL RESOURCES AND WATER DEFICIT UNDER THE MOST LIKELY SCENARIO FOR THE WEST BANK

According to the “most likely water scenario for 2032”, the supply-demand gap in the West Bank will be narrowed but not closed. Domestic water deficits will be decreased from 95.58 MCM/year in 2032 to 17.2 MCM/year with a total anticipated capital investment of $291 million if the recommended untapped resources are implemented. The agricultural water deficit, despite being cut in half and lowered to 56 MCM/year at a cost of $328 million, will continue to be a key impediment to food security and economic growth (See Table 57).

On the other hand, under this scenario, and given the expansion of wastewater treatment and reuse, environmental pollution will be significantly reduced, preventing further deterioration of groundwater quality and safeguarding vital ecosystems for the benefit of current and future Palestinian generations.

Table 57: Additional Potential Resources and Water Deficit Under the 2032 Most-likely Scenario for the West Bank

Potential Additional Resource	**Potential Additional Quantity by 2032 (MCM/year)**	**Estimated Capital cost (million USD)**
Domestic Use		
Development of additional groundwater wells	30	150
Water imported from Israel	37.4	67
Reduction of non-revenue water of quantities available through 2021	16	74
Less 3 percent losses from the additional potential resources	-2	0
Total additional resources for domestic use	**81.4**	**291**
Projected domestic water deficit by 2032 assuming no additional resources are developed	98.58	
Projected domestic water deficit by 2032 after developing additional water resources	17.18	
Agriculture Use		
Expanding wastewater treatment and reuse	42.9	254
Improving agricultural water productivity	14.25	74
Total additional resources for agriculture use	**57.15**	**328**
Projected agricultural water deficit by 2032 assuming no additional resources are developed	113.52	
Projected agricultural water deficit by 2032 after developing additional resources	56.37	
Total potential additional resources by 2032	**138.55**	**619**
Total water deficit in the West Bank by 2032 if the identified additional resources are developed	**73.55**	

3.1.7.3 POTENTIAL UNTAPPED RESOURCES IN GAZA STRIP BY 2032

Gaza Strip relies primarily on an overexploited groundwater that suffers from deterioration in its quality rendering 97.5 percent of its water not meeting the WHO drinking water standards, and thus unfit for human consumption. Therefore, all efforts should be focused on developing additional resources that would not only decrease the stress on the Coastal Aquifer but also replenish it, particularly desalinated water. As for the agricultural water, expanding wastewater treatment and reuse and improving the agricultural water productivity are the two potential resources to bridge the agricultural water supply-demand gap.

3.1.7.3.1 INCREASING DESALINATED WATER PRODUCTION

The $600 million Gaza Central Desalination Plant and Associated Works Program is the centerpiece of PWA's strategy to address Gaza Strip's water crisis. This program, which was initiated in 2015, includes two components: a desalination plant and associated works. The desalination plant includes a 55 MCM/year sea water reverse osmosis desalination plant, a 22MW solar farm, 4MW wind turbines, and 2MW onsite solar panels, plus two dual engines. While, the north-south carrier, 12 major pumping stations, 5 main booster stations, and blending tanks with a combined capacity of 200,000 m^3 are all part of the associated works component (PWA, 2018, p. 3). Though there has been tremendous work on the ground on the second component in recent years (PWA - GPCU, 2021, pp. 16-19), there has been essentially no progress on the first component. The main reason for the delay in the first component is a shortage of finance, as well as concerns about the long-term sustainability of such investments in light of Israeli military attacks on Gaza Strip. Given that desalination is the only way to address Gaza Strip's domestic water insecurity, the PA should continue to make every political effort to ensure that funds pledged during the 2018 Donors' Conference in Brussels are met (UfM, 2018). As for the Associated Works component, $117 million have been committed (World Bank, 2020) out of a total anticipated cost of $164 million (PWA, 2018, p. 3).

In addition, three STLV desalination plants exist in Gaza Strip (see Table 24, Section 3.6.3), but none of them is fully operational due to the intermittent electric grid. Equipping these three STLVs with a reliable source of energy, such as a solar panel, will ensure their continuous operation and boost their production capacity from 3.3 MCM/year to 13 MCM/year.

With a total capital investment of $377 million, the desalinated water production by 2032 would increase by 64.7 MCM/year without any blending with groundwater resources, or by 97 MCM/year with blending at a ratio of 2:1 (desalinated: groundwater). However, the blending ratio would have to be determined on a case-by-case basis based on the actual quality of the groundwater wells.

Table 58: Estimated Capital Cost for Increasing Desalinated Water Production in Gaza Strip

Description	Estimated Capital cost (million USD)	Notes
Gaza Central Desalination Plant Component	315	
Associated Works Component funding gap	47	Based on Literature Review
Provision of solar energy for Gaza Desalination Plant, Middle Area Desalination Plant, and Khan Younis Desalination Plant	15	Rough estimate based on market rates. Energy needs for the three plants is estimated at 9 MW
Total estimated cost for increasing desalinated water production in Gaza Strip	**377**	

3.1.7.3.2 WATER IMPORTED FROM ISRAEL

Under the auspices of the Israel-Jordan Read Sea-Dead Sea Arrangement, the Israelis and Palestinians signed a new bulk sales agreement in July 2017 for an additional 32 MCM/year; out of which 10 MCM/year are dedicated to Gaza Strip (Ahren & Lidman, 2017). Due to inadequate infrastructure, the Palestinians have only received 3.2 MCM/year of the 10 MCM/year so far (See Table 21, Section 3.6.2). However, with the recent upgrade of the Bani Sohaila and Bani Said Connection Points (PWA - GPCU, 2021, p. 5) and the significant progress made towards the north-south carrier, the Palestinians will be able to receive the remaining 6.8 MCM immediately.

Furthermore, it is highly recommended that the PWA procures additional 16 MCM/year from Israel in order to immediately increase the quantity of potable water for the people of Gaza Strip and help alleviate the water crisis until the Gaza Central Desalination Plant is operational. It is not anticipated that importing an additional 22.8 MCM/year from Israel for Gaza Strip would entail additional capital funding because the infrastructure required to accept this additional quantity has either been completed or funds have already been committed, as is the case with the Reconfiguration of Water Supply Infrastructure - Northern Gaza project (PWA - GPCU, 2021, p. 19).

Without any additional investment, the amount of domestic water could be increased to 34.2 MCM/year if blended with groundwater at a ratio of 2:1. However, and as stated earlier, the provisions of the water sales agreement with Israel should be based on the Palestinian water rights.

3.1.7.3.3 EXPANDING WASTEWATER TREATMENT AND REUSE FOR IRRIGATION

Reclaimed treated wastewater provides an excellent potential in Gaza Strip to enhance the amount of water available for agriculture. Currently, barely 20 MCM/year of treated wastewater meets Palestinian reuse standards, and none is reused for agriculture. Expanding the existing treatment plants to include tertiary treatment, as well as establishing recovery and reuse schemes for these plants, will increase the amount of water available for agriculture by 89.7 MCM/year at a capital cost of $315 million.

Table 59: Additional Reclaimed Wastewater by 2032 from Expanding Wastewater Treatment and Reuse in Gaza Strip

Description	**Reuse Potential (MCM/year)**	**Estimated Capital Cost (million USD)**	**Notes**
Expansion of North Gaza WWTP (NGEST) reuse and recovery Scheme	22	40	Soil Aquifer Treatment (SAT) is an integral component of NGEST. Funding has already been secured for reuse scheme of existing plant (PWA - GPCU, 2021, p. 25). Cost includes expanding NGEST from 13 MCM/year to 20 MCM/year. Very rough estimate using analogous estimating method.
Upgrade Gaza Central WWTP	22	70	Cost includes upgrading the plant to include tertiary treatment, solar panels, and reuse scheme. Very rough estimate using analogous estimating method.
Upgrade and expansion of Gaza Sheikh Ejleen WWTP	22	85	The existing WWTP requires significant upgrade and expansion. The cost includes the WWTP upgrade, expansion of the collection system, solar panels, as well as the reuse scheme. Very rough estimate using analogous estimating method.
Khan Younis WWTP collection system expansion and reuse scheme	9.7	50	Cost includes upgrading the main sewage pumping station, expansion of sewer collection system, solar panels, , as well as the reuse scheme. Cost is based on PWA estimate.
Upgrade and expansion of Rafah WWTP	14	70	The existing WWTP requires significant upgrade and expansion. The cost includes the WWTP upgrade, expansion of the collection system, solar panels, as well as the reuse scheme. Very rough estimate using analogous estimating method.
Totals	**89.7**	**315**	

On the operational level, incorporating Soil Aquifer Treatment (SAT) within these plants, as is the case in North Gaza and Khan Younis WWTPs, allows for the storage of water underground, protected from pollutants and evaporation, until it can be reused during the dry seasons.

3.1.7.3.4 IMPROVING AGRICULTURAL WATER PRODUCTIVITY IN GAZA STRIP

Studies and field observations suggest that water savings from replacing conventional irrigation by smart irrigation range from 20 to 30 percent (Arad Group, 2017); (Cleary, 2017); (Grolms, 2019). In 2032, the projected agricultural water demand is 192.23 MCM/year, which will be used to irrigate 163,408 dunums of irrigated land. According to market research, smart drip irrigation costs $1,000 per dunum on average for holdings larger than 80 dunums (Grupa et al., 2021); (Let's Nurture, 2022). If all irrigated land holdings larger than 80 dunums, which account for 29.5 percent of total agricultural land holdings (MoA, 2016, p. 10), are converted to smart drip irrigation, approximately $49 million will be required over the next ten years to save 14.6 MCM/year.

3.1.7.3.5 SUMMARY OF ADDITIONAL POTENTIAL RESOURCES UNDER THE MOST LIKELY SCENARIO FOR GAZA STRIP BY 2032

The supply-demand gap for all users will be closed under this scenario for Gaza Strip (See Table 60), considerably enhancing water security, especially that 70 percent of generated wastewater will be collected, treated, and reused for irrigation.

Table 60: Additional Potential Resources Under the 2032 Most-likely Scenario for Gaza Strip

Potential Additional Resource	**Potential Additional Quantity by 2032 (MCM/year)**	**Estimated Capital cost (million USD)**
Domestic Use		
Desalinated water blended with groundwater	97	377
Water imported from Israel blended with groundwater	34.2	0
Less 3 percent losses from the additional potential resources	-3.9	0
Total additional resources by 2032	**127.30**	**377**
Projected domestic water deficit by 2032 assuming no additional resources are developed	128.27	
Projected domestic water deficit by 2032 after developing additional resources	**0.97 MCM/year (Supply ≈ Demand)** Gap is considered closed	
Agriculture Use		
Expanding wastewater treatment and reuse	89.7	315
Improving agricultural water productivity	14.6	49
Total	**104.3**	**364**
Projected agricultural water deficit by 2032 assuming no additional resources are developed	100.8	
Total water deficit in Gaza Strip by 2032 if the identified additional resources are developed	**No deficit: supply > demand**	
Total potential additional resources to be developed by 2032	**231.6**	**741**

The major challenges for realizing this scenario, which are discussed further in Section 3.2, include securing the necessary funds, power grid reliability, financial sustainability, and political reality including the Fatah–Hamas conflict.

3.2 DISCUSSION

3.2.1 CURRENT STATE OF WATER SECURITY IN PALESTINE

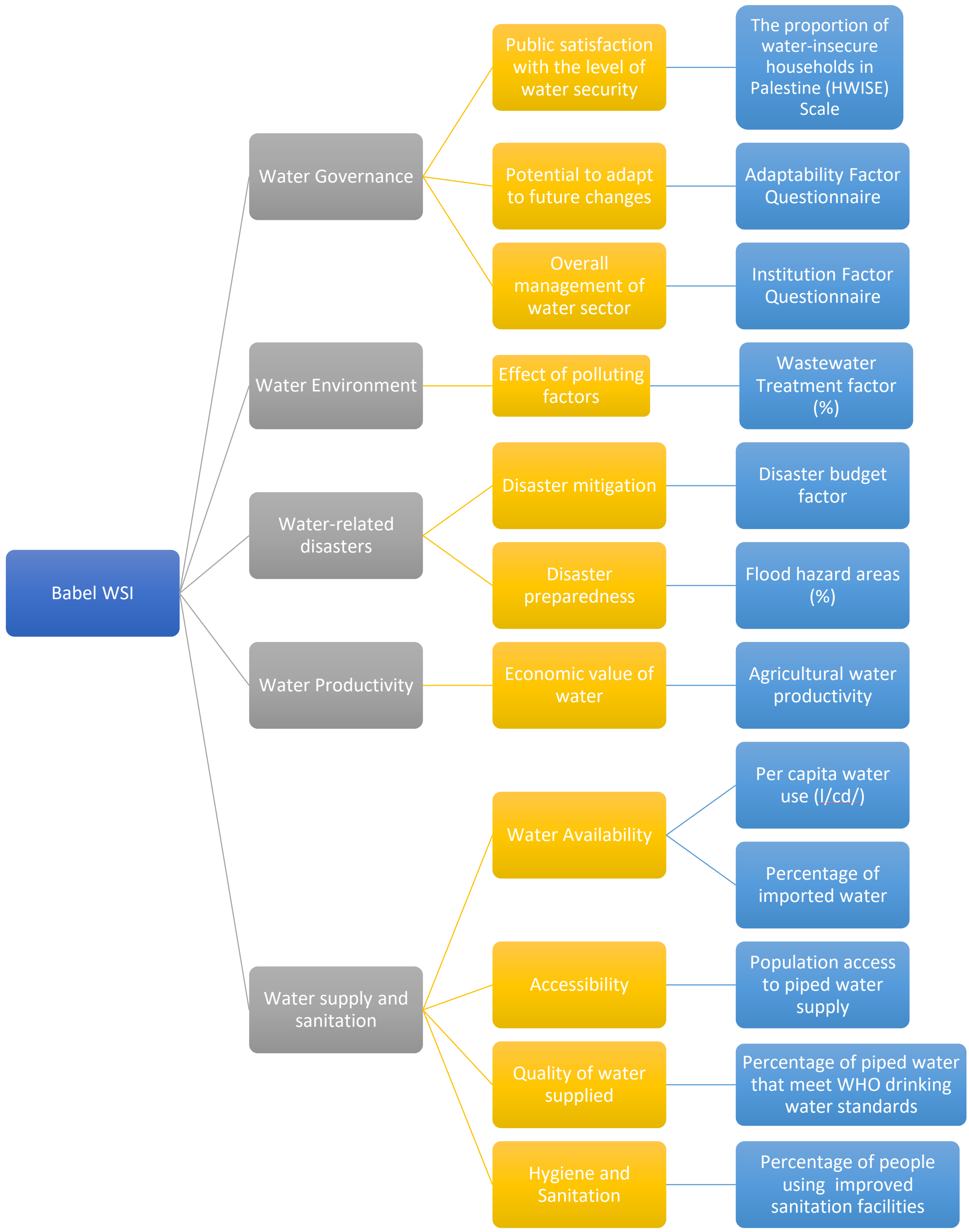
The literature review of the Palestinian Water Authority publications including strategic plans, press releases, and reports showed that the Palestinian Water Authority (PWA) did not adopt the term water security nor employed a holistic water security indicator to describe the existing or future status of water in Palestine. The PWA depended heavily on the metric indicator of domestic water made available per person per day or l/c/d (PCBS & PWA, 2021), (PCBS & PWA, 2022), (PWA, 2013, p. 36). Additionally, and even though the Palestinian Water Authority's National Water Policy for Palestine 2013-2032 (PWA, 2013) addressed some aspects of water security, it did not include a holistic water security indicator, instead opting for a series of individual metric performance indicators.

The same is true for the publications of international organizations. The two World Bank reports "Securing Water for Development in the West Bank and Gaza" (World Bank, 2018b) and "Toward Water Security for Palestinians" (World Bank, 2018c), for example, expounded on water security components in the West Bank and Gaza Strip and offered a number of metric indicators. However, neither study included a comprehensive water security indicator that both measures current water security and forecasts how it would improve if the proposed steps were adopted.

Given the gap identified in establishing a holistic water security indicator for Palestine, it was critical to measure the water security in Palestine using an international-recognized, yet locally relevant, water security index. Deploying an internationally recognized water security indicator can emphasize the magnitude of Palestine's water security challenges and promote Palestine's water rights advocacy. It also improves the odds of enhancing water security by identifying the water security elements that need to be strengthened, while encouraging accountability and providing a framework for tracking performance.

The Babel Water Security Index (Babel WSI), chosen for this study because of its comprehensiveness and adaptability, is comprised of eleven (11) indicators quantified through 12 variables that capture the five key dimensions of water security, namely water supply and sanitation, water productivity, water-related disasters, water environment, and water governance (See Figure 25).

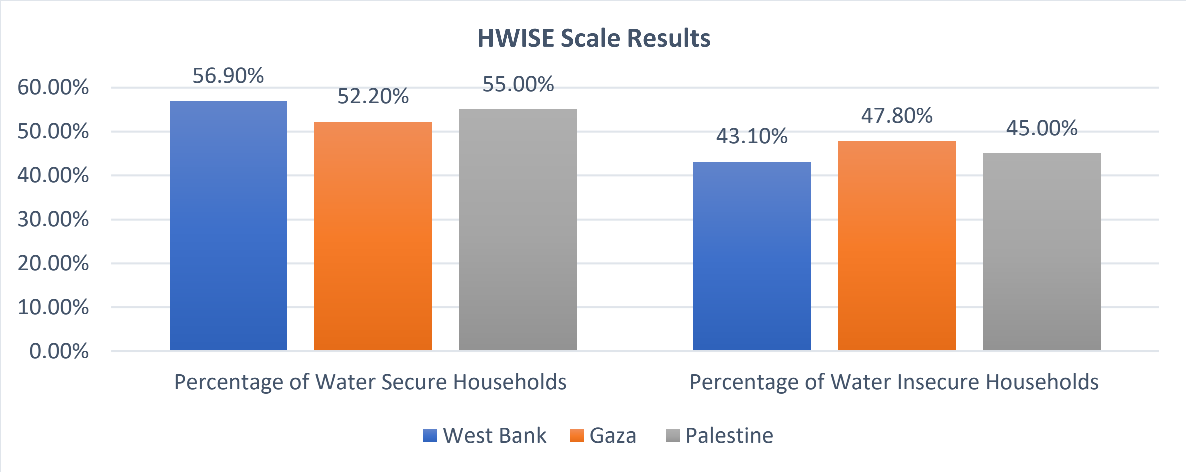
Figure 25: Babel WSI Framework



Note. Adapted from Babel et al., 2020

A nationwide survey was designed and conducted to determine the proportion of water-insecure Palestinian households using the HWISE Scale. The results showed that 43.1 percent of West Bank households are water insecure, compared to 47.8 percent in Gaza Strip, implying that 45 percent of Palestinian households are water insecure (See Figure 26).

Figure 26: HWISE Scale Results for Palestine



According to the HWISE scale results, approximately 457,600 Palestinian households are water insecure, accounting for 45 percent of all households in the West Bank and Gaza Strip. Household water insecurity affects numerous elements of Palestinian lives, including their financial and psychological well-being, and adds to the social and economic hardship that Palestinians are already experiencing due to the country's current political and economic situation.

The results revealed a lack of correlation between per capita allocation and the HWISE scale. For example, on a national level, the per capita allocation analysis revealed that the average per capita allocations in the West Bank and Gaza Strip are 94 l/c/day and 136 l/c/day, respectively, which do not correspond to the high percentages of water insecure households in the West Bank and Gaza Strip of 43 and 47 percent, respectively. The same conclusion applies at the governorate level. For example, while the per capita allocation in Ramallah and Al Bireh Governorate is rather high (117 l/c/day), the HWISE scale found that 100 percent of the governorate's households are water insecure. The HWISE scale results indicate water inequity and an intermittent supply mode in Ramallah and Al Bireh Governorate, which are not reflected in the per capita metric. Similarly, in North Gaza governorate, although the per capita allocation exceeds 160 l/c/day, 81 percent of the households are water insecure. This disparity is mostly attributable to the fact that per capita allocation is based on water quantity rather than water quality.

The lack of correlation between per capita allocation and HWISE scale provides strong evidence that using per capita allocation as a standalone indicator to measure water security produces unreliable results that do not accurately reflect the degree of Palestine's water insecurity. It also emphasizes the importance of deploying a more comprehensive water security indicator that accounts for all aspects of water security.

Therefore, the Babel WSI index was used to assess the current state of water security in Palestine, yielding a score of 2.24 out of 5, with 2.22 for the West Bank and 2.26 for the Gaza Strip (See Figures 27 and 28). These results indicate that Palestine has a "fair" water security state and is thus classified as a water insecure country in some respects such as imported water, wastewater collection and treatment, water quality in the Gaza Strip, agricultural water productivity, and disaster mitigation and preparedness.

Figure 27: Current Water Security Index Score for the West Bank

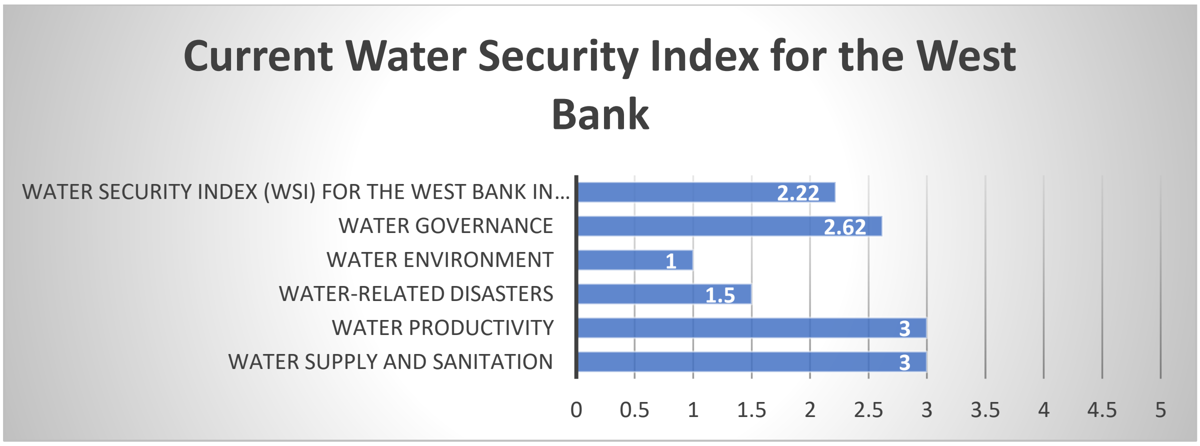
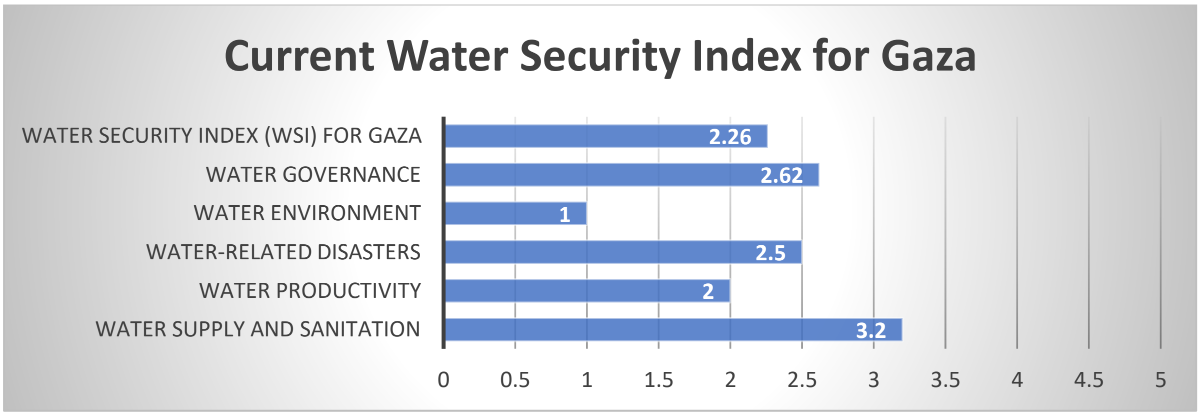


Figure 28: Current Water Security Index for Gaza Strip



If some of these key contributors to Palestine's water insecurity, namely imported water, poor wastewater collection and treatment, low agricultural water productivity, and poor water quality in

Gaza Strip are addressed, more resources will be made available; public satisfaction will naturally rise; and the fiscal budget burden will be lessened, allowing funds to be diverted to other areas such as disaster mitigation and preparedness.

More than half of the West Bank's domestic water resources are imported from Israel, limiting Palestinian sovereignty over its water resources, and making the West Bank's water accessibility extremely vulnerable to the geopolitical climate. Aside from that, water sales agreements have been, so far, concluded on commercial terms between, increasing the cost of water to the PWA and forcing the government to increase its water subsidy. Bulk water is purchased from Israel at 3.6 NIS/m^3, while sold to service providers at approximately 2.6 NIS/m^3 (wattan news, 2018). Because importing water from Israel is unavoidable in the short and medium term, the Palestinian Authority should reconsider the terms of its sales agreements with Israel, particularly given that the imported water is extracted by Israel from the West Bank's groundwater basins. By insisting that the provisions of the water sales agreement are based on the Palestinian water rights, PWA has a great opportunity to improve water availability while also emphasizing the Palestinian water rights.

Inadequate wastewater collection and treatment leads not only in the loss of millions of cubic meters of non-conventional, climate resilient resource, but it also pollutes the environment and degrades groundwater resources. Furthermore, poor wastewater treatment puts a financial burden on the Palestinian Authority. Israel deducts around 110 million shekels from Palestinian customs and VAT revenues for transboundary wastewater treatment in Israel (World Bank Group, 2021, p. 29), equating to 6 NIS per cubic meter of treated wastewater. Until now, Israel has been treating and reusing all Palestinian transboundary wastewater without offering any quantity in exchange for Palestinians. To add to the complication of transboundary wastewater, the amount of transboundary wastewater is still a point of contention between Israel and the Palestinian Authority, especially as most, if not all, transboundary streams lack joint water meters.

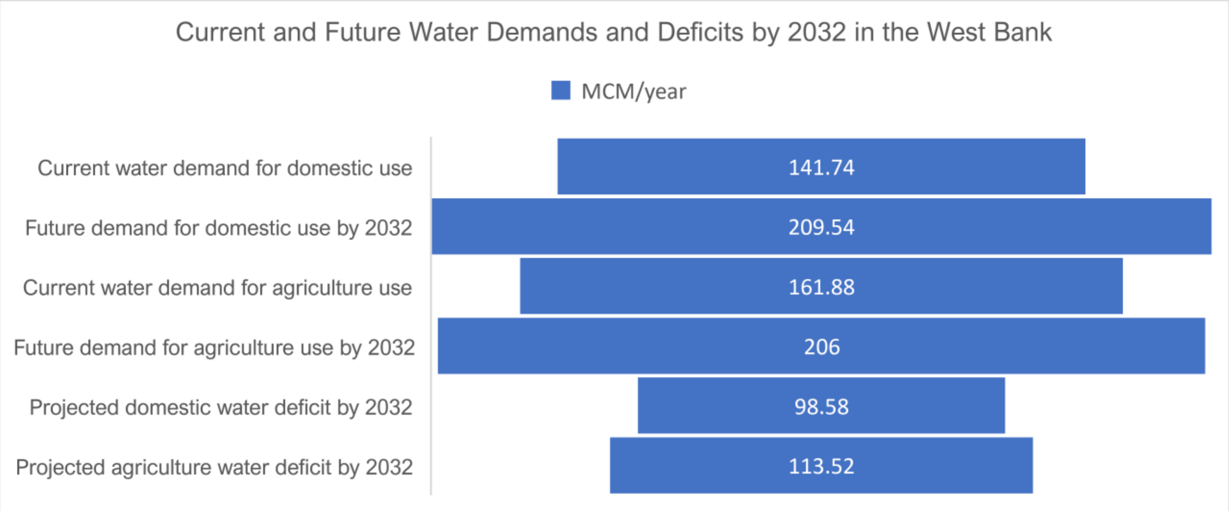
Low agricultural water productivity is mostly related to reliance on traditional irrigation practices, which increases non-beneficial water consumption. By fine-tuning irrigation timing and frequency to the evapotranspiration cycle, modernization of irrigation practices and capitalization on breakthroughs in this field can result in significant water savings. According to studies and field observations, shifting to smart agriculture saves 20 to 30 percent of water, depending on the technology used, while lowering greenhouse gas emissions and energy consumption and increasing average crop output. Overfertilization, which is now contributing to the high nitrate level in groundwater in the Gaza Strip, can also be managed by switching to smart agriculture.

Finally, poor water quality in Gaza is a serious concern that will demand a variety of actions, including the development of additional resources to reduce the stress on the Coastal Aquifer, the expansion of wastewater collection and treatment, and the improvement of agricultural practices.

3.2.2 Between Available and Potential Resources, the Possibility of Achieving Water Security in the West Bank by 2032

The current water demand for domestic use in the West Bank, which includes household, industrial, commercial, touristic, and government uses, is estimated at 141.74 MCM/year, with a projected future demand of 209.54 MCM/year by 2032. The current agricultural water demand, including livestock, is estimated at 161.88 MCM/year, with a projected increase to 206 MCM/year by 2032. If no additional resources are developed, the domestic water supply-demand gap is expected to be 98.58 MCM/year in 2032, compared to an agricultural water supply-demand gap of 113.52 MCM/year (See Figure 29).

Figure 29: Current and Future Demands and Deficits by 2032 in the West Bank assuming no additional resources are developed in MCM/year



To determine whether developing new resources over the next ten years will enable the West Bank to realize a water security state, untapped potential resources were identified and analyzed. These untapped resources were developed and framed under the "most likely water scenario for 2032". This scenario assumes that no significant progress on the permanent status negotiations will be made, given that the Declaration of Principles on Interim Self Government Arrangements was signed over 28 years ago, and permanent status negotiations are still blocked.

Five major untapped resources in the West Bank were identified in the "most likely water scenario for 2032" including expanding wastewater treatment and reuse for agriculture, developing additional groundwater wells for domestic use, increasing water importation from Israel based on the Palestinian water rights, reducing non-revenue water, and improving the agricultural water productivity. If these additional resources, which will require approximately $619 million in capital investment, are all developed by 2032, the supply-demand gap will be narrowed but not closed. A domestic water deficit of 17 MCM/year and an agricultural water deficit of 56 MCM/year will still exist in 2032, with gaps expected to grow with each year following 2032 due to population growth.

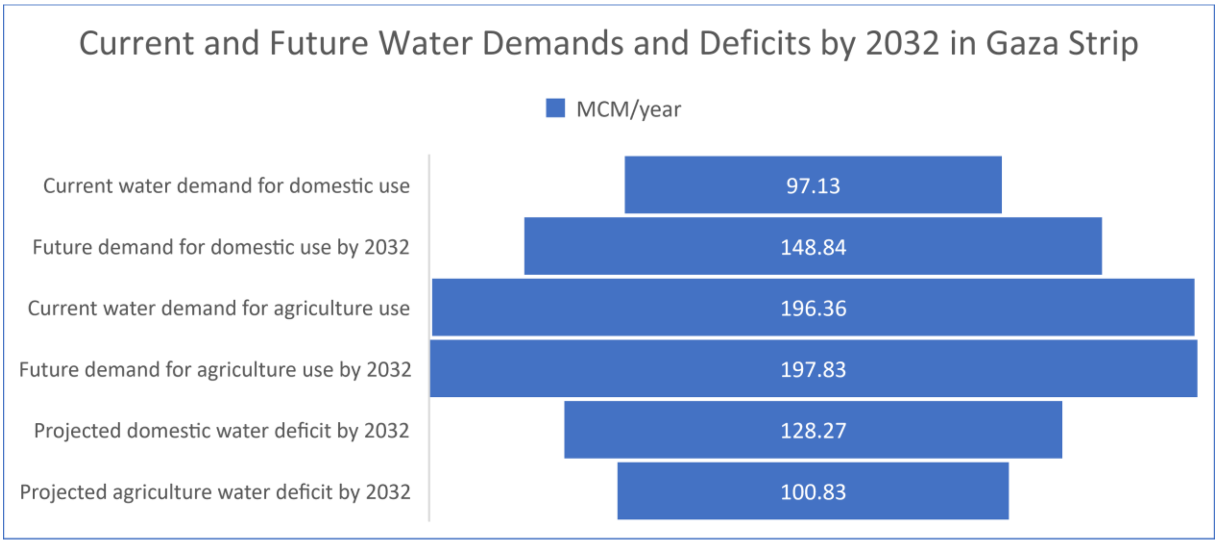
The "most likely water scenario for 2032" analysis suggests that increasing water resource management practices alone will not be enough to achieve water security in the West Bank, as two of the four pillars of water security, namely political stability and sustainable development will not be realized. Economic growth and sustainable development will be hampered by a severe agricultural water deficit. More crucially, given the unlikelihood of concluding fair negotiations with Israel by 2032, water will increase political instability and fuel social unrest, particularly as the West Bank becomes more reliant on imported water from Israel. The evidence-based, data-driven approach used in this research demonstrated that water security in the West Bank can only be achieved after the conclusion of a fair and sustainable peace agreement and the establishment of a fully independent State of Palestine.

That said, Palestinians should continue to identify and develop additional resources, such as the ones identified in this research, to ensure human wellbeing, reduce environmental pollution, prevent further deterioration of groundwater quality, and safeguard vital ecosystems for the benefit of current and future Palestinian generations, with a special focus on expanding wastewater treatment and reuse as a viable climate-resilient resource. Furthermore, Palestinians should demand an immediate allocation of their share of the Jordan River based on 1997 United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses.

3.2.3 Between Available and Potential Resources, the Possibility of Achieving Water Security in Gaza Strip by 2032

The current water demand for domestic use in Gaza Strip is estimated at 97.13 MCM/year, with a projected future demand of 148.84 MCM/year by 2032. The current water demand for agriculture, including livestock, is estimated at 196.36 MCM/year, with a projected increase to 197.83 MCM/year by 2032. If no untapped resources are developed, the domestic water supply-demand gap is expected to be 128.27 MCM/year, compared to an agricultural water supply-demand gap of 100.83 MCM/year (See Figure 30).

Figure 30: Current and Future Demands and Deficits by 2032 in Gaza Strip



To determine whether developing new resources over the next ten years will enable the Gaza Strip to realize a water security state, untapped potential resources were identified and analyzed. Based on the international community's and the PA's serious commitment to resolve Gaza Strip's water crisis and a realistic design, permitting, and construction timeline, four major untapped resources were identified for Gaza Strip. These include increasing desalination water production, expanding wastewater treatment and reuse for agriculture, increasing water importation from Israel based on the Palestinian water rights, and improving agricultural water productivity. If all these additional resources are developed by 2032, the Gaza Strip's supply-demand gap will be closed promoting public health. Water productivity will also increase dramatically, boosting economic growth and employment. As a result, social unrest and political instability will decrease. Furthermore, groundwater stress will be significantly decreased, allowing the Coastal Aquifer to begin its recovery process. Finally, by minimizing the amount of untreated wastewater discharged into the environment, environmental protection will be significantly improved.

The "most likely water scenario for 2032" analysis suggests that Gaza Strip can achieve water security by 2032 with a $741 million capital expenditure, but only if critical constraints including power grid reliability, financial sustainability, political reality, and the Fatah–Hamas conflict are overcome. To address power grid reliability, and in the absence of real on-the-ground progress on the 'Gas for Gaza' initiative, equipping water and wastewater facilities with solar energy and wastewater treatment plants with biogas components will help mitigate this risk.

Political reality, on the other hand, will continue to be a major constraint pending not only Fatah-Hamas reconciliation but also the final status negotiations between Israel and the Palestinian Authority. However, it is a risk that must be accepted in order to avoid a humanitarian crisis in the Gaza Strip.

Furthermore, in order to develop the proposed new facilities, the siege imposed on Gaza Strip must be lifted and the Gaza Reconstruction Mechanism must be deactivated, allowing the unrestricted flow of all supplies into Gaza Strip. The international community should hold Israel accountable for its pledge to support the Gaza Central Desalination Plant and Associated Works Program, particularly in terms of facilitating material entry into Gaza Strip (PWA, 2018, p. 24).

Finally, reform efforts must be advanced and water tariffs revisited to support the establishment of self-sustaining service providers. It is envisaged that as service delivery and water quality improve, collection efficiency would naturally increase because Gazans will no longer have to rely on private desalination companies at prices 20-30 times higher than public mains.

Chapter Four: Conclusions and Recommendations

4.1 CONCLUSIONS

The results of the Babel WSI show that the West Bank, Gaza Strip, and ultimately Palestine are water insecure. Palestine's Babel WSI score of 2.24 out of 5, with 2.22 for the West Bank and 2.26 for the Gaza Strip, indicates that Palestine is in a “fair” water security condition and is thus regarded as a water insecure country in certain aspects, including imported water, wastewater collection and treatment, water quality in Gaza, agricultural water productivity, as well as disaster mitigation and preparedness.

In terms of water security at the household level, the HWISE Scale results show that 45 percent of Palestinian households are water insecure. This means that 457,600 Palestinian households do not have access to safe, reliable, affordable, and sufficient water for their good health and wellbeing.

According to analysis, the current domestic water demand in the West Bank is estimated at 141.74 MCM/year, and the future domestic water demand by 2032 is 209.54 MCM/year, compared to current and projected agricultural water demands of 161.88 MCM/year and 206 MCM/year in 2032, respectively. The West Bank’s domestic water supply-demand gap is expected to be 95.58 MCM/year by 2032 if no new resources are developed, compared to an agricultural water supply-demand gap of 113.52 MCM/year.

In the Gaza Strip, the current domestic water demand is estimated at 97.13 MCM/year, with a projected future domestic water demand of 148.84 MCM/year by 2032, compared to current and projected agricultural water demands of 196.36 MCM/year and 197.83 MCM/year in 2032, respectively. The domestic water supply-demand gap in Gaza Strip is expected to be 128.27 MCM/year by 2032 if no additional resources are developed, compared to an agricultural water supply-demand gap of 100.83 MCM/year.

Based on the results of the Babel WSI analysis, the supply-demands gaps analysis, and the political reality, several untapped additional potential resources were identified under what is referred to as “the most likely water scenario for 2032”. The identified additional untapped resources in the West Bank include expanding wastewater treatment and reuse, developing additional groundwater wells for domestic use, increasing water importation from Israel based on the right to water, reducing non-revenue water, and improving agricultural water productivity. The results shows that if all of the identified additional resources totaling $619 million in capital investment are developed by 2032, the

West Bank's supply-demand gap will be significantly narrowed but not closed by 2032. A domestic water deficit of 17 MCM/year and an agricultural water deficit of 56 MCM/year will still exist in 2032.

In Gaza Strip, desalinated water is the most significant additional resource for domestic use, while improving wastewater treatment and reuse and enhancing agricultural water productivity are two viable resources for bridging the agricultural water supply-demand gap. The analysis shows that if these additional resources are developed by 2032, the water supply-demand gap will be closed in Gaza Strip, bringing the water deficit to near zero in 2032.

Regarding the central question, the result shows that the West Bank cannot achieve water security by 2032 since two of the four pillars of water security, namely political stability and sustainable development, will not be realized. The substantial agricultural water deficit will stymie economic growth and sustainable development. More importantly, it is expected that water insecurity will increase political instability and fuel social unrest. The findings also suggest that improving water resource management alone will not be sufficient to achieve water security in the West Bank because the Palestinians' access to and control of their water resources in the West Bank is constrained by the hydropolitical situation. Given the dominance of the hydropolitical dimension, water security in the West Bank could only be achieved following the conclusion of a fair and permanent peace agreement and the establishment of a fully independent State of Palestine.

Unlike the West Bank, the results show that Gaza Strip can achieve water security by 2032 with a $741 million capital investment if certain constraints are overcome including the power grid reliability, financial sustainability, and the political reality (including Fatah–Hamas conflict). Though the political reality poses a significant risk, it is one that must be accepted and should not deter the Palestinian Authority from developing the identified additional resources.

Although the results show that water security cannot be achieved by 2032 in the West Bank, the Palestinian Authority must continue to act prudently toward its state and people by identifying and developing additional resources, such as those identified in this research. These additional resources will serve as a stopgap measure to ensure human well-being, support food security, avoid further deterioration of groundwater resources, and protect vital ecosystems for the benefit of the current and future Palestinian generations.

The findings of this research can be used to justify the Palestinian appeals for international assistance in concluding final status negotiations on shared water resources. Besides, the results of this research are expected to help secure funds for the Palestinian water sector by correctly placing Palestine on the world map of water insecurity.

4.2 RECOMMENDATIONS

Based on the findings of this research, and in addition to the identified additional resources, the following are recommended:

1. The Palestinian Water Authority should develop a comprehensive water security index that captures all elements of water security and utilize it to measure and track performance. This would not only support informed decision-making process because “If you can’t measure it, you can’t manage it” (Patrinos, 2014), but also promotes transparency and accountability.

2. The Palestinian Water Authority should refrain from relying solely on the metric indicator of per capita allocation as it provides inaccurate and somehow misleading results.

3. Palestinians should demand an immediate allocation of their share of the Jordan River based on 1997 United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses.

4. The Palestinian Authority should reconsider the terms under which water sales agreements with Israel are formalized. By shifting away from a commercial to a right to water basis, PWA will not only be able to increase water supply in the West Bank, but also to emphasize the Palestinian water rights until the final status negotiations are concluded.

5. Given that the Palestinian Authority is already paying for the cost of treatment in Israel, the Palestinian Authority should demand that Israel exchanges Palestinian wastewater that is treated and utilized in Israel for freshwater or treated water for the West Bank.

6. On the governance level, reform efforts should be advanced based on the 2014 Water Law. Revising the tariff structure, strengthening the policy and regulatory framework, and enforcing the law are crucial to the establishment of self-sustaining service providers and the promotion of public-private partnerships.

7. The Palestinian Water Authority should conduct groundwater mapping of all groundwater resources in the West Bank and Gaza Strip to identify the safe yield of the Mountain and Coastal Aquifers and subsequently, ensure the long-term sustainability of Palestine's primary source of water.

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Annexes

Annex I- HWISE Scale Form

LABEL	ITEM	SCORE
Worry	In the last 4 weeks, how frequently did you or anyone in your household worry you would not have enough water for all of your household needs?	
Interrupt	In the last 4 weeks, how frequently has your main water source been interrupted or limited (e.g. water pressure, less water than expected, river dried up)?	
Clothes	In the last 4 weeks, how frequently have problems with water meant that clothes could not be washed?	
Plans	In the last 4 weeks, how frequently have you or anyone in your household had to change schedules or plans due to problems with your water situation? (Activities that may have been interrupted include caring for others, doing household chores, agricultural work, income-generating activities, sleeping, etc.)	
Food	In the last 4 weeks, how frequently have you or anyone in your household had to change what was being eaten because there were problems with water (e.g., for washing foods, cooking, etc.)?	
Hands	In the last 4 weeks, how frequently have you or anyone in your household had to go without washing hands after dirty activities (e.g., defecating or changing diapers, cleaning animal dung) because of problems with water?	
Body	In the last 4 weeks, how frequently have you or anyone in your household had to go without washing their body because of problems with water (e.g., not enough water, dirty, unsafe)?	
Drink	In the last 4 weeks, how frequently has there not been as much water to drink as you would like for you or anyone in your household?	
Angry	In the last 4 weeks, how frequently did you or anyone in your household feel angry about your water situation?	
Sleep	In the last 4 weeks, how frequently have you or anyone in your household gone to sleep thirsty because there wasn't any water to drink?	
None	In the last 4 weeks, how frequently has there been no useable or drinkable water whatsoever in your household?	
Shame	In the last 4 weeks, how frequently have problems with water caused you or anyone in your household to feel ashamed/excluded/stigmatized?	
	TOTAL	

Source: Young et al. (2019, p.7)

Annex II- HWISE Scale Form in Arabic

البيانات سرية
مسح ميداني متخصص حول تجارب الأمن المائي المنزلي
حضرة الأخوة والأخوات المحترمين، **رسالة الباحثة**: تهدف هذا الاستبانة الى قياس تجارب الأمن المائي المنزلي في الضفة الغربية وغزة ويهدف هذا المقياس الى التقاط التجارب التي عاشها اي أحد من افراد الاسرة خلال الاسابيع الاربعة السابقة.

	الرقم المتسلسل للاستمارة (للأسرة):	V1	☐☐☐☐
1) الضفة الغربية 2) قطاع غزة	المنطقة	V2	☐
________________	اسم التجمع	V3	☐☐
	المحافظة	V4	☐☐
1) حضر (مدينة) 2) ريف (قرية) 3) مخيم	نوع التجمع السكاني	V5	☐
	اسم الباحث/ة	V6	
	رقم الباحث/ة	V7	☐☐
	تاريخ يوم العمل (يوم – شهر – سنة)	V8	☐☐☐☐☐☐
	وقت بدء المقابلة(hh:mm)	V9	☐☐☐☐

1) ذكر 2) أنثى	**الجنس**	**Gender**	☐
	العمر	**Age**	☐☐
في الأسابيع الأربعة الماضية، ما مدى تكرار قلقك أنت أو أي شخص في أسرتك بأنه لن يكون لديك ما يكفي من الماء لجميع احتياجات منزلك؟ 1) أبداً (0 مرات) 2) نادرا (1-2 مرات) 3) أحيانًا (3-10 مرات) 4) غالبًا (11-20 مرة) 5) دائمًا (أكثر من 20 مرة)			
1) أبدا 2) نادرا 3) أحيانا 4) غالبا 5) دائما	في الأسابيع الأربعة الماضية، ما مدى تكرار المرات التي انقطع بها مصدر المياه الرئيسي (مثل ضغط المياه، مياه أقل من المتوقع ...الخ)؟	S1	☐
1) أبدا 2) نادرا 3) أحيانا 4) غالبا 5) دائما	في الأسابيع الأربعة الماضية ، ما مدى تكرار المرات التي لم يكن فيها الكثير من الماء للشرب كما ترغب أنت أو أي شخص في منزلك؟	S2	☐
1) أبدا 2) نادرا 3) أحيانا 4) غالبا 5) دائما	في الأسابيع الأربعة الماضية ، ما مدى تكرار عدم وجود مياه صالحة للشرب أو الاستخدام في منزلك على الإطلاق؟	S3	☐
1) أبدا 2) نادرا 3) أحيانا 4) غالبا 5) دائما	في الأسابيع الأربعة الماضية، ما مدى اضطرارك أنت أو أي شخص في منزلك إلى عدم غسل اليدين بعد الأنشطة القذرة (على سبيل المثال، التغوط أو تغيير الحفاضات) بسبب مشاكل المياه؟	S4	☐
1) أبدا 2) نادرا 3) أحيانا 4) غالبا 5) دائما	في الأسابيع الأربعة الماضية، ما مدى اضطرارك أنت أو أي شخص في أسرتك إلى عدم غسل أجسادكم بسبب مشاكل المياه (على سبيل المثال، عدم وجود كمية كافية من الماء، أو مياه غير آمنة)؟	S5	☐

☐	S 6	في الأسابيع الأربعة الماضية، ما مدى اضطرارك أنت أو أي شخص في أسرتك إلى تغيير ما تم تناوله (أكله) بسبب وجود مشاكل مع الماء (على سبيل المثال، لغسيل الأطعمة والطهي وما إلى ذلك)؟	1) أبدا 2) نادرا 3) أحيانا 4) غالبا 5) دائما
☐	S 7	في الأسابيع الأربعة الماضية ، ما مدى تكرار مشاكل الماء التي أدت إلى عدم إمكانية غسل الملابس؟	1) أبدا 2) نادرا 3) أحيانا 4) غالبا 5) دائما
☐	S 8	في الأسابيع الأربعة الماضية، ما مدى شعورك بالقلق أنت أو أي شخص في أسرتك من عدم توفر كمية كافية من الماء لجميع احتياجات أسرتك؟	1) أبدا 2) نادرا 3) أحيانا 4) غالبا 5) دائما
☐	S 9	في الأسابيع الأربعة الماضية، ما مدى شعورك فيها أنت أو أي شخص في أسرتك بالغضب بشأن وضعك المائي؟	1) أبدا 2) نادرا 3) أحيانا 4) غالبا 5) دائما
☐	S 10	في الأسابيع الأربعة الماضية، كم مرة اضطررت أنت أو أي شخص في أسرتك لتغيير برامجكم أو الخطط الخاصة بكم أو باسركم بسبب مشاكل تتعلق بوضعك المائي؟ (تشمل الأنشطة التي قد تكون قد توقفت رعاية الآخرين، والقيام بالأعمال المنزلية، والأعمال الزراعية، والأنشطة المدرة للدخل، والنوم، وما إلى ذلك)	1) أبدا 2) نادرا 3) أحيانا 4) غالبا 5) دائما
☐	S 11	في الأسابيع الأربعة الماضية، ما مدى تكرار المرات التي نمت فيها أنت أو أي شخص في منزلك وأنت تشعر بالعطش بسبب عدم وجود ماء للشرب؟	1) أبدا 2) نادرا 3) أحيانا 4) غالبا 5) دائما
☐	S 12	في الأسابيع الأربعة الماضية ، كم مرة تسببت مشاكل المياه في شعورك أنت أو أي شخص في أسرتك بالخجل / الإقصاء / الوصم؟	1) أبدا 2) نادرا 3) أحيانا 4) غالبا 5) دائما

أسئلة خلفية عامة			
☐	**V10**	**طبيعة مسكن الأسرة:**	1) شقة في عمارة 2) بيت مستقل 3) خيمة 4) براكية (بيت زينكو)
☐	**V11**	**الوضع المعيشي والاقتصادي للأسرة**	1) ممتاز 2) جيد جدا 3) جيد 4) متوسط 5) فقير (سيئ) 6) فقير جدا (سيئ جدا)
☐☐	**V12**	**عدد أفراد الأسرة الذين يعيشون ويأكلون في نفس المنزل**	
☐☐☐☐	**V13**	**وقت انتهاء المقابلة(hh:mm)**	