

FROM SCARCITY TO SECURITY

EXAMINING THE WATER-ENERGY-FOOD NEXUS IN

THE WEST BANK AND GAZA

WITHIN THE CONTEXT OF CLIMATE CHANGE



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FOREWORD

This report was prepared prior to the conflict that started in October 2023, as one of a series of background papers for the Country Climate and Development Report (CCDR). The CCDR highlights the impact of climate change, which is reducing the availability of water, food, and energy, inhibiting private-sector activity, undermining human capital formation, and diminishing economic opportunities. It advances a set of policy recommendations designed to support the shift from a development pathway marked by Continued Fragility to one characterized by Increased Resilience and estimates the need for climate financing between now and 2050 at US\$5.5 billion.

The CCDR highlights the importance of increasing resilience in the face of the cascading effects of climate change on the water-energy-food (WEF) nexus, which will be critical to improving the lives of the Palestinian people. This report provides a deeper analysis that identifies exogenous vulnerabilities, such as climate change, and their impacts on the WEF nexus in the West Bank and Gaza. It provides an analysis of the water, agriculture, and energy sectors and identifies potential adaptation responses, institutional measures, and investments anchored in the WEF nexus to improve sustainability and resiliency in the context of increasing uncertainty. These recommendations remain broadly relevant even in the context of the ongoing conflict and could provide useful guidance to inform the reconstruction and recovery efforts.

The conflict is expected to leave lasting impacts on the affected populations in Gaza, the West Bank, and Israel, beyond what can be easily captured in any assessment. The Palestinian economy has experienced one of the largest shocks recorded in recent economic history since October 2023, with a 35 percent decline in real GDP growth in the first quarter of 2024. Over this period, Gaza's economy has been brought to the brink of total collapse, with an 86 percent contraction, while the economy in the West Bank has contracted by 25 percent. The near-complete halt of economic activity has left Gaza in a deep recession, with its share of the economy plummeting from 17 percent to less than 5 percent. A sharp decline in economic activity, including trade, coupled with a sharp reduction in so called clearance revenues has worsened an already acute fiscal crisis, severely impacting the delivery of public services. Poverty was already high in Gaza before the conflict, with more than half of households relying on aid as the primary source of income. At present, almost every resident in Gaza lives in poverty and faces acute food insecurity. Poverty levels are on the rise also in the West Bank, due to a marked economic slowdown, constrained fiscal capacity and a deteriorating security situation.

Against the backdrop of the humanitarian emergency and in line with our mission, the World Bank is working in close collaboration with development partners to support urgent relief efforts for the affected people. In the immediate term, we are mobilizing resources that deliver help to the poorest and most vulnerable people. The funds mobilized are being used to provide lifesaving interventions, including emergency medical supplies, food and water. These activities are being implemented through UN Agencies based upon their ability to operate on the ground during an active conflict. The World Bank grieves the tragic loss of life and devastating impact on all civilians from this conflict.

The World Bank Group's work in the West Bank and Gaza is aligned with our mandate to remain actively engaged in fragile and conflict settings, supporting people in the most challenging circumstances while building the foundations of development that are essential to ending poverty on a livable planet.

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ABBREVIATIONS AND ACRONYMS

<i>AFD</i>	Agence Française de Développement
<i>APV</i>	agri-photovoltaics
<i>AWP</i>	Associated Works Project
<i>CMIP6</i>	Coupled Model Intercomparison Project
<i>CMWU</i>	Coastal Municipalities Water Utility
<i>CSA</i>	climate-smart agriculture
<i>DISCO</i>	distribution company
<i>EIB</i>	European Investment Bank
<i>EQA</i>	environmental quality authority
<i>EU</i>	European Union
<i>FAO</i>	Food and Agriculture Organization
<i>GCDAWP</i>	Gaza Central Desalination and Associated Works Program
<i>GCDP</i>	Gaza Central Desalination Program
<i>GDP</i>	gross domestic product
<i>GHG</i>	greenhouse gas
<i>GPP</i>	Gaza Power Plant
<i>ICA</i>	Israeli Civil Administration
<i>IPCC</i>	Intergovernmental Panel on Climate Change
<i>JMP</i>	Joint Monitoring Program
<i>JSCs</i>	Joint Service Councils
<i>JWC</i>	Joint Water Committee
<i>KFAED</i>	Kuwait Fund for the Arab Economic Development
<i>lcd</i>	liters per capita per day
<i>IEC</i>	Israel Electric Corporation
<i>LGUs</i>	local government units
<i>MCM</i>	million cubic meters
<i>MENA</i>	Middle East and North Africa
<i>MoA</i>	Ministry of Agriculture
<i>MoH</i>	Ministry of Health
<i>MoLG</i>	Ministry of Local Government
<i>MW</i>	megawatts
<i>NAP</i>	national adaptation plan
<i>NBS</i>	nature-based solutions
<i>NDC</i>	nationally determined contributions

<i>NGEST</i>	North Gaza Emergency Sewage Treatment Plant
<i>NGOs</i>	nongovernmental organizations
<i>NGWWTP</i>	North Gaza Wastewater Treatment Plant
<i>NIS</i>	New Israeli Shekel
<i>NREAP</i>	National Renewable Energy Action Plan
<i>NRW</i>	nonrevenue water
<i>NWC</i>	National Water Company
<i>O&M</i>	operations and maintenance
<i>PA</i>	Palestinian Authority
<i>PCBS</i>	Palestinian Central Bureau of Statistics
<i>PENRA</i>	Palestinian Energy and Natural Resources Authority
<i>PLO</i>	Palestine Liberation Organization
<i>PMD</i>	Palestinian Meteorological Department
<i>PV</i>	photovoltaics
<i>PWA</i>	Palestinian Water Authority
<i>RSDS</i>	Red Sea-Dead Sea
<i>RWH</i>	rainwater harvesting
<i>RWUs</i>	regional water utilities
<i>SCADA</i>	Supervisory Control and Data Acquisition
<i>SDP</i>	strategic development plan
<i>SPs</i>	service providers
<i>SSPs</i>	shared socioeconomic pathways
<i>STLV</i>	short-term low-volume
<i>TWW</i>	treated waste water
<i>UNFCCC</i>	United Nations Framework Convention on Climate Change
<i>VCs</i>	village councils
<i>WWTP</i>	wastewater treatment plant
<i>WB&G</i>	West Bank and Gaza
<i>WBWD</i>	West Bank Water Department
<i>WEF</i>	water-energy-food
<i>WFP</i>	World Food Program
<i>WHO</i>	World Health Organization
<i>WMS</i>	wastewater management sustainability
<i>WSRC</i>	Water Sector Regulatory Council



EXECUTIVE SUMMARY



Image by Shareef Sarhan

The prospects for a prosperous future in the West Bank and Gaza are deeply intertwined with the regional context. Restrictions on the movement of people and goods and access to natural resources, particularly land and water, coupled with recurrent episodes of conflict, uncertain political and policy pathways, and the lack of control over critical natural resources have undermined development and constrained socioeconomic growth. An escalation of the conflict in the Middle East, centered in Gaza, that started in 2023 (hereafter, "the conflict"), makes it difficult to attract foreign investment and develop a stable economy. Given these constraints, the economy in the West Bank and Gaza is heavily dependent on foreign aid, which can be unpredictable and subject to the prevailing political conditions. This is particularly acute for the people of Gaza, who face chronic shortages of basic services, exacerbated by frequent and significant destruction of critical infrastructure as well as high levels of poverty and unemployment. These drivers of fragility increase social, economic, and environmental exposure to a range of vulnerabilities and create deep uncertainty about the future.

Climate change is accentuating uncertainty and imposing further constraints on development. The West Bank and Gaza faces numerous risks and is considered one of the world's most climate-vulnerable economies. Although its contributions to global emissions are negligible, the West Bank and Gaza is a hot spot for climate change and its impacts. Coupled with more frequent and extreme weather events, existing water scarcity could be further exacerbated, decreasing crop yields, undermining food security, and damaging agricultural infrastructure. Higher temperatures will also likely lead to increased demand for electricity for cooling and to support water and agriculture investments, putting additional pressure on the already strained energy sector. Already challenged by high population densities, sea level rise in Gaza could lead to increased coastal erosion, the loss of land, and the displacement of people.

There is an increasing urgency to enhance resilience to a number of exogenous shocks. Shifting demographic patterns and rapidly changing economic conditions in the West Bank and Gaza, coupled with increasing variability of climate and weather systems, evolving social expectations, and rapidly changing regional conditions, make for a high degree of uncertainty. As such, robust, data-driven decision-making is becoming increasingly important to address systemic risks and exogenous constraints to the development, operation, and management of the complex interdependencies of water, energy, and food. These risks and constraints can result in cascading and compounding impacts across sectors, with significant social and economic consequences.

Understanding the water-energy-food (WEF) nexus is key for increasing resilience and enabling sustainable development in the West Bank and Gaza. However, managing the WEF nexus requires a holistic approach that recognizes the complex interactions between these systems and that promotes integrated strategies for water management and conservation, smart and sustainable agriculture, and energy efficiency, with an emphasis on cross-cutting institutional reforms, education, and awareness. Within the current context of the West Bank and Gaza, the complex system of restrictions on movement and access maintained by Israel imposes significant impediments to realizing the opportunities presented by the nexus approach.

An analysis of the WEF nexus in the context of hypothetical scenarios assesses the social and macroeconomic impacts of water scarcity and climate change in the West Bank and Gaza. The scenarios reflect the regional realities, the constraints these imposed on the economy, and climate priorities. The analysis identifies the benefits of advancing climate resilience and mitigation interventions that are aligned to the West Bank and Gaza's international climate commitments, specifically, the economy's Nationally Determined Contribution (NDC) and National Adaptation Plan. The analysis also identifies the costs to society of climate-related damages and their cascading effects in the absence of climate action. The analysis builds on sector-level analyses and is informed by extensive stakeholder consultations.

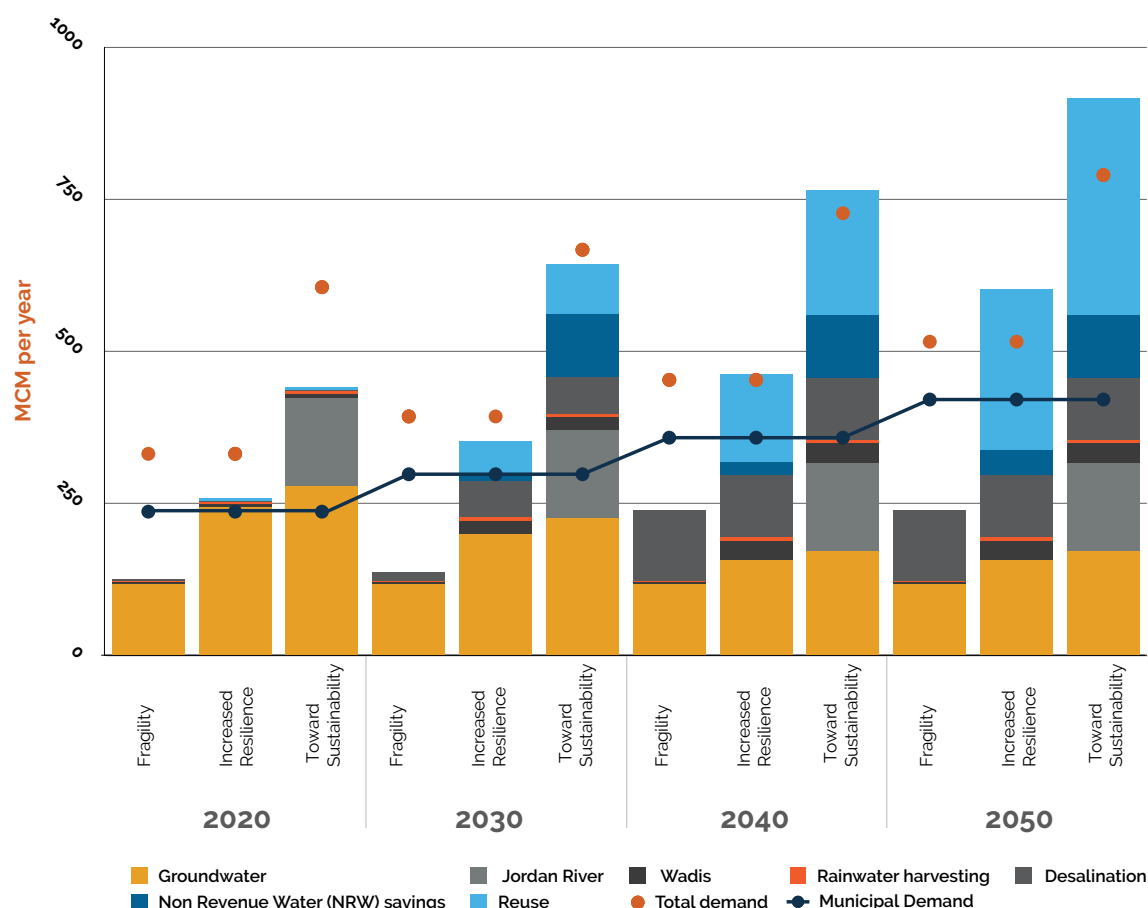
Three hypothetical scenarios are used to project potential development pathways in the water, energy, and agri-food sectors. These scenarios explore the impact of different levels of policy ambition, particularly as they relate to access to natural resources, access to finance, climate change mitigation and adaptation, and modeled changes in the regional context.

- **Continued Fragility:** This scenario assumes a reference case in terms of restrictions in access to resources in Area C—the 61 percent of land in the West Bank under Israeli control—and groundwater resources limited to those specified in the interim arrangements in the Oslo II Accords, along with no adaptation or mitigation interventions.
- **Increased Resilience:** This scenario assumes the Palestinian Authority takes action that is within its capacity and in line with the NDC (e.g., commitments to desalination, reuse of treated wastewater, and reductions in nonrevenue water) under the current political conditions.
- **Toward Sustainability:** This scenario assumes the Palestinian Authority takes action that is within its capacity and in line with the NDC and aspires toward improved cooperation with neighboring countries. It further assumes there are no restrictions in access to land or resources within Area C and that water allocations are equivalent to entitlements from the Jordan River.

Existing water scarcity imposes significant constraints on human well-being and socioeconomic development. The increasing demand for water driven by population growth requires an ambitious plan to improve security, even in the absence of climate change. According to the forecast, municipal demand can be fully met only under the optimistic assumptions of the Toward Sustainability Scenario (figure ES.1). However, in the Continued Fragility and Increased Resilience scenarios, people of the West Bank and Gaza would continue to depend on over-abstraction of groundwater and on external private sources (such as short-term, low-volume desalinated water and water from water tankers), along with imports from Israel. Nevertheless, reliance on these sources would be significantly lower in the latter scenario (accounting for 22 percent of demand versus 68 percent). Furthermore, although the agricultural demand for water is expected to be met under the Toward Sustainability and Increased Resilience scenarios, it would require complete reuse of treated wastewater, which will not occur until 2050 even under the most optimistic scenario. While long-term sustainability relies on a political solution regarding access to resources, interventions to reduce nonrevenue water, increase desalination and storage, and promote the reuse of treated wastewater for irrigation will enhance water supplies in the short term.

Food security differs greatly between a relatively food secure West Bank and a highly food insecure Gaza. Food security concerns are exacerbated by restrictions on access to land and to water resources for irrigation. These restrictions limit the ability of farmers to cultivate lands and develop agricultural infrastructure. Despite these constraints, there has been a significant shift towards vegetable production and a small overall increase in cropped area in both the West Bank and Gaza between 2010 and 2020, as agents in the agriculture sector responded to water scarcity by shifting to drought-tolerant crops in rainfed agriculture and switching to higher-value crops in irrigated systems. These practices help farmers increase their income and reduce the risks associated with water scarcity while the Palestinian Authority (PA) develops its strategy to provide water for irrigation by increasing wastewater reuse. Additionally, there is an opportunity to build resilience to water and energy constraints by implementing targeted and tailored sector policies, such as (1) increasing water use efficiency in irrigated agriculture by optimizing the crop mix, upgrading irrigation systems, and promoting covered cultivation; (2) building resilience in rainfed systems through climate-smart agriculture (CSA) and rainwater harvesting; and (3) exploring opportunities for climate change mitigation such as agri-photovoltaics and solar water pumps in conjunction with enforcing water allocations and limits on groundwater abstractions.

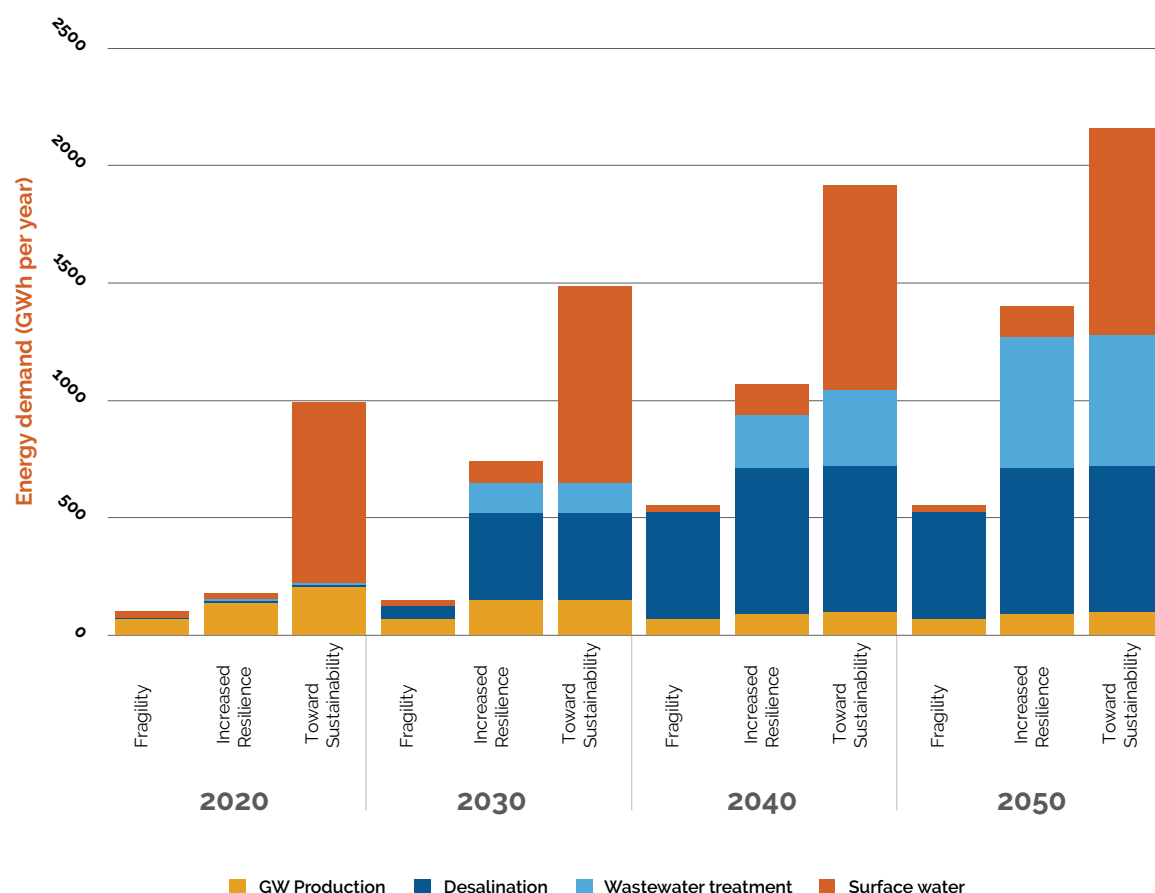
Figure ES.1 Water Supply by Source and Demand in the West Bank and Gaza under Three Scenarios



Source: Authors' elaboration based on World Bank data.

The energy sector in the West Bank and Gaza is characterized by underserved demand and a reliance on imports. Despite efforts to increase own generation and imports from Jordan, purchases from the Israeli Electricity Company still represent the largest share of the energy mix (73 percent), and reliable power remains a problem. This interdependence of energy, water (Fig. ES.2), and agriculture will continue to drive the demand for electricity, which is projected to increase by 3.5 percent annually in the West Bank, reaching an estimated 8,779 gigawatt hours (GWh) by 2035. Projected growth in Gaza is higher, at around 8 percent, due to the growing population and reconstruction efforts after damages in 2014 and 2021, which were exacerbated by the conflict that began in 2023. Relatively simple measures to increase energy efficiency, such as conducting energy audits, upgrading obsolete equipment, and optimizing operational procedures could greatly increase energy savings and reduce the gap between demand and supply. Similarly, the development of renewable energy sources, such as solar and wind power could also reduce that gap and provide a potential solution to the WEF nexus in the West Bank and Gaza. However, to meet the expected increase in demand, renewable generation should be growing at a rate of about 5 percent to 10 percent per year, which would come with financing requirements significantly greater than current funding and financing opportunities in the sector.

Figure ES.2 Energy Requirements for Water Production by Source in Each Scenario

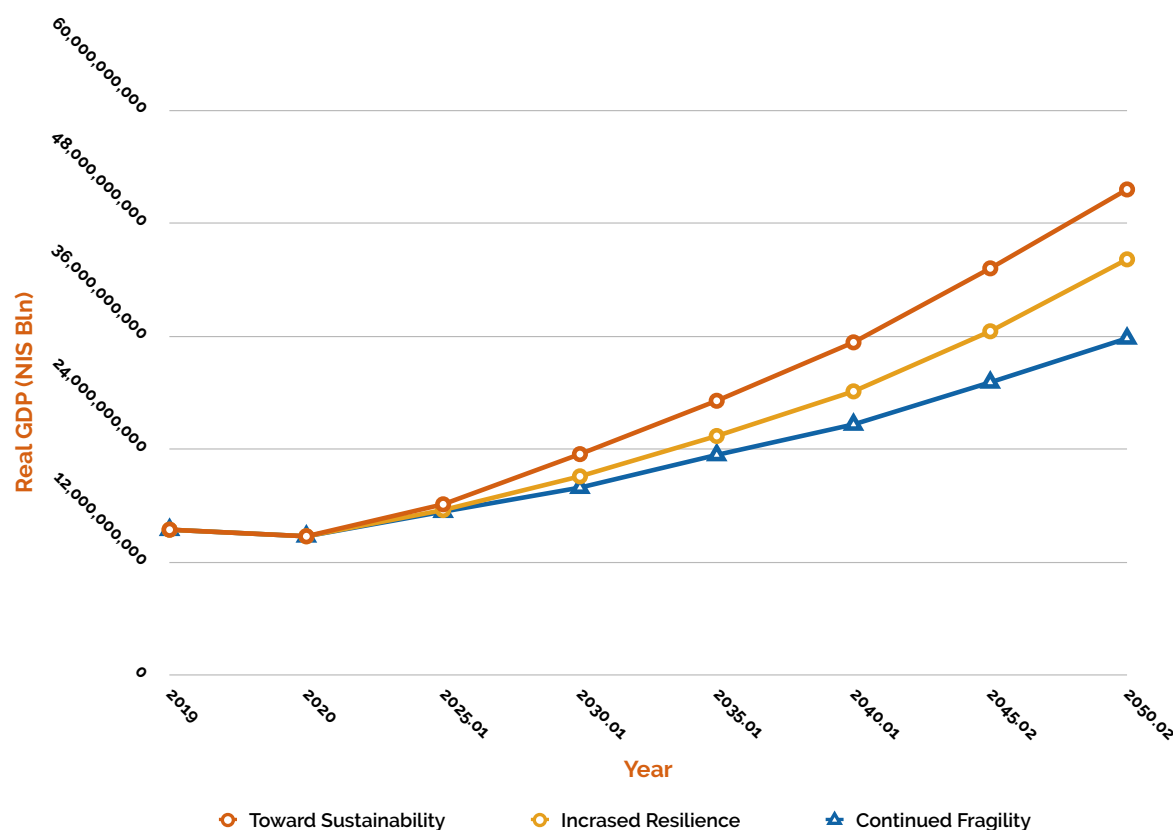


Source: Authors' elaboration based on World Bank data.

While the impacts of climate change are expected to aggravate the constraints on opportunities within the WEF nexus, these impacts are overshadowed by broader exogenous challenges. In the modeling exercise, the combined effects of water scarcity shocks resulting from climate change were evaluated by incorporating gradual increases in demand and decreases in supply sources vulnerable to climate change from 2030 to 2050. Under the assumed conditions, the impact of climate change will widen the gap between water demand and supply to 73 percent by 2050 under the Continued Fragility Scenario, compared with 68 percent when no climate change impacts are considered. Within the Increased Resilience Scenario, the reduction in groundwater, surface water, and rainwater harvesting will increase the municipal water gap from 22 percent to 33 percent. However, agricultural demand can still be met through an increase in wastewater reuse, resulting in a total compound gap of 22 percent (compared with 15 percent when climate change impacts are not accounted for). In the Toward Sustainability Scenario, the primary impact of climate change is observed in agricultural demand, resulting in an agricultural gap of 28 percent, contributing to a total gap of 15 percent within this scenario.

Economic modeling projections highlight the influence of water availability on the economic landscape in the West Bank and Gaza. Using the assumptions of the Continued Fragility Scenario as a baseline, modeling of water availability scenarios indicates that an increase in water availability will have a positive impact on real gross domestic product (GDP), particularly when factoring in the indirect and induced effects of water on the economy (figure ES.3). Thus, in the Increased Resilience Scenario, the effect of the additional water supply is projected to lead to an increase in GDP compared with the Continued Fragility Strategy baseline: 3 percent in 2030, 4.8 percent in 2040, and 6.5 percent in 2050. The projected effects in the Toward Sustainability Scenario are even more significant, with increases of 8.3 percent, 10.5 percent, and 10.6 percent for 2030, 2040, and 2050, respectively, when compared to the baseline.

Figure ES.3 Gross Domestic Product Projections under Three Scenarios



Source: Authors' elaboration based on World Bank data

Note: GDP = gross domestic product

Addressing the challenges affecting the water, energy, and agriculture sectors in the West Bank and Gaza requires significant investments across the nexus and building resilience to exogenous shocks. The implemented priority actions identified in the NDC over the period to 2040 are estimated to cost US\$5.9 billion, with a funding gap of 46 percent. Additionally, the estimated financial cost of meeting priority investments in the WEF nexus are significant, at nearly US\$2 billion over the period to 2050. This figure does not reflect the impact associated with the damage inflicted following the conflict that started in 2023, preliminary estimates of which indicate more than US\$300 million in direct damages to water-related infrastructure alone at the end of 2023. Investments required for the reconstruction and recovery of Gaza following the conflict will be significant and will need to be factored in. Considering the fiscal constraints in the West Bank and Gaza, all investments should reflect whole-of-life costs, which will have significant implications for financial sustainability, particularly for desalination, which has a much higher production cost than existing sources of water and one well beyond the current tariff regime. Such investments are vulnerable to increases in electricity tariffs and require careful consideration with specific provisions to ensure that financial sustainability is balanced against affordability and safeguards for poor and vulnerable households.

Exogenous impacts on the WEF nexus can be managed but not eliminated. Even under the most optimistic circumstances the impacts of climate change undermine sustainability. Maintaining a status quo based on a pre-2023 business-as-usual model would continue to erode resilience in the economy and worsen the impacts of access restrictions, which will be compounded by the cascading effects of climate change. Such a trajectory would ultimately undermine the peace process. A more optimistic alternative can be achieved through political will and trust building, accompanied by sustained commitment from all parties and significant financial commitments. However, establishing resilience across the WEF nexus in the West Bank and Gaza requires a comprehensive technical approach, combined with a political process that addresses underlying issues, ensures security for all, and recognizes the rights and aspirations of all stakeholders.

In the absence of a comprehensive political solution there is an urgency to provide pragmatic approaches that can promote resilience to exogenous shocks. These approaches include measures that can be implemented immediately within the purview of the PA, those that require participation in the permitting process, and others that will continue to rely on a more comprehensive solution to the challenges around Area C. Specific measures include the following:

- Invest in no regret measures, such reducing nonrevenue water, increasing reuse of treated wastewater, and improving awareness among consumers to improve efficiency and increase available water supplies.
- Identify and mobilize financial resources within the three sectors sufficient to cover both capital expenditures and operating expenditures, and optimize the programming and alignment of both in support of the WEF nexus.
- Implement complementary institutional reforms that can improve investment planning and the capacity to engage in negotiations that can unlock needed investments, particularly those with mutual benefits.
- Establish a clear framework and move from a sectoral to a more holistic and comprehensive nexus approach. Support this transition with development of a framework for improving policy coherence across the WEF nexus, overseen by a cross-sectoral coordination body responsible for ensuring effective implementation.
- Strengthen the PA and the Palestinian Water Authority to negotiate more equitable and efficient coordination mechanisms that can facilitate a review of existing interim agreements in the West Bank and Gaza that are no longer viable and fit for purpose.
- Increase the ability of the PA to implement effective governance and development policies that can leverage synergies and improve the effectiveness of the WEF nexus.
- Restructure the joint governance system established under the Oslo Accords to empower the system to facilitate rational planning and development of water resources infrastructure. In the interim, improve the functioning of the existing Joint Water Committee (JWC). An independent, third-party arbitrator should be introduced to accelerate decision-making, improve efficiency, and ensure equity within the revised JWC.
- Improve regional cooperation to ensure equity and empower effective collaborative mechanisms that can facilitate robust, sustainable outcomes. The interim agreement put in place as part of the Oslo Accords to govern access to water in the West Bank is no longer fit for purpose. It is therefore necessary to reassess and renegotiate a more realistic and equitable agreement that is suitable for the new reality. Regional agreements with other neighboring countries are also needed to facilitate more cost-effective and diversified sources of energy to meet growing demand.
- Ensure long-term commitment to strategic engagement that extend beyond the short-term emergency response. There is a long history of support from a range of development partners and the water, energy, and agricultural sectors have received considerable support over the years. However, these partnerships often move between the political context and the development challenge, and there is a need to ensure international actors, regional powers, and development partners continue to play a forward-leaning role.
- Revive confidence-building measures to promote an atmosphere of trust and cooperation, specifically addressing issues related to the nexus and fostering an environment conducive to productive negotiations that can facilitate agreement on more equitable and sustainable solutions to water, energy, and agriculture. These measures will be increasingly important following the events of October 2023.

The PA should not only take the lead in securing the necessary financing for investments but also in improving efficiency and demonstrating a strong commitment to developing an enabling environment.

To achieve these goals, international actors, regional powers, and development partners must be encouraged to play a more proactive role. This role will require commitments to long-term strategic engagements, not just short-term humanitarian responses, to facilitate more resilient development.

While these are persistent problems that have proven to be intractable over the past decades, the perpetuation of a status quo based on business-as-usual assumptions prior to the conflict that started in 2023 will continue to erode the resilience of people in the West Bank and Gaza, as well as the economy, to restrictions in access and the cascading effects of climate change.

The collective threat posed by climate change provides an opportunity to explore new cooperative pathways for enhancing resilience in the West Bank and Gaza. Looking at future uncertainties through a climate lens may encourage sustained commitment and open new opportunities. Integrating technical solutions with a process that acknowledges the rights and aspirations of all stakeholders could contribute to a more resilient and prosperous future for the people of the West Bank and Gaza.





Image by Ahmed Zaqout

A photograph showing a man in a dark jacket and grey sweater pouring soup from a small metal pot into a white bowl. In the foreground, a large metal pot is filled with soup, with steam rising from it. A person's hand is visible holding the handle of the small pot. In the background, several children are watching. The text "CHAPTER ONE" is overlaid in white, bold, serif font.

CHAPTER ONE



Image by Ahmed Zaout

INTRODUCTION

The West Bank and Gaza faces numerous development challenges and is subject to multiple social, economic, and climatic shocks. Due to complex regional circumstances and decades of hostilities and violence, it faces increasing insecurity, rising poverty and unemployment, food vulnerability, and a lack of access to basic services. Coupled with the impacts of the persistent conflict and instability, restrictions on the movement of people, trade, and goods, as well as access to natural resources constrain economic opportunities. These restrictions are reversing any development gains, with poverty rates having increased from around 19 percent in 2011 to 29.7 percent in 2020. This growth is driven largely by Gaza, where pre-pandemic poverty rates were at 53 percent for Gaza compared with 13.9 percent for the West Bank (World Bank 2022). These figures have worsened significantly since the conflict that started in 2023. Challenges are accentuated by the lack of access to quality basic services, especially in Gaza, where multiple rounds of conflict have destroyed critical infrastructure, including power generation, water supply, and wastewater facilities.

Climate change will impose a series of cascading and compounding challenges on development in the West Bank and Gaza. High-resolution regional climate models suggest warming will be larger than global annual mean warming, at between 2.2°C and 5.1°C, with annual precipitation likely decreasing 10 percent by 2020 and 20 percent by 2050, with an increased risk of summer drought.¹ Coupled with more intense rainfall events and extended dry periods, these changes will increase drought risks and the possibility of flood risks. The Nationally Determined Contributions (NDC) submitted in October 2021 acknowledges the negligible contribution of the West Bank and Gaza to global emissions and recognizes its vulnerability to climate change. The NDC therefore emphasizes the importance of adaptation pathways to manage the uncertainty associated with climate change and the development of action plans for vulnerable sectors, including agriculture, energy, and water. These plans emphasize the need to engage youth, women, and other vulnerable groups in NDC implementation.

There is an increasing urgency to build resilience against different types of shocks and stresses. Achieving resilience requires tackling multiple dimensions simultaneously (e.g., natural hazards, drivers of poverty, access to services, governance, fragility, and conflict), including external regional threats, global pandemics (such as COVID-19), political shocks (such as Russia's invasion of Ukraine and disruptions to the global supply chain), and economic shocks (such as the worldwide surge of inflation). The increasing exposure of the population in the West Bank and Gaza to the impacts of climate change, coupled with ongoing challenges related to political instability, fragility and conflict, restrictions, and the resulting poverty and inadequate service delivery levels mean that improving resilience and building adaptive capacity to the compounding effects of climate change will be intrinsically linked to the well-being of the Palestinians, the prevailing political economy, and broader development agenda.



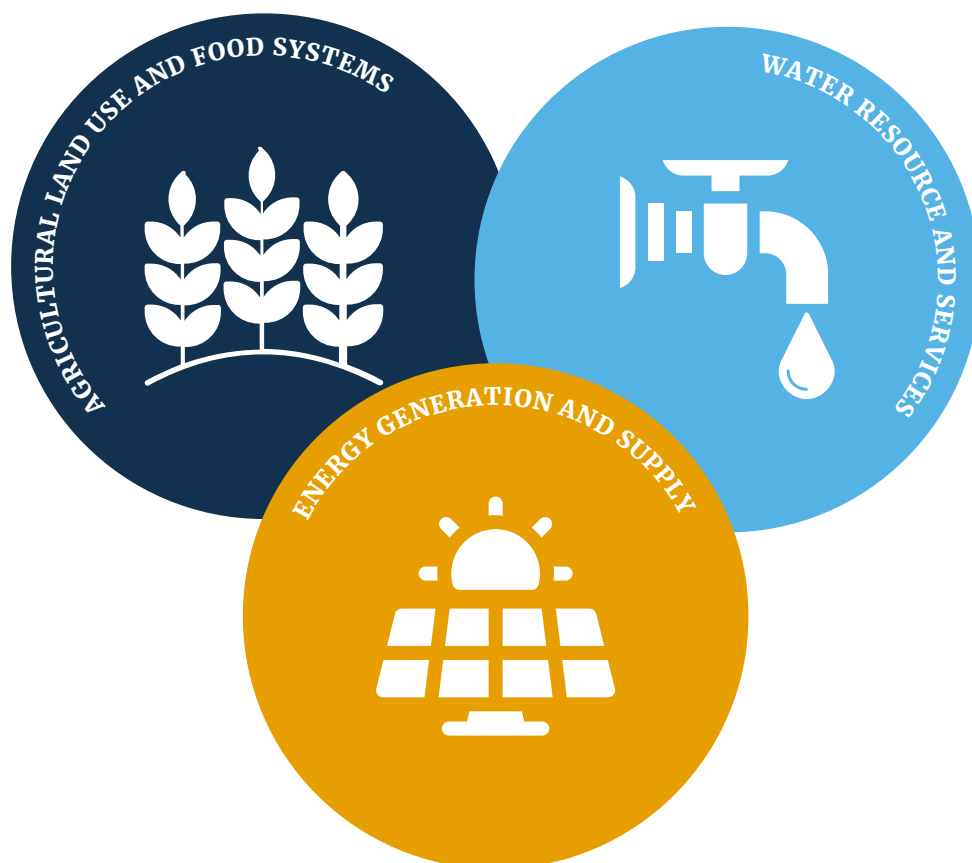
Image by Mustafa Abu Shamla

Increasing resilience to the cascading effects of climate change on the water-energy-food (WEF) nexus will be critical to improving the lives of the people in the West Bank and Gaza. Interlinkages between water, energy, and food are growing in importance as demand for each increases (see figure 1.1). These interlinkages and mutual dependencies across the WEF nexus provide a powerful framework for identifying synergies and for managing risks that arise from these linkages. The nexus is important because changes in one sector can have impacts on the other sectors. For instance, constraints on water availability impact agriculture and food production, while energy is needed to bring groundwater to the surface for use in irrigation and to support the production, treatment, and use of water and wastewater. Similarly, policies that promote energy efficiency can also have benefits for water conservation and food security. There is evidence of the effects of climate change on the availability and demand for water, energy, and food, and many parts of the world are already experiencing challenges in relation to securing water, food, and energy—challenges that hamper progress toward sustainable economic growth. Finding climate-smart solutions that increase resilience therefore has the potential to protect and create new jobs, mitigate inequalities, and improve water, energy, and food security, while boosting long-term growth potential and resilience.

Water, energy, and food in the West Bank and Gaza are vulnerable to a range of exogenous factors that require a multifaceted response. Their mutual dependencies and interlinkages have important implications for investment planning related to adaptation and mitigation measures that can increase resilience. The objective of this report is, therefore, to (1) identify exogenous vulnerabilities, such as climate change, and their impacts on the WEF nexus in the West Bank and Gaza; (2) provide an analysis of the water, agriculture, and energy sectors to identify opportunities; and (3) evaluate potential adaptation responses, institutional measures, and investments anchored in the WEF nexus to improve sustainability and resiliency in the context of increasing uncertainty.

Figure 1.1 Interlinkages at the Nexus of the Water, Energy, and Food Sectors

CLIMATE SYSTEMS



Source: Authors' elaboration.

Box 1.1**IMPACTS AND UNCERTAINTY ASSOCIATED WITH THE CONFLICT THAT BEGAN IN OCTOBER, 2023**

This report was prepared as one of a series of background papers for the Country Climate and Development Report (CCDR) and prior to the conflict that started in October 2023. Since then, the conflict has caused an unprecedented and rapidly deteriorating humanitarian crisis and the Palestinian economy has experienced one of the largest shocks recorded in recent economic history. In Gaza, the loss of life, the speed and extent of fixed assets damage, and the reduction in production flows are unparalleled. The knock-on effects in the West Bank include massive job losses and a spiraling fiscal crisis for the Palestinian Authority.

The death toll continues to increase, with more than 47,000 people having lost their lives as of January 2025. At least 13,000 of these are children and 7,200 are women, with at least 111,000 having been injured. Over 2 million people, almost the entire population in Gaza, have been uprooted from their homes and are facing acute shortages of all necessities. The conflict has affected the entire population of Gaza and generated enormous humanitarian needs, including hunger, malnutrition, widespread explosive ordnance, and disease outbreaks. The severe shortage of supplies to meet basic needs has also severely endangered livelihoods. In the West Bank, increasing violence, restricted access and movement restrictions on Palestinians, and displacement have caused human suffering, stifled economic activity, curtailed access to basic services, and severely damaged the fiscal situation of the Palestinian Authority. The reconstruction and recovery needs in Gaza require an estimated US\$53 billion as of January 2025. This includes about US\$30 billion in damages to physical structures, with economic losses from reduced productivity, foregone revenues, and operating costs estimated at US\$19 billion.



The destruction in the economy's productive capacity has been severe and will have a lasting impact. GDP declined by 86 percent in the fourth quarter of 2023, with almost all sectors in Gaza having experienced a total halt in economic production. Prices have soared over 300 percent in one year, with food prices alone up by 450 percent. The economy in Gaza was projected to have contracted by 83 percent in 2024, dropping its overall contribution to 3 percent, despite being home to 40 percent of the population in the Palestinian territories. The West Bank's economy has also suffered and was projected to have shrunk by 16 percent in 2024.

The Water-Energy-Food Nexus have been severely impacted. Over 89 percent of WASH infrastructure has been destroyed or partially damaged as of January 2025, leaving water and sanitation services in a dire state with most households lacking clean water. In the energy sector, approximately 80 percent of power generation and distribution assets destroyed or rendered non-operational, with prolonged power outages imposing severe economic and social costs, estimated at over US\$243 million. Over 86 percent of people in Gaza experience acute food insecurity and nearly 133,000 people facing catastrophic levels, with acute malnutrition 10 times higher than before the escalation of hostilities. These drivers of fragility increase social, economic, and environmental exposure to a range of vulnerabilities, create deep uncertainty about the future. The outlook remains uncertain and tied to the conflict's evolution and level of future restrictions imposed by Israel.

NOTE

¹ These projections from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change are for the southern and eastern Mediterranean according to a realistic emissions scenario (Scenario A1B).

REFERENCE

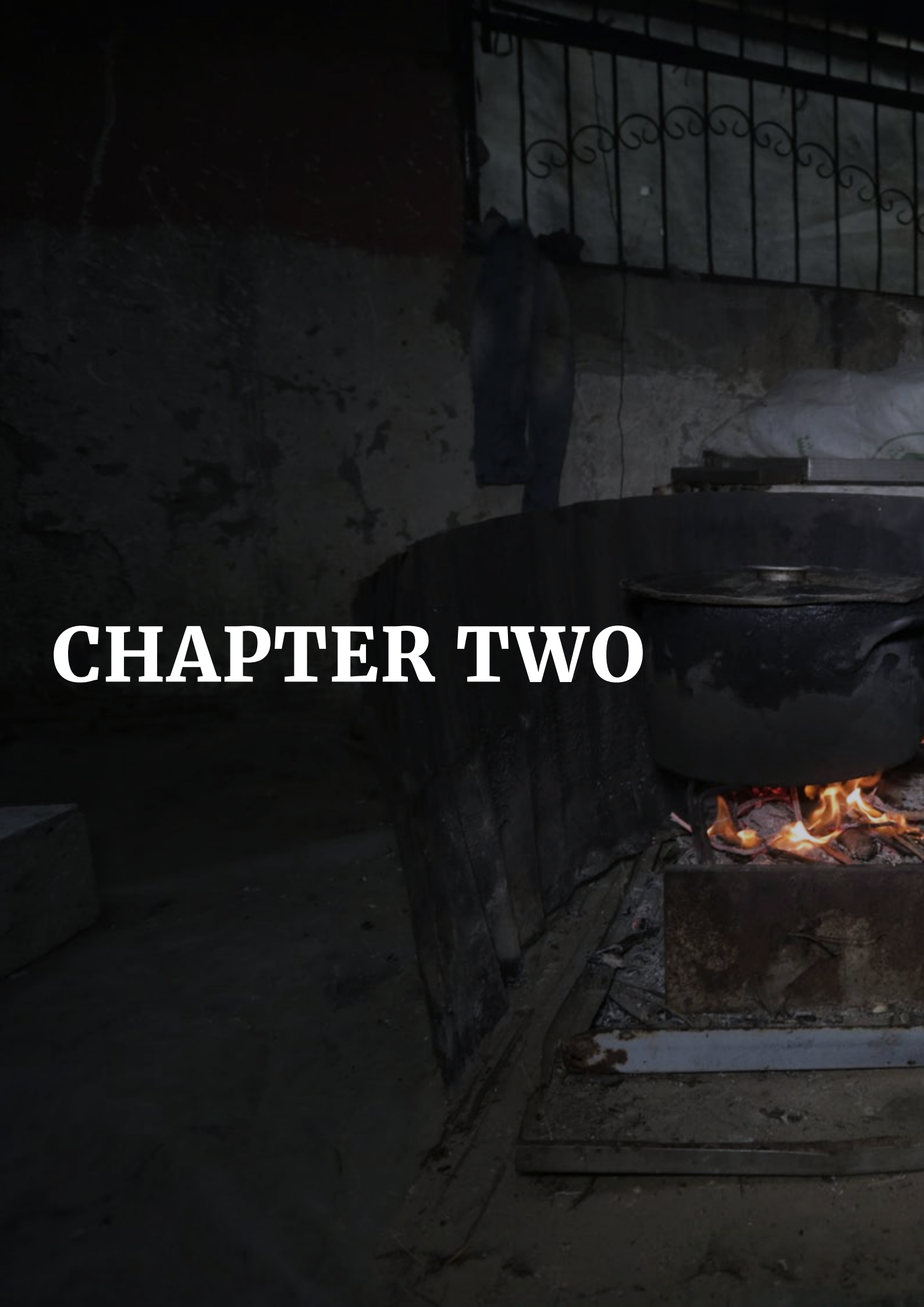
- World Bank. 2022. Economic Monitoring Report to the Ad Hoc Liaison Committee.

<https://documents1.worldbank.org/curated/en/099407305062233565/pdf/IDU0g1fed1da019eb042d6090100a9320aa572de.pdf>





Image by Mustafa Abu Shamlah

A dark, atmospheric photograph of a traditional wood-burning stove. A fire burns brightly in the hearth, heating a large, dark metal pot. The stove is built into a rough, textured wall. In the background, a metal grate with decorative scrollwork is visible. The overall mood is somber and rustic.

CHAPTER TWO



THE CLIMATE CONTEXT IN THE WEST BANK AND GAZA

THE CONTEXT

The West Bank and Gaza faces numerous climate risks and is considered one of the world's most vulnerable regions. Due to its location, the West Bank and Gaza has a great diversity of local climate conditions, making it highly susceptible to several extreme weather conditions, including high temperatures, erratic rainfall and high precipitation events, strong winds that result in sandstorms, and, in Gaza, sea level rise. While its contributions to global emissions are negligible, the West Bank and Gaza is a hot spot for climate change and its impacts, with the potential to exacerbate existing water scarcity. Coupled with more frequent and extreme weather events, water scarcity could negatively impact crop yields, undermine food security, and damage agricultural infrastructure. Higher temperatures will also likely lead to increased demand for electricity for cooling and increased demand to support water and agriculture investments, putting additional pressure on the already-strained energy sector. In Gaza, sea level rise could lead to increased coastal erosion, the loss of land, and the displacement of people already challenged by high population densities.

Climate change is imposing compounding and cascading effects that further undermine social and economic development in the West Bank and Gaza. Continued political instability and economic dependency on Israel, coupled with restrictions on movement and access, combined with resource constraints, create a very difficult environment within which to plan and implement long-term development projects that could increase resilience to exogenous and hydro-climatic shocks. The capacity of the Palestinians to cope with, and adapt to, these challenges is constrained by the limited control of the Palestinian Authority (PA) over the West Bank and Gaza, which undermines its ability to implement effective governance and development policies. Restrictions imposed by Israel limit access to, and control over, natural resources, especially land and water, resulting in fragile and unsustainable practices. Mitigation and adaptation to these challenges requires strategic planning, investment in sustainable and climate-resilient infrastructure, and cooperation at local, national, and international levels. However, the political situation and conflict in the region often complicate these efforts. Climate-related challenges could further stress governance systems and contribute to social tension and political instability in the region.



Image by Ahmed Zaqout



Image by Ahmed Zaqout

HISTORICAL CLIMATE TRENDS

The climatic conditions in the West Bank and Gaza vary significantly, reflecting the area's geophysical diversity that influences precipitation dynamics and rainfall trends (Environment Quality Authority 2016). Situated in a transition zone between the cooler, relatively wetter Mediterranean climate to the north and the hot, arid climate characteristic of West Asia, the West Bank and Gaza experiences a great diversity of local climate conditions. Depending on latitude and altitude, these conditions range from extremely arid to humid, especially in the West Bank (United Nations Development Program 2010). This climate diversity is characterized by five major climate zones (FAO Aquastat 2008):

1. Jordan Valley region, about 75–90 meters (m) above sea level, has an average annual rainfall of only 100–200 millimeters (mm)
2. Eastern slopes region, a transitional zone between the Mediterranean and the desert, has an average annual rainfall of 150–300 mm
3. Central highlands region lies 400–1,000 m above sea level, with annual rainfall between 300 mm in the south to 600 mm in the north
4. Semi-coastal region lies 100–300 m above sea level, with rainfall 400–700 mm per year
5. Coastal plain (Gaza Strip) has rainfall of 200–400 mm per year



Image by Ahed izhiman

Historical trends in temperature and precipitation have not been static and are highly variable. These variable trends, and the relatively small size of the West Bank and Gaza, create challenges in establishing a baseline for future climate projections. The National Adaptation Plan (NAP) (United Nations 2016) provides an assessment of the historical climate trends (table 2.1), concluding with very high confidence that temperatures have risen over the past 100 years or so, but less confidence in assessed quantitative rates of change because of spatial and temporal dependencies and issues of data quality. In contrast, there is very low confidence that annual and seasonal rainfall have increased or decreased over the past 50 years, but equally low confidence that there has been no change in annual and seasonal rainfall totals. This finding corresponds with data from local meteorological stations (figures 2.1 and 2.2) and international projections that indicate a general warming trend from the 1960s, with average annual mean temperature having increased from 18.6°C to 19.6°C in the West Bank and from 19.9°C to 20.9°C in Gaza, and highly variable annual and seasonal changes in the precipitation regime in the West Bank and Gaza (table 2.2)

Table 2.1 Historic Climate Trends in the West Bank and Gaza.

PARAMETERS	FROM THE PERSPECTIVE OF CHANGE
Average temperatures	Very high confidence that temperatures have risen over the past 100 years but less confidence in quantitative rates of change, due to spatial and temporal dependencies and data quality.
Temperature extremes	High confidence that warm days/nights and cold days/nights have increased/decreased respectively in frequency.
Rainfall totals	Very low confidence that annual and seasonal rainfall totals have changed in either direction over the past 50 years or so, but also very low confidence that there has been no change in annual and seasonal rainfall totals.
Rainfall extremes	Only very low confidence can be ascribed to changes in rainfall because of the limited evidence, combined with the relative rarity of such events.

Source: National Adaptation Plan to Climate Change (2016)

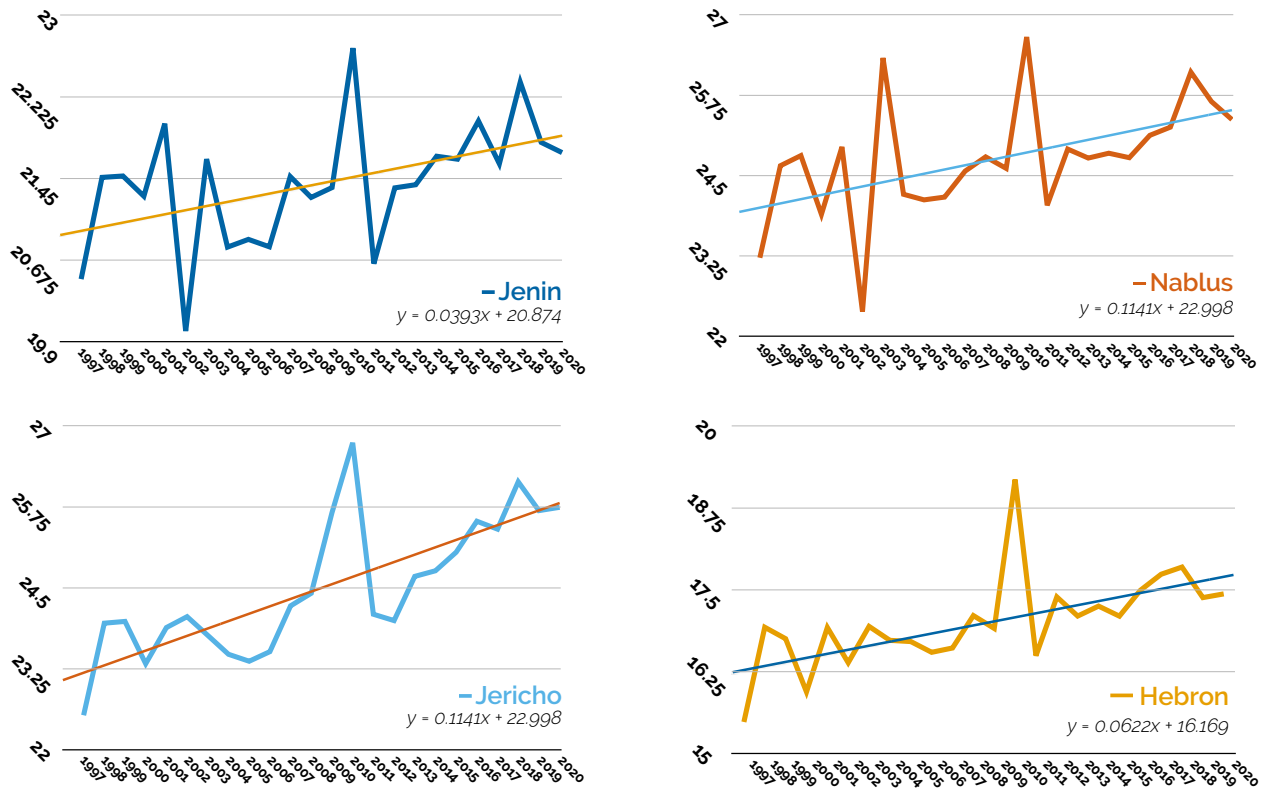
Table 2.2 West Bank and Gaza Data Snapshot: Summary Statistics

CLIMATE VARIABLE	1961–1990		1991–2020	
	WEST BANK	GAZA	WEST BANK	GAZA
Mean annual temperature (°C)	18.5	19.9	19.6	20.9
Mean annual precipitation (mm)	525.9	286.6	486.9	257.1
Mean maximum annual temperature (°C)	24.2	26.0	25.2	26.8
Mean minimum annual temperature (°C)	13.0	14.0	14.0	15.0

Source: World Bank (2022). Climate Knowledge Portal – Climate Risk Country Profile for West Bank and Gaza.

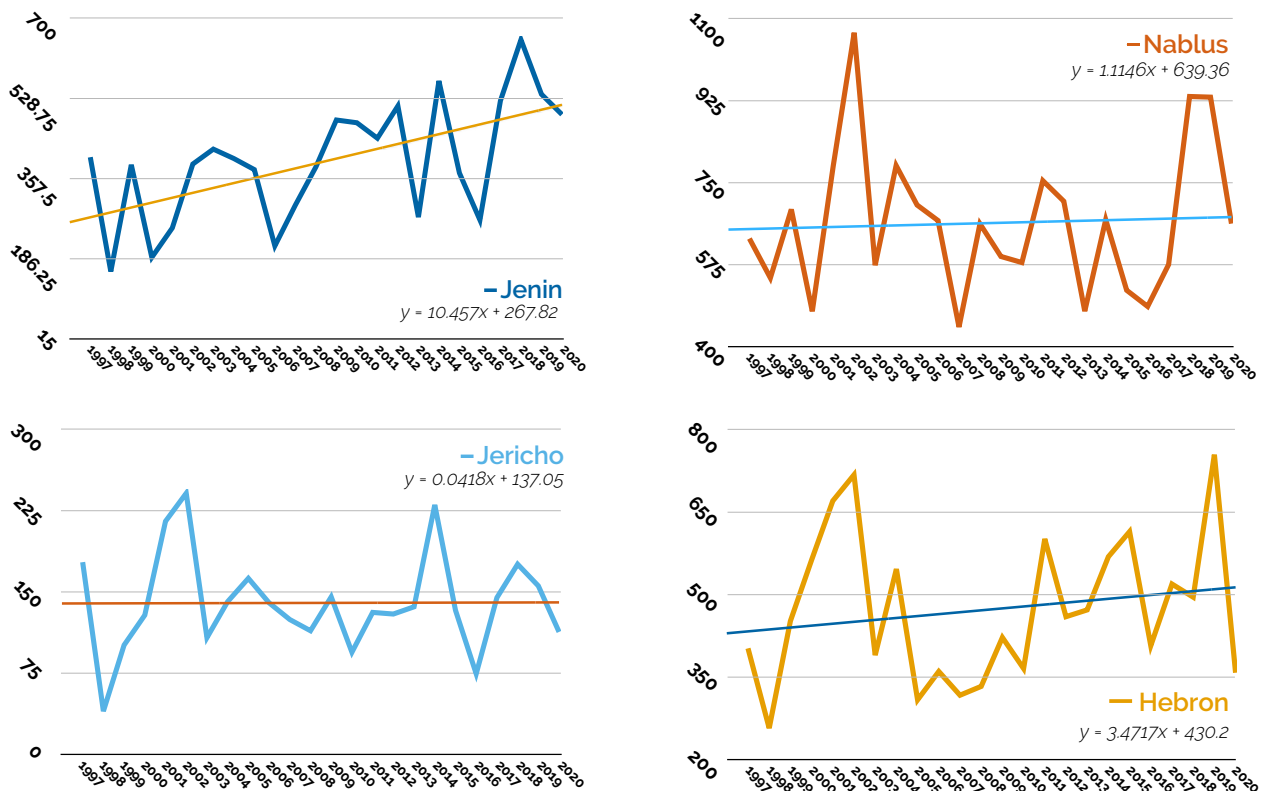


Figure 2.1 Average Annual Temperature Trend Analysis for Jenin, Nablus, Jericho, and Hebron, 1997–2021



Source: Based on data from the Palestinian Meteorological Department.

Figure 2.2 Annual Rainfall Trend Analysis for Jenin, Nablus, Jericho, and Hebron, 1997–2021



Source: Based on data from the Palestinian Meteorological Department.



FUTURE CLIMATE PROJECTIONS

The inherent uncertainty around future climate predictions is exacerbated by the geophysical diversity across the West Bank and Gaza. As such, the climate system of the past can no longer be considered sufficient to assess future climate-related risks and inform the boundary limits for the current and future climate system. Caution is also needed when applying projections from climate models due to the use of simplifying parameterizations, the different emission scenario runs, and the generally coarse spatial resolution of the models compared to the size of the West Bank and Gaza (Environment Quality Authority 2016). Even high-resolution models often miss local orographic and environmental variations within the West Bank and Gaza. Multi-model comparative approaches can reduce uncertainty regarding the future impacts of climate change. The sixth phase of the Coupled Model Intercomparison Project (CMIP6) allows statistics to be computed across a suite of models that leads to more robust projections than those produced by any individual model. It also allows quantification of confidence or uncertainty in those projections.

Shared socioeconomic pathways (SSPs) are used to represent climate responses to future uncertainties. SSPs are based on a range of future climate change scenarios that encompass various levels of greenhouse gas (GHG) and aerosol emissions and varying assumptions about socioeconomic changes, including population, education, urbanization, gross domestic product, economic growth, rate of technological development, energy supply and demand, land use changes, among other factors. Each scenario represents an alternative storyline about how the world might develop over the coming century in the absence of climate policy (box 2.1). For the purposes of determining future projections for the West Bank and Gaza, CMIP6 includes scenarios with high and very high GHG emissions (SSP3-7.0 and SSP5-8.5) and CO₂ emissions that roughly double from current levels by 2100 and 2050, respectively; scenarios with intermediate GHG emissions (SSP2-4.5) and CO₂ emissions remaining near current levels until the middle of the century; and scenarios with very low and low GHG emissions and CO₂ emissions declining to net zero by or after 2050, followed by varying levels of net negative CO₂ emissions (SSP1-1.9 and SSP1-2.6) (World Bank 2022).



Image by hosny salah from Pixabay

Climate projections consistently show temperatures higher than the historical mean but a wide variation in precipitation projections (figure 2.3). Temperatures are expected to increase across all emissions scenarios in the West Bank and Gaza through mid-century, with more substantial rates of change under higher emissions scenarios for mean, minimum, and maximum temperatures (table 2.3). Precipitation conditions continue to exhibit high variability across emissions scenarios in the West Bank and Gaza, with a relatively high degree of uncertainty (table 2.4). Rainfall in the West Bank and Gaza is often convective (i.e., when the land warms, it heats the air, causing the air to expand and rise, then cool and condense, leading to rainfall) and is controlled to an extent by landform. Thus, geographically close rainfall gauges may provide very different recordings of any particular event, and it is plausible that a slight change in predominant wind direction might result in a rainfall trend at particular locations (Environment Quality Authority 2016).

Box 2.1: Shared Socioeconomic pathways

SSP1: SUSTAINABILITY — TAKING THE GREEN ROAD (LOW CHALLENGES TO MITIGATION AND ADAPTATION)

- The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries.
- Management of the global commons slowly improves, educational and health investments accelerate the demographic transition, and economic growth shifts toward a broader emphasis on human well-being.
- Driven by an increasing commitment to development goals, inequality is reduced both across and within countries.
- Consumption is oriented toward low material growth and lower resource and energy intensity.



SSP2: MIDDLE OF THE ROAD (MEDIUM CHALLENGES TO MITIGATION AND ADAPTATION)

- The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns.
- Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations.
- Global and national institutions work toward but make slow progress in achieving sustainable development goals.
- Environmental systems experience degradation, although there are some improvements, and the intensity of resource and energy use generally declines.
- Global population growth is moderate and levels off in the second half of the century.
- Income inequality persists or improves only slowly, and vulnerability to societal and environmental changes remains.



SSP3: REGIONAL RIVALRY—A ROCKY ROAD (HIGH CHALLENGES TO MITIGATION AND ADAPTATION)

- A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues.
- Policies become increasingly oriented toward national and regional security issues.
- Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development.
- Investments in education and technological development decline.
- Economic development is slow, consumption is material-intensive, and inequalities persist or worsen.
- Population growth is low in industrialized countries and high in developing countries.
- A low international priority for addressing environmental concerns leads to severe environmental degradation in some regions.

Image by hosny salah from Pixabay



SSP4:INEQUALITY—A ROAD DIVIDED (LOW CHALLENGES TO MITIGATION, HIGH CHALLENGES TO ADAPTATION)

- Highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries.
- The gap widens between an internationally connected society that contributes to knowledge- and capital-intensive sectors of the global economy and a fragmented collection of lower-income, poorly educated societies that work in a labor-intensive, low-tech economy.
- Social cohesion degrades and conflict and unrest become increasingly common.
- Technology development is high in the high-tech economy and sectors.
- The globally connected energy sector diversifies, with investments in both carbon-intensive fuels like coal and unconventional oil, but also low-carbon energy sources.
- Environmental policies focus on local issues around middle- and high-income areas.

SSP5: FOSSIL-FUELED DEVELOPMENT—TAKING THE HIGHWAY

(HIGH CHALLENGES TO MITIGATION, LOW CHALLENGES TO ADAPTATION)

- Increasing faith is placed in competitive markets, innovation, and participatory societies to produce rapid technological progress and develop human capital.
- Global markets are increasingly integrated.
- Large investments are made in health, education, and institutions to enhance human and social capital.
- At the same time, the push for economic and social development is coupled with exploitation of abundant fossil fuel resources and adoption of resource- and energy-intensive lifestyles around the world.
- All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century.
- Local environmental problems such as air pollution are successfully managed.
- There is faith in humanity's ability to effectively manage social and ecological systems, including by geo-engineering if necessary.



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Note: SSP = shared socioeconomic pathways

Table 2.3 CMIP6 Ensemble Projection Anomalies for Annual Mean Temperature

ANNUAL MEAN TEMPERATURE ANOMALY (°C)	2020–39	2040–59	2080–99
WEST BANK			
<i>SSP1–1.9</i>	0.83°C (0.21–1.25)	0.98°C (0.21–1.52)	0.67°C (0.14–1.29)
<i>SSP2–4.5</i>	0.95°C (0.51–1.24)	1.47°C (1.01–2.10)	2.34°C (1.61–3.34)
<i>SSP3–7.0</i>	0.82 (0.52–1.12)	1.59 (1.25–1.93)	3.37 (2.89–4.23)
GAZA			
SSP1–1.9	0.81°C (0.2–1.25)	0.9°C (0.24–1.53)	0.59°C (0.2–1.29)
SSP2–4.5	0.92°C (0.5–1.19)	1.42°C (0.96–2.14)	2.28°C (1.56–3.31)
SSP3–7.0	0.8°C (0.52–1.04)	1.56°C (1.2–2.03)	3.3°C (2.83–4.13)

Source: World Bank (2022). Climate Knowledge Portal – Climate Risk Country Profile for West Bank and Gaza.

Note: CMIP6 = Coupled Model Intercomparison Project 6; SSP = shared socioeconomic pathways

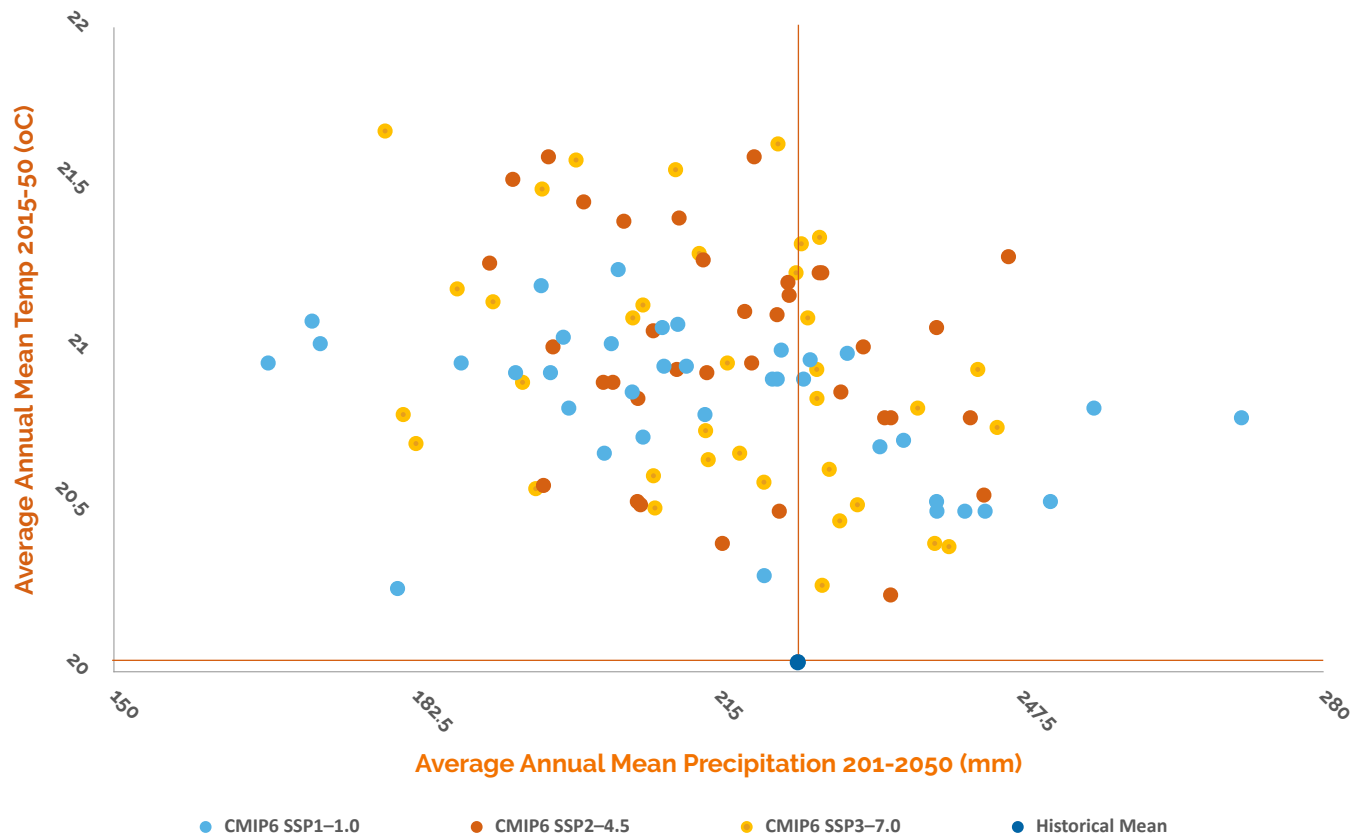
Table 2.4 CMIP6 Ensemble Projection Anomalies for Annual Mean Precipitation

ANNUAL MEAN PRECIPITATION ANOMALY (MM)	2020–39	2040–59	2080–99
WEST BANK			
SSP1–1.9	–0.47 mm (–99.4–107.9)	1.4 mm (–97.2–117.7)	12.0 mm (–99.4–107.9)
SSP2–4.5	–4.5 mm (–89.6–121.6)	–16.2 mm (–101.5–134.5)	–21.9 mm (–101.7–114.0)
SSP3–7.0	–11.6 mm (–90.7–122.1)	–19.15 mm (–106.2–102.9)	–38.51 mm (–113.7–58.6)
GAZA			
SSP1–1.	17.25 mm (–64.6–69.0)	9.27 mm (–57.6–76.8)	7.7 mm (–64.6–69.0)
SSP2–4.5	–0.3 mm (–50.1–61.3)	–7.94 mm (–58.0–71.2)	–17.4 mm (–54.6–55.4)
SSP3–7.0	–6.1 mm (–50.0–72.6)	–10.11 mm (–57.04–66.34)	–24.3 mm (–65.94–42.18)

Source: World Bank (2022). Climate Knowledge Portal – Climate Risk Country Profile for West Bank and Gaza.

Note: CMIP6 = Coupled Model Intercomparison Project 6; SSP = shared socioeconomic pathways

Figure 2.3 Average Annual Mean Temperature versus Average Annual Mean Precipitation, 2015–50



THE POLICY RESPONSE

The PA is committed to making responding to climate change a priority, with the 2021 update to the Nationally Determined Contribution (NDC) focusing on climate adaptation and resilience. The PA became a party to the United Nations Framework Convention on Climate Change (UNFCCC) in March 2016 and ratified the Paris Agreement in April 2016. That same year, the PA prepared its National Adaptation Plan to Climate Change, which identified vulnerabilities and prioritized adaptation actions. In 2017, the PA submitted both its first NDC, with specific adaptation and mitigation targets, and its Initial National Communication Report to the UNFCCC. The updated (2021) NDC document states that the key climate goal is to reduce climate vulnerabilities, primarily by increasing adaptive capacities, thus enhancing the climate resilience of the national development process and local communities. All NDC actions are conditioned on international aid. A major milestone in the updated NDC is the development of implementation action plans for six of the 12 most vulnerable sectors, as identified in the 2016 NAP. The six priority sectors include agriculture, energy, health, transport, waste, and water. The other six sectors highly vulnerable to climate change are coastal and marine ecosystems, food, industry, terrestrial ecosystems, tourism, and urban infrastructure. The updated NDC's GHG emissions-reduction targets are more ambitious than the initial NDC's targets. The first NDC aimed for a 12.8 percent reduction by 2040 relative to business as usual, whereas the 2021 NDC aims for a 17.5 percent reduction under a status-quo scenario.

The updated NDC recognizes the need to approach climate adaptation and mitigation simultaneously to increase community resiliency. It approaches adaptation and mitigation through a context- and needs-driven lens that reflects local climate vulnerabilities and risks. Consequently, eight NDCs and corresponding priority actions focus on the water-food-energy (WEF) nexus (table 2.5). To tackle

increased demand for, and diminished quality of the water resource, NDC implementation action plans call for reusing treated wastewater in large-scale wastewater treatment plants, reducing nonrevenue water in the West Bank, and financing the construction of the Gaza Central Desalination Plant to provide quality fresh drinking water. The PA is supporting the adaptation of irrigation to climate change in Gaza, increasing the availability of alternative water resources, and preparing projects to integrate nature-based solutions and agricultural water management to improve water security in a changing climate.¹ Climate-smart agriculture (CSA) and climate-resilient land planning and management feature prominently in the NDC to cope with the increased risk of drought and flood and subsequent diminished food production. As for energy, with domestic electricity production fulfilling only 7 percent of consumption in the West Bank and Gaza, the NDC focuses on energy distribution, energy efficiency, and renewable energy production (primarily from solar photovoltaic (PVI)), all with significant adaptation co-benefits.

In addition to the sector-specific policies linked to the NDC, other sectoral strategies are organically connected to climate action along the WEF nexus. For example, the Agricultural Sector Strategy "Resilience and Development" included objectives that target increasing resilience such as efficient and sustainable management of natural resources and enhanced agriculture production, productivity, and competitiveness. The Water Sector Strategy and Water Sector Reform Plan cover the impacts of climate change and proposes demand management and strategic planning to address water security challenges. The National Renewable Energy Action Plan for the period 2020–30 aims for 10 percent of electricity generation to come from renewable energy—80 percent from solar PV, 10 percent from wind energy, and 10 percent from biogas/biomass. To meet this target, 500 MW of renewable energy must be installed over the planning period to 2030.

A policy framework that integrates climate change considerations in sector investments and policies has yet to be developed, despite increasing awareness by policymakers. Effective action along the WEF nexus would require the inclusion of measures to achieve the targets set by the enabling policy framework. These measures would, in turn, signal the need for further mitigation and adaptation action and for a program to strengthen the capacity of sectoral and ministerial institutions to gather data, monitor climate change indicators, and report to the Environmental Quality Authority (EQA). The EQA aims to integrate the environment and climate change as a cross-cutting requirement in all upcoming strategies for the West Bank and Gaza. Along with the provision of guidance, the EQA is responsible for the compilation, exchange and evaluation of data related to climate change. Given the number of stakeholders involved in the collection of data, stronger coordination mechanisms are needed to facilitate cross-sectoral coordination and cooperation.



Image by Ahmed Zaqout

Table 2.5 NDCs Relevant to WEF Nexus

NDC TITLE	PRIORITY OBJECTIVES	TARGETS/ACTIONS
WATER		
<i>Increasing water treatment and conservation</i>	Enhance the use of additional and alternative water resources for nondomestic purposes in the West Bank and Gaza.	- Seventy percent of the treated wastewater in large-scale wastewater treatment plants in the West Bank and Gaza is reused by 2032. - Seven MCM of rainwater in the West Bank is harvested by 2032.
<i>Improving water networks infrastructure</i>	- Control leakage from distribution systems. - Develop and improve stormwater systems and drainage infrastructure.	- Nonrevenue water is reduced by 15 percent by 2032. - Five percent of rainwater in priority urban areas is drained and collected by 2032.
<i>Improving water sources infrastructure</i>	Rehabilitate water sources: wells, canals, and springs.	One hundred percent of identified wells and springs are rehabilitated by 2030.



Image by hosny salah from Pixabay

NDC TITLE	PRIORITY OBJECTIVES	TARGETS/ACTIONS
FOOD/ AGRICULTURE		
<i>Climate-smart agriculture</i>	• Implement CSA (West Bank). • Manage crop production systems, including soil and water resources, for environmental sustainability and increased economic profitability for farmers (Gaza).	• Fifty percent of farms apply gender-sensitive CSA by 2040.
<i>Climate-resilient land planning and management</i>	• Enhance access to productive agricultural land and water through a range of investments in land development, rangeland development, soil improvements, and agriculture. • Strengthen the resilience of small farmers and livestock keepers to current and anticipated impacts of climate variability and change by financing capacity development, and by testing and monitoring the adaptation benefits and cost-effectiveness of land development approaches and practices applicable for the conditions of the West Bank and Gaza.	• Increase carbon stock in plant biomass and soil organic matter through agroforestry and rangeland development to support an annual 2 percent increase in green areas. • Increase afforestation. • Improve land use planning and management aimed at greening, afforestation, and rangeland development.



Image by Alaa Badarneh

NDC TITLE	PRIORITY OBJECTIVES	TARGETS/ACTIONS
ENERGY		
<i>Renewable energy production</i>	Scale up renewable energy program for the commercial, industrial, and domestic sectors to enhance energy security and reduce GHG emissions.	- Develop Solar PV 100 MW. - Increase concentrated solar power (PV-based) and wind - Increase distributed solar PV (rooftop solar PV). - Promote solar water heater program. - Renewable energy, primarily from solar PV, generates from 20 percent to 33 percent of electricity by 2040.
<i>Energy efficiency</i>	Scale up renewable energy program for the commercial, industrial, and domestic sectors to enhance energy security and reduce GHG emissions.	- Improve energy efficiency by 20 percent (versus business as usual) across all sectors by 2035. - Enforce and implement building codes. - Develop standards and labels with testing labs for lighting, cooling, heating, pumps. - Develop financial and business models as part of a capacity development program.
<i>Energy distribution</i>	Enhance energy security by assessing and upgrading the grid system and upgrading power generation technology.	Provide reliable electricity supply (West Bank) and upgrade the electricity grid (West Bank).

Source: Original for this publication based on NDC and sector investment plans.

Note: NDC = Nationally Determined Contribution; CSA = climate-smart agriculture; GHG = greenhouse gas; PENRA = Palestinian Energy and Natural Resources Authority; WEF = water-energy-food; PV = Photovoltaics; MCM = million cubic meters





Image by hosny salah from Pixabay

NOTES

¹ Update on Climate Change Activities in Palestine, Communication by the Environmental Quality Authority, Ramallah, National Committee of the Code of Conduct (NCCC) meeting, February 28, 2023.

REFERENCE

- FAO (Food and Agricultural Organization of the United Nations) Aquastat. 2008. "Country Profile—Palestine."

<https://www.fao.org/aquastat/en/countries-and-basins/country-profiles/country/PSE>

- Environment Quality Authority. 2016. National Adaptation Plan (NAP) to Climate Change.

https://unfccc.int/files/national_reports/non-annex_i_parties/application/pdf/national_adaptation_plan_state_of_palestine.pdf

- United Nations Development Program. 2010. Climate Change Adaptation Strategy and Program of Action for the Palestinian Authority.

https://eprints.lse.ac.uk/30777/1/PA-UNDP_climate_change.pdf

- World Bank. 2022. Climate Change Knowledge Portal—Climate Risk Country Profiles West Bank and Gaza. Washington DC. World Bank.

<https://climateknowledgeportal.worldbank.org/>

A young girl with dark hair, wearing a dark coat and patterned leggings, stands barefoot in the rain. She is holding a clear glass cup from which water is dripping. The background is a rough stone wall with a doorway where another child is visible. The ground is wet and littered with debris. The overall mood is somber and evocative.

CHAPTER THREE



THE WATER-ENERGY-FOOD NEXUS

STRATEGIC PILLARS FOR IMPROVING RESILIENCE

Understanding and managing the water-energy-food (WEF) nexus is critical for ensuring sustainable development and improving resilience to exogenous shocks. It requires a holistic approach that recognizes the complex interactions among these systems and that promotes integrated management strategies. Improving resilience across the WEF nexus requires a multifaceted approach that addresses the interconnectivity and interdependence of water, energy, and food. This approach requires complex considerations related to integrated planning, water management and conservation, smart and sustainable agriculture, and energy efficiency with an emphasis on cross-cutting institutional reforms, education, and awareness.

Addressing the complexities of the WEF nexus in the West Bank and Gaza requires acknowledgment of the underlying political, legal, and economic challenges. The complex system of restrictions on movement and access maintained by Israel imposes significant impediments to realizing the opportunities presented by the nexus approach, which involves advancing equitable access to water resources, enhancing agricultural practices, promoting renewable energy projects, and empowering Palestinian institutions to manage and govern their resources effectively. This system of restrictions separates Gaza and the West Bank and further divides the West Bank into three areas that were outlined in a temporary agreement under the Oslo Accords. Furthermore, a series of restrictions imposed on an extensive range of goods deemed as "dual use" since 2007 are part of a near-blockade on Gaza that has virtually isolated it from the rest of the world and severely limited economic diversification and sustainable growth.

Understanding the territorial divisions is central to understanding opportunities (and constraints) to realizing the potential of the WEF nexus. The West Bank has been divided into three categories since 1996, when the Interim Agreements between Israel and the Palestine Liberation Organization were introduced (map 3.1). Originally intended to outline the temporary governance and administration arrangements during the peace process, these arrangements continue to divide the West Bank, the status and administration of which remain contentious. Area A represents those areas in the West Bank where the Palestinian Authority (PA) has full

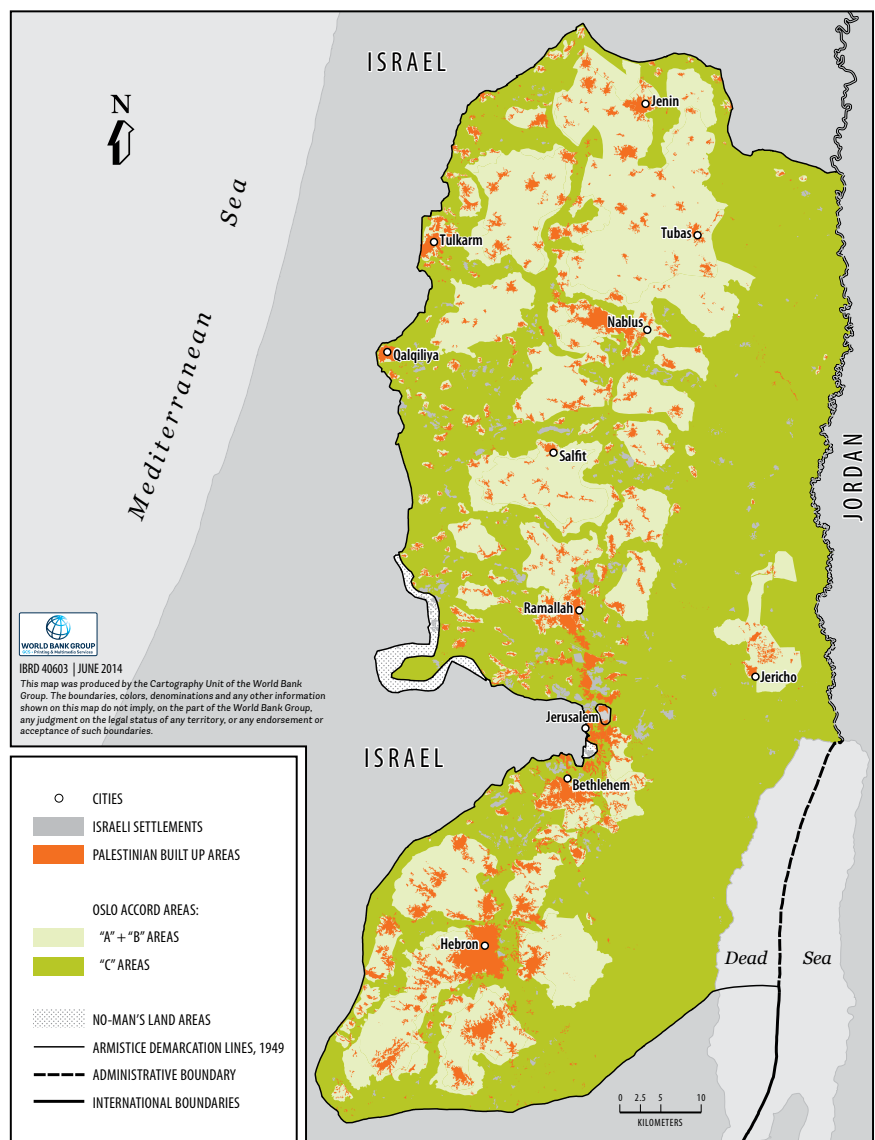




Image by hosny salah from Pixabay

administrative and security control. It includes major Palestinian cities and population centers, such as Ramallah, Bethlehem, and Jenin. The PA is responsible for maintaining law and order, civil administration, and the provision of basic services within these areas. Area B includes those areas where the PA has civil control but shares security responsibilities with the Israeli authorities. It includes smaller towns and villages within the West Bank. Under this arrangement, the PA exercises limited administrative control, while Israeli forces retain the right to enter and operate within these areas for security purposes. Area C, as defined by the Oslo Accords, constitutes the largest portion of the West Bank and is under full Israeli control. It encompasses Israeli settlements, military zones, and strategic areas. Israel has authority over planning and zoning, security, infrastructure development, and resource management, which includes control over water resources, land allocation, and construction permit issuance.

Map 3.1 West Bank Land Categories after the 1996 Interim Agreements between Israel and the Palestine Liberation Organization



Source: World Bank (2014). *Area C and the Future of the Palestinian Economy*.



The implications of Area C for the WEF nexus in the West Bank are significant and multifaceted. Area C constitutes about 61 percent of the West Bank territory. It is defined by the 1996 Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip as “areas of the West Bank outside Areas A and B, which, except for the issues that will be negotiated in the permanent status negotiations, will be gradually transferred to Palestinian jurisdiction in accordance with this Agreement” (United Nations 1996). According to the Interim Agreement, the gradual transfer should have been completed by 1997 (United Nations 1996). However, it has not been implemented as envisaged, and in the meantime, access to this area for most kinds of economic activity has been severely limited (Niksic, Eddin, and Cali 2014). Area C is richly endowed with natural resources and is contiguous, with the potential to make a significant contribution to the Palestinian economy, whereas areas A and B are smaller territorial islands with limited natural resources (Niksic, Eddin, and Cali 2014). Continued restrictions on economic activity in Area C of the West Bank have been particularly detrimental to the economy (Niksic, Eddin, and Cali 2014), and the political and legal complexities, including land ownership disputes and restrictions imposed by Israeli authorities, create uncertainties and challenges for development efforts. These limitations on control and decision-making power in Area C inhibit comprehensive planning and hinder the effective management of the WEF nexus.

Area C encompasses significant land and natural resources that are essential for Palestinian economic development. Area C contains vital water resources, including the majority of the West Bank’s underground aquifers and areas within the catchment of the Jordan River. Israel exercises control over water infrastructure and permits, leading to restrictions on access to water resources. Palestinians face challenges in drilling new wells, expanding water infrastructure, and effectively managing water resources, which directly affects agricultural activities and overall water availability for domestic and industrial use. Area C is crucial for agricultural development and food security, but Israeli restrictions on land use, access to agricultural lands, and water resources, severely impact Palestinian farming communities. Farmers face difficulties in irrigating their crops, obtaining permits for agricultural structures, and developing their agricultural potential. These restrictions have adverse effects on food production, local food security, and the livelihoods of Palestinian farmers. Similarly, the development and management of energy infrastructure, such as renewable energy projects and electricity grids, are constrained in Area C due to Israeli control. This control limits the ability of Palestinians to develop sustainable energy sources, optimize energy efficiency, and enhance energy security. Dependence on Israeli-controlled energy infrastructure can lead to vulnerabilities and hinder the integration of clean energy solutions.



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Area C is key to harnessing the potential of the WEF nexus. Since most of the natural resources in the West Bank are found in Area C, the impact of Israeli restrictions on the economy in the West Bank and Gaza has been considerable (Niksic, Eddin, and Cali 2014). The decisive negative economic impact of these restrictions, and the rationale for them, have been analyzed in many reports produced by the World Bank and other development agencies. According to the 2014 World Bank report "Area C and the Future of the Palestinian Economy", rolling back the restrictions would bring substantial benefits to the economy in the West Bank and Gaza and could usher in a new period of increasing gross domestic product (GDP) and substantially improved prospects for sustained growth. Within this setting, Area C is particularly important because it is either off limits for economic activity in the West Bank and Gaza or is accessible only with considerable difficulty and often at prohibitive cost. This, in turn, affects the overall socio-economic conditions and the ability to achieve a sustainable WEF nexus.

Opportunities to harness the potential of the nexus are further hampered by restrictions on dual use goods. These are products and technologies normally used for civilian purposes but which may have military applications. A series of unilateral restrictions on access to dual use goods has been imposed on the West Bank and Gaza. The first restrictions, in 1976, included a limited number of chemicals and fertilizers that were considered a threat to the Israeli security. The dual use list has been amended over the years to increase the number of items and lower the maximum allowed concentration levels. By 2019, the list included 56 items, including fertilizers (6 types), pesticides (2 types), and 23 chemicals in their pure form, in addition to 31 types of materials, machinery, and equipment, restricted in both the West Bank and Gaza. The list had another 62 items, including reinforcing steel, cement, aggregates, insulating panels, and timber for furniture manufacture, restricted only in Gaza. Dual use restrictions do not discriminate sufficiently between legitimate and illicit uses, the procedure for administering the dual use list is opaque, and Palestinian businesses have no ability to appeal administrative decisions (World Bank 2019). Dual use restrictions impose a number of constraints and adversely impact the delivery of public infrastructure projects, especially in Gaza, where less than 16 percent of items needed to construct water infrastructure could be obtained before the 2023 conflict (OXFAM 2024). The costs of the dual use restrictions on the economy are significant. Compared with a scenario of continued restrictions, a scenario of no restrictions would bring about an estimated additional cumulative growth of about 11 percent to the economy in Gaza and 6 percent to the economy in the West Bank (World Bank 2019).

THE WATER SECTOR

The water sector in the West Bank and Gaza is influenced by a range of exogenous factors and a lack of control over water resources. This has resulted in significant restrictions on the access to water, infrastructure development, and utility performance, along with routine operation and maintenance. These restrictions impose significant constraints on growth and development of the sector, with cascading economic and social impacts. These constraints result in a water sector that is characterized by low and declining per capita water availability, limited scope for new investments, and operational and maintenance issues, resulting in inadequate water services, high costs, low levels of reliability, poor water quality, and a range of systemic institutional challenges. These limitations have far-reaching implications that significantly impact the development trajectories of all other sectors in the West Bank and Gaza.

Any assessment of the water sector in the West Bank and Gaza has to account for varying assumptions and the high degree of uncertainty. The long-term strategy that governs the water sector has been designed by the Palestinian Water Authority (PWA) in anticipation of a fully independent Palestinian state. This strategy has many important implications for planning, development, and management of water, and it relies on political solutions that have thus far proved elusive. Therefore, this report relies on a range of different scenarios. Given the complex enabling environment and prevailing context, it considers assumptions that result in wide-ranging estimates of the water resources available to Palestinians and projections of future demand. The assessment presented herein is intended to provide a balanced analysis of the potential implications of climate change on the development trajectory in the West Bank and Gaza. It is not intended to provide a detailed master plan of investments required for the water sector, but rather focuses on hypothetical scenarios to explore the implications of water scarcity and opportunities to increase resilience. The scenarios illustrate the challenges facing Palestinians in securing water to sustain basic human needs and socioeconomic development. Where possible, the scenarios are based on official data and information from the PWA or other Palestinian authorities as appropriate. Where such data and information are not available, efforts have been made to rely on internationally recognized sources, all of which are cited to ensure transparency.



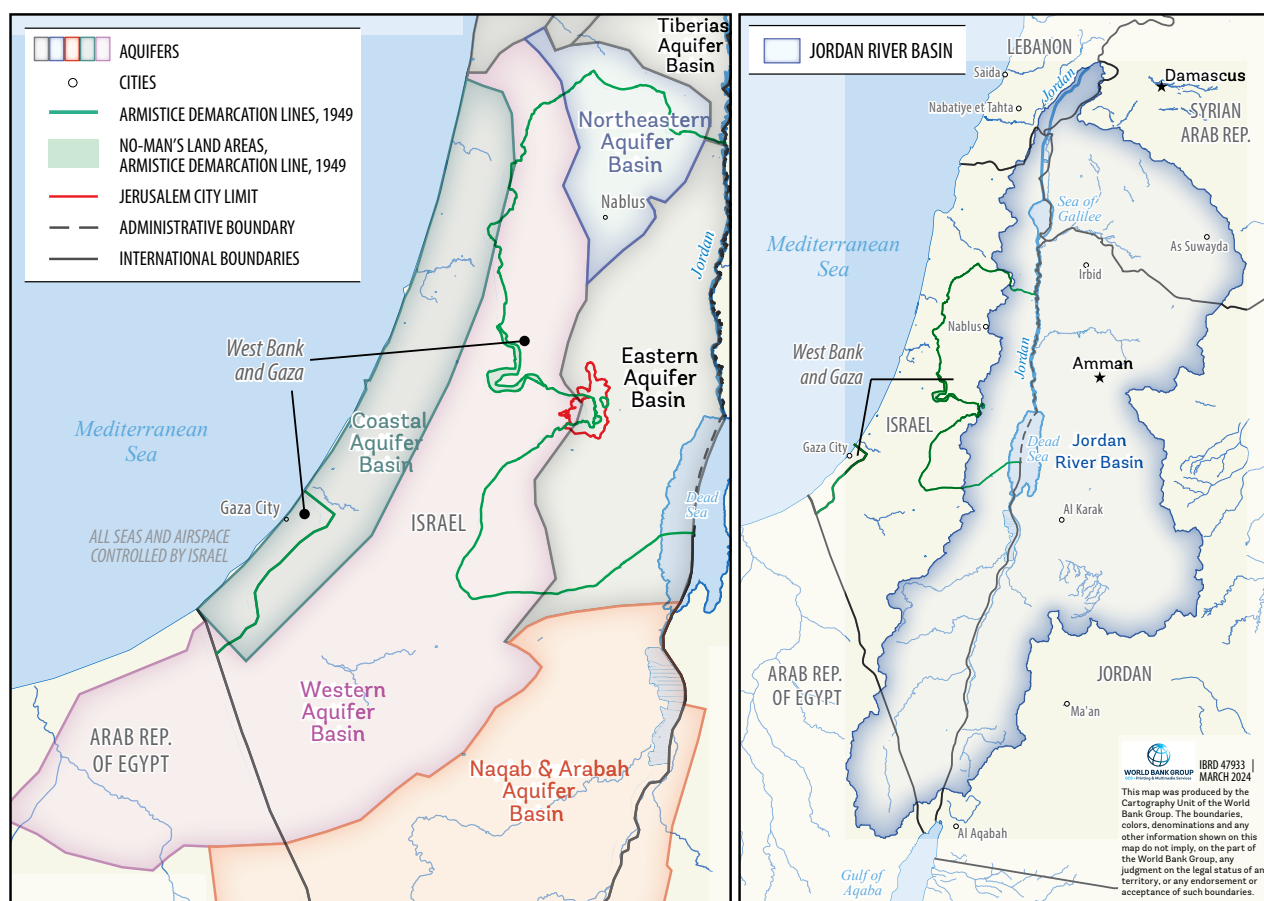
Image by hosny salah from Pixabay



Water Resources

The main conventional water resources are all transboundary and highly contested. These include three aquifers that are commonly referred to as the Mountain Aquifer, which has historically been the major source of water for the West Bank, as well as one of the main sources of freshwater for Israel; the Coastal Aquifer, which is the only freshwater resource in Gaza; and the Jordan River, which covers the West Bank, Israel, Jordan, Lebanon, and Syria (map 3.2). Palestinians have had no access to the resources of the Jordan River since 1967 and these waters remain some of the most heavily disputed in the world. Given increasing demand and greater uncertainty due to a range of hydro-climatic and exogenous factors, there is increasing recognition of the need to develop nonconventional water resources, including desalination, wastewater reuse, and rainwater harvesting, to increase resilience. All of these resources combined provided an estimated 373.5 million cubic meters (MCM) in 2020 for the West Bank and Gaza (table 3.1). Imports purchased from Israel are used to bridge the gap when supplies are insufficient to meet basic demands, giving a total of 464.2 MCM in 2020.

Map 3.2 Coastal and Mountain Aquifers and the Jordan River



Source: Original for this publication

Table 3.1 Available Water Resources, 2020

GOVERNORATE	GROUND WATER	SURFACE WATER	WASTE WATER REUSE	DESALINATION	WATER HARVESTING	WATER IMPORTS	TOTAL AVAILABLE
WEST BANK							
Jenin	9.1	0		0		2.5	11.6
Tubas	31.2	0		0		6.1	37.3
Nablus	27.0	0		0		5.0	32.0
Tulkarm	25.0	0		0		0.5	25.5
Qalqilia	17.7	0		0		0.9	18.6
Salfit	0.9	0		0		3.3	4.2
Jericho	48.1	0		0.5	0.75	2.8	52.15
Ramallah & Jerusalem ^a	4.9	0		0		24.5	29.4
Bethlehem	10.5	0		0	0.45	31.5	42.45
Hebron	2.1	0		0			2.1
SUB-TOTAL	176.5	0	0	0.5	1.2	77.1	255.3
GAZA							
North Gaza	51.4	0		0.6		0	52.0
Gaza	38.4	0		2.2		8.0	48.6
Middle	30.1	0		1.3		2.1	33.5
Khanyunis	45.8	0		0.7		3.2	49.7
Rafah	24.2	0		0.9		0	25.1
SUB-TOTAL	189.9^b	0	0	5.7	0	13.3	208.9
TOTAL	366.4	0	0	6.4	1.2	90.7	464.2

Source: PWA annual supply reports.

^a/ Excludes data from east Jerusalem^b/ Natural recharge is estimated at 55 MCM per year; most of the water is brackish and not fit for human consumption.

Note: PWA = Palestinian Water Authority; MCM = million cubic meters

Groundwater resources are the primary source of water for most Palestinians through either wells or springs. The total renewable groundwater resources have been estimated at 578–814 MCM per year in the West Bank and at 55 MCM per year in Gaza. The three aquifers that make up the Mountain Aquifer are all largely karstic limestone formations and are characterized by significant depth, averaging around 250 meters, and relatively rapid flow. The recharge area lies largely within Area C. The Western Aquifer flows from the western slopes of the Palestinian hills toward the coast, with an estimated renewable yield of 335–450 MCM of high-quality water per year. The recharge of the Eastern Aquifer, which lies almost completely within the West Bank and drains to the Jordan River and the Dead Sea, is estimated at 155–237 MCM, while recharge of the North-Eastern Aquifer is estimated at 130–200 MCM per year. The Coastal Aquifer extends along the eastern Mediterranean coast from the northern Sinai Peninsula in Egypt, along the Gaza Strip and Israel, and provides the only conventional source of water for the population in Gaza.

Access to these groundwater resources was discussed during the Oslo II Accord.¹ Water was referred to as one of the final status issues and remains unresolved, with interim arrangements put in place in anticipation of reaching a permanent solution. Article 40 of the interim arrangements, related to water and sewage, established the main principles for developing additional water resources, coordinating management of water resources and wastewater systems, treating influent for eventual reuse, and ensuring water quality and the prevention of harm. These principles recognized the importance of water for human security, economic development, and regional cooperation. For the interim period before the final status negotiations, the Oslo Accords called for the creation of the Joint Water Committee (JWC), comprised of an equal number of members from Israel and the PA, whose functions would include the coordinated management of water resources and water and sewage systems in the West Bank. The provisions recognized Palestinian water rights in the West Bank and the need to develop additional water supply. The Oslo II Accord proposed that the Palestinians should have access to 118 MCM per year in the West Bank (table 3.2). Section 7 of Article 40 called for an additional 20.5 MCM for "immediate needs" to be developed for Palestinian use from the "unallocated" resources of the Eastern Aquifer, giving a total of 138.5 MCM per year. An additional 78 MCM per year was to be developed on the basis of subsequent agreements. The final principle (paragraph 25) related to Gaza and maintained the status quo on existing provisions and agreements relating to water resources and sewage systems.

Table 3.2 Interim Water Allocations as per the Oslo II Agreement

USE	AQUIFERS (MCM)			
	WESTERN	NORTH-EASTERN	EASTERN	TOTAL
<i>Israel</i>	340	103	40	483
<i>Palestinian territories</i>	22	42	54	118
<i>Additional quantity for Palestinian development</i>	–	–	78	78
<i>Basin total</i>	362	145	172	

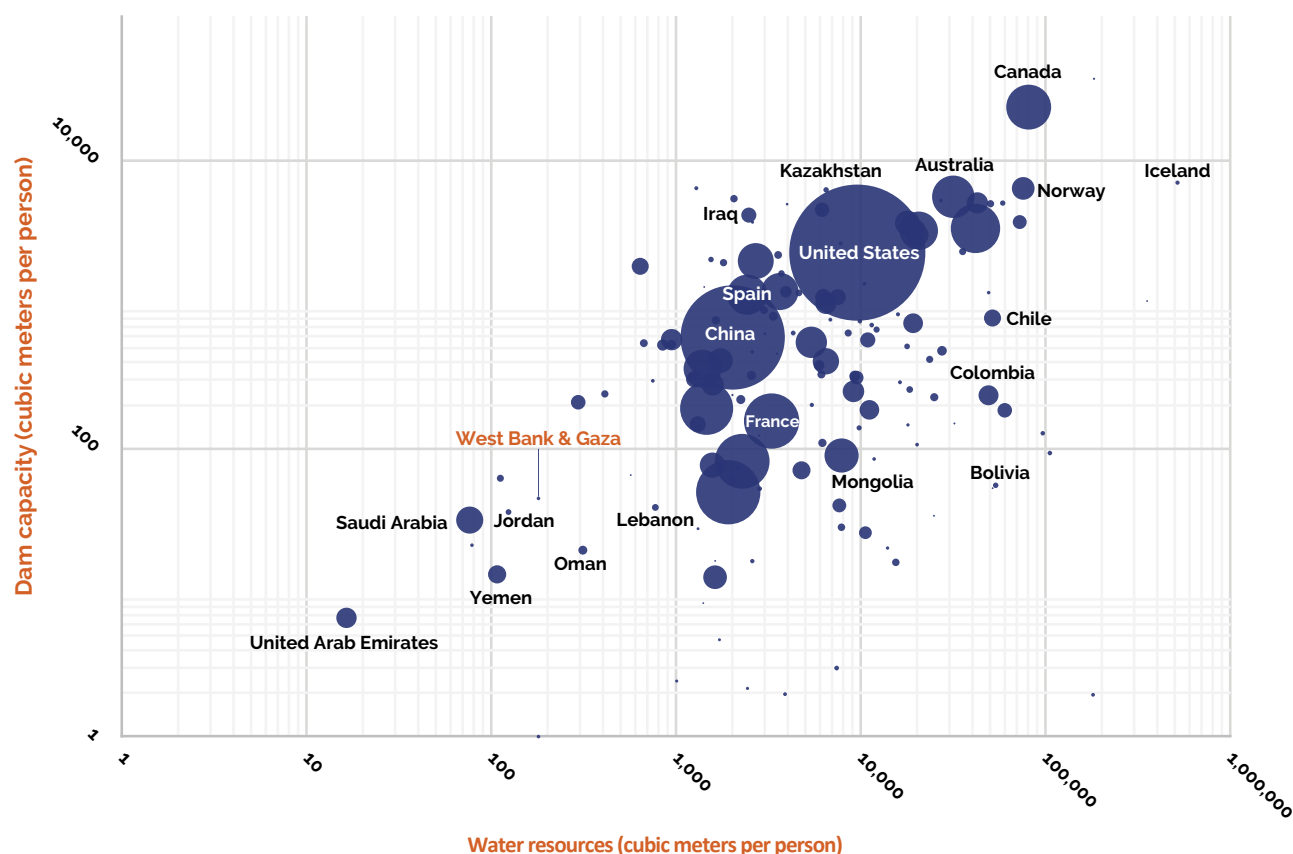
Source: Annex III of the Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip (Oslo II)

The limited access to surface water resources in the West Bank and Gaza is accentuated by a lack of storage. Surface water resources are limited to those of the Jordan River and around 33 wadis that originate in the West Bank. These either flow westward to the Mediterranean Sea or eastward to the Jordan Valley and the Dead Sea. Access to these resources is heavily restricted and subject to approvals through the JWC. As already noted, the Palestinians have had no access to the resources of the Jordan River since 1967, and these waters remain some of the most heavily contested in the world. Historically, the quantity of water flowing into the Jordan River and discharging into the Dead Sea is estimated to have been between 1,485 MCM and 1,671 MCM per year. Prior to 1967, there were estimated to be some 150 pumps in the West Bank withdrawing roughly 30 MCM per year (Shuval and Dweik 2007). Since 1967, Israel has abrogated all Palestinian water rights and diverted the water resources from the Jordan River for irrigation and domestic water supply. As a result, the water in the Jordan River is presently estimated at not more than 30 MCM per year.

The Palestinian Water Sector Strategy does not specify the exact volume of water to be used from the Jordan River. However, it does indicate that the specific allocations per riparian country will be agreed on in a basin-wide agreement according to principles of international water law. These international principles inform negotiations among riparian states and commonly take into account a range of different factors, including the contribution to runoff and the area or population in the basin. The West Bank accounts for roughly 11 percent of the basin area over the 300 mm isohyet. Accordingly, the PWA estimates the entitlement could be between 200 MCM and 400 MCM per year. Although any such an allocation is unrealistic given the resources are fully utilized, recognition of entitlement provides the basis for further negotiations and potential compensatory mechanisms.

Wadis originating in the West Bank provide opportunities for increasing storage and increasing resilience. The 33 wadis that originate in the West Bank have an estimated average annual runoff of 164.8 MCM per year. Sixteen of these wadis flow westward to the Mediterranean Sea, with an estimated average total runoff around 122.7 MCM per year. Nine wadis flow eastward to the Jordan Valley, with an average total runoff estimated at 20.6 MCM per year. Eight wadis flow eastward to the Dead Sea, with an average total runoff estimated at 21.5 MCM per year. According to the National Water Strategy, the long-term strategic objective is to collect about 45 MCM per year from major wadis in the West Bank for various purposes, including artificial recharge, along with 10 MCM per year from Wadi Gaza to be used for infiltration to the aquifer, irrigation, or both. The planned development of storage projects within the West Bank and Gaza would increase the dam capacity per person from zero to an estimated 45 MCM, bringing storage capacity closer to that of other countries in the region, such as Jordan, Yemen, and Saudi Arabia (figure 3.1).

Figure 3.1 Water per Capita, Dam Capacity per Person, and Gross Domestic Product



Source: Authors' elaboration based on World Bank and FAO data

Rainwater harvesting from rooftops and local springs for both domestic and agricultural purposes is a long-standing practice in the West Bank and Gaza. The West Bank has an estimated 82,656 cisterns, each with an average volume of 55 cubic meters, giving a total of around 4.5 MCM per year.² In addition, there is an estimated 1 MCM per year being harvested through collection systems for greenhouses and agricultural use. There is significant potential to increase water security through rainwater harvesting based on the targets outlined in the Nationally Determined Contribution (NDC), with an additional 7 MCM per year estimated to be available in the West Bank by 2032. Access to the land resources in Area C could increase the potential yield from rainwater harvesting, particularly in the northern and central regions, where rainfall is higher. In Gaza, average annual rainfall is much lower than that in the West Bank, and the potential for technically feasible, large-scale rainwater harvesting there is limited. Nevertheless, rainwater harvesting can supplement water supply in Gaza, particularly for non-potable uses such as irrigation.

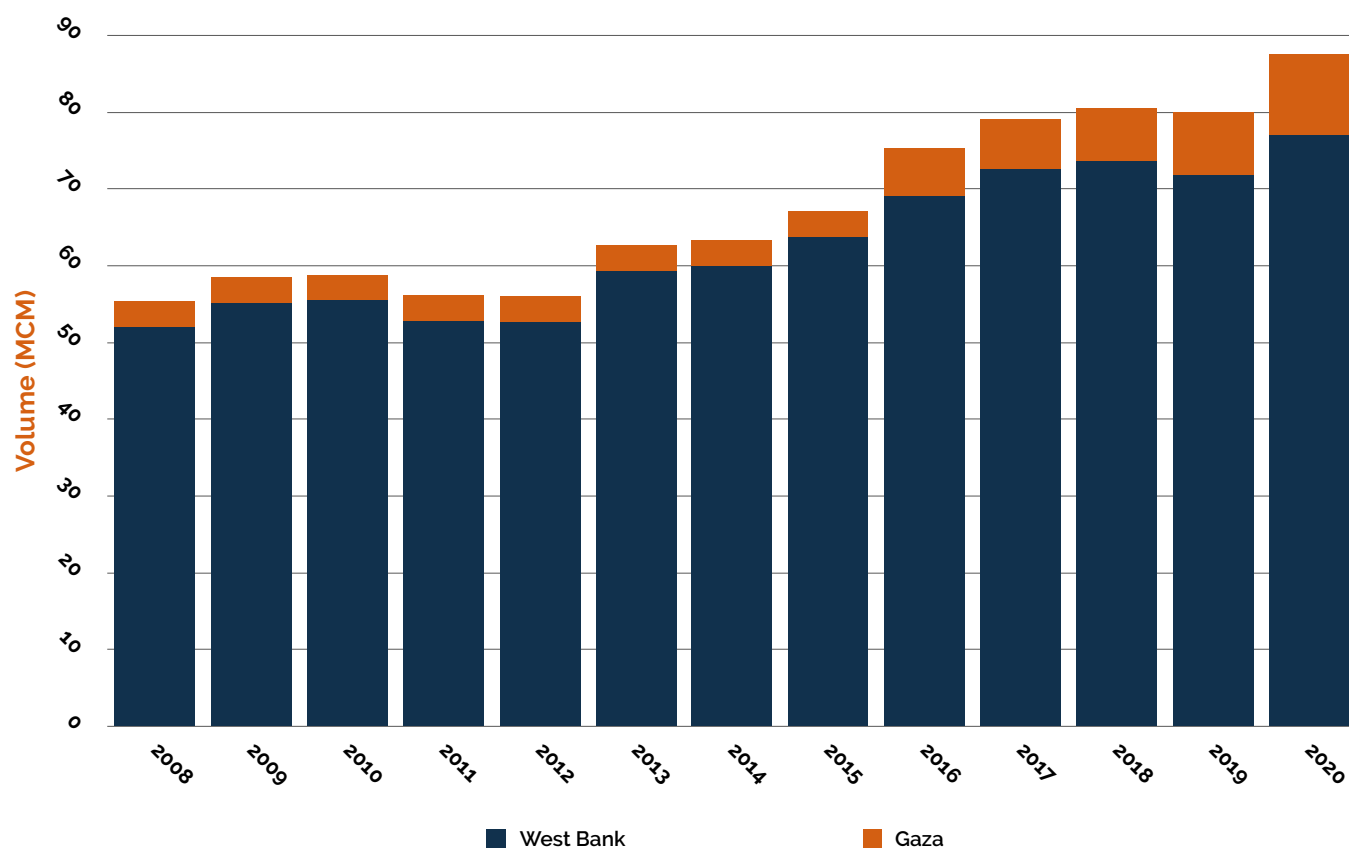
Desalination has the potential to provide a solution to the supply of clean and safe drinking water to the people in Gaza, alleviate pressure on groundwater resources, and allow for recharge of the aquifer. Before the conflict that began in 2023, short-term low-volume (STLV) desalination plants provided an estimated 1.75 MCM per year, and desalination was expected to increase to 55 MCM per year by 2030 with a reverse osmosis desalination plant in the works with financial support from the European Investment Bank. An additional 55 MCM per year was expected to be online by 2040 with completion of a second phase. In addition, there are a number of small pilot projects established by the private sector for brackish water desalination, mostly in the Jordan Valley for agricultural purposes, with a total capacity of less than 0.5 MCM per year. A larger facility in the West Bank, downstream from the Fashka Springs near the Dead Sea, was to have a production capacity of at least 22 MCM per year by 2022 in order to increase water supply for the southern part of the West Bank, and was planned to be extended to 40 MCM per year.



Wastewater reuse is a potentially important source of water for agricultural purposes. It is not currently used for municipal water supply in the West Bank and Gaza. The NDC includes a target of 70 percent of treated wastewater (TW/W) in the West Bank and Gaza being reused by 2030, with the assumption that 80 percent of the water supplied is collected as wastewater for treatment. In 2020, five wastewater treatment plants (WWTPs), with a total design capacity of 201,600 cubic meters per day (73.6 MCM per year), were either operating or under implementation in Gaza with six WWTPs in the West Bank (two in Ramallah and one each in Al-Bireh, Nablus Jericho, and Jenin) having the capacity to treat 27,500 cubic meters per day (10 MCM per year). While there were plans to upgrade three WWTP in Gaza with an additional 117,400 cubic meters per day (42.8 MCM per year), only the North Gaza Emergency Sewage Treatment Plant (NGEST) and the Khan Younis WWTP have the capabilities to recharge the TW/W effluent to the aquifer; roughly 70,000 cubic meters of wastewater is treated in Gaza (25.5 MCM per year) and discharged directly into the sea every day. In the West Bank, the estimated reuse of TW/W was about 2.6 MCM in 2020, representing some 2.6 percent of the domestic supply. Reuse of TW/W is projected to increase to 23.9 MCM by 2030 (13 percent of the domestic supply) and to 54.8 MCM by 2042 (22.8 percent of the domestic supply). Some two-thirds of the collected wastewater is not properly treated and is released directly into the environment, with an estimated 30.4 MCM of untreated wastewater discharged between July 2020 and June 2021. The 2023 updates to the water strategy indicate that wastewater is treated downstream in WWTPs managed by seven independent Israeli wastewater treatment operators who invoiced the PA NIS 64.4 million for treatment in 2021.

Imports are acknowledged in the National Strategy as a way to address the unequal distribution of water resources and to offset the constraints imposed by Israel on the development of water resources. Imports grew from 55 MCM in 2008 to just under 90 MCM in 2020 (figure 3.2) and are viewed as part of the long-term strategy, but only after rights to groundwater and surface water resources have been obtained to meet customer demand with the most cost-effective options. In the scenarios, imports are used to bridge any gap between supply and demand. As such, their values do not reconcile with those projections included in the various national strategies and planning documents. These differences are further accentuated by the assumptions used herein, specifically those relating to per capita consumption and nonrevenue water.

Figure 3.2 Actual Water Imports, 2008–20

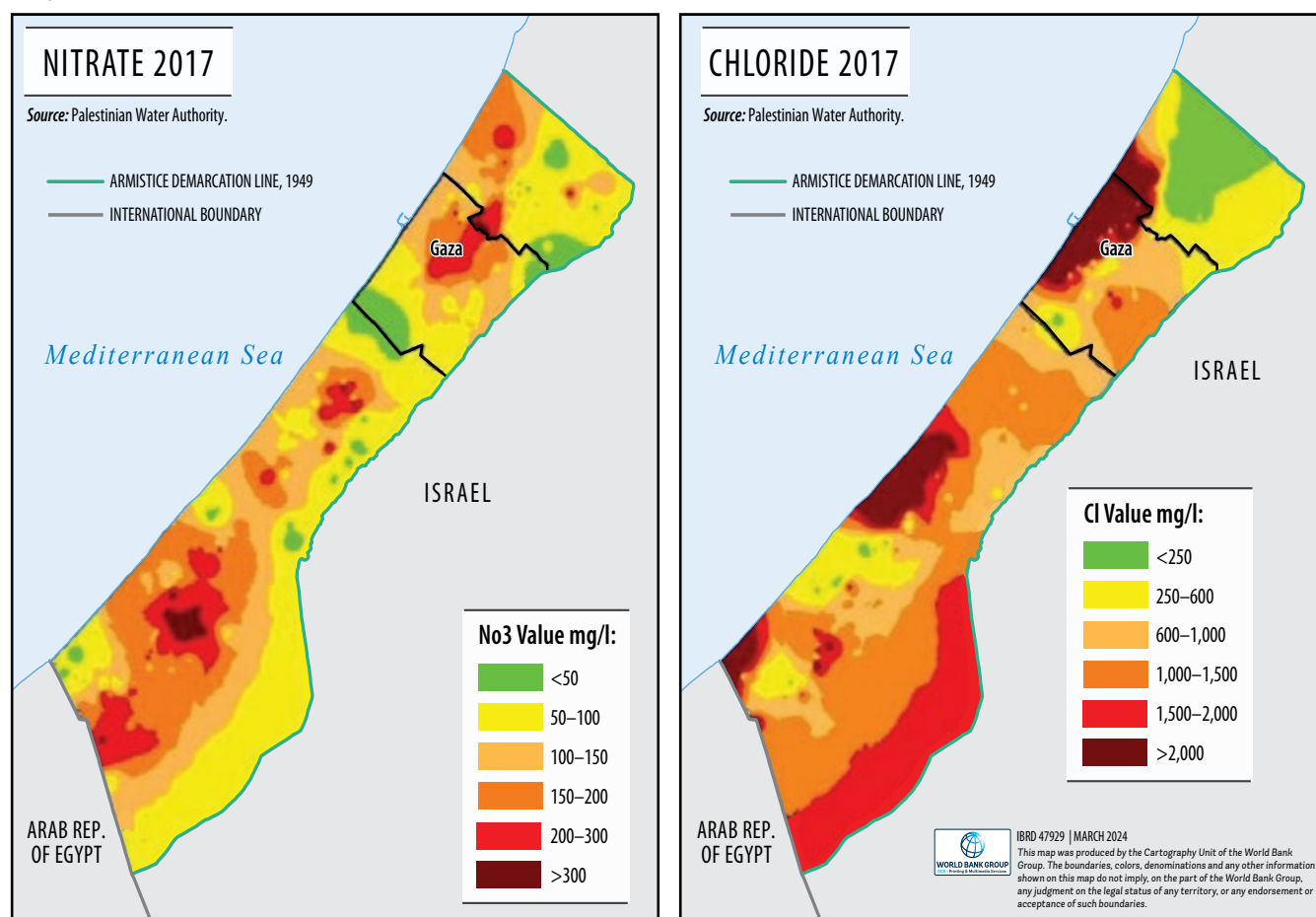


Source: Authors' elaboration based on PWA Supply Reports.

Note: PWA = Palestinian Water Authority; MCM = million cubic meters

Poor water quality further constrains the scarcity of water available for domestic consumption and productive purposes. The main sources of pollution include the discharge of untreated wastewater from domestic and industrial sources, agricultural activities, and nonengineered landfill sites. These challenges are accentuated in some areas due to Israel's ban on the importation of water treatment chemicals that were identified as dual use goods, particularly in industrial areas such as Hebron (Friedman 2014). The Wadi Gaza, the only ephemeral surface water in Gaza, is highly degraded due to anthropogenic activities, including discharge of municipal sewage, use of fertilizers and pesticides, and dumping of solid waste (map 3.3). The flow of poorly treated or raw sewage, coupled with the lateral inflow of seawater due to over-abstraction of the groundwater makes this water largely undrinkable, with high concentrations of nitrate; more than 97 percent of the water pumped from the aquifer does not meet World Health Organization (WHO) water quality standards. As a result, groundwater resources are supplemented by STLV desalination plants and imports from Israel, although an estimated 97 percent of the population are forced to rely on water from expensive and unregulated small-scale private providers.

Map 3.3 Nitrate and Chloride Contours, 2017



Source: Palestine Water Authority (2000) Gaza Coastal Aquifer Management Program (CAMP).

The significant geographic differences between the West Bank and Gaza require them to be considered separately for the purposes of planning. In Gaza, the water resources are limited to groundwater from the Coastal Aquifer. This groundwater is supplemented with wastewater reuse for agriculture, desalination (3 percent), and imports purchased from Israel (6 percent). The flow rate of Wadi Gaza, which extends 9 kilometers (km) from the truce line to the Mediterranean Sea, is limited most days due to barriers at the border with Israel. There is a need to reduce over-abstraction of the aquifer to within sustainable limits and to promote recharge and recovery, meaning that desalination is the only large-scale solution to ensuring water for domestic consumption. In the West Bank in 2020, the majority of the estimated 255.3 MCM of water supplied came from groundwater (69 percent); roughly 30 percent of the water was imported from Israel through 190 delivery points, and some wastewater was reused for agricultural purposes. While additional water resources are available in the West Bank, the long-term options for augmentation rely on a political solution and on complex approval and permitting processes that have thus far proven largely elusive.

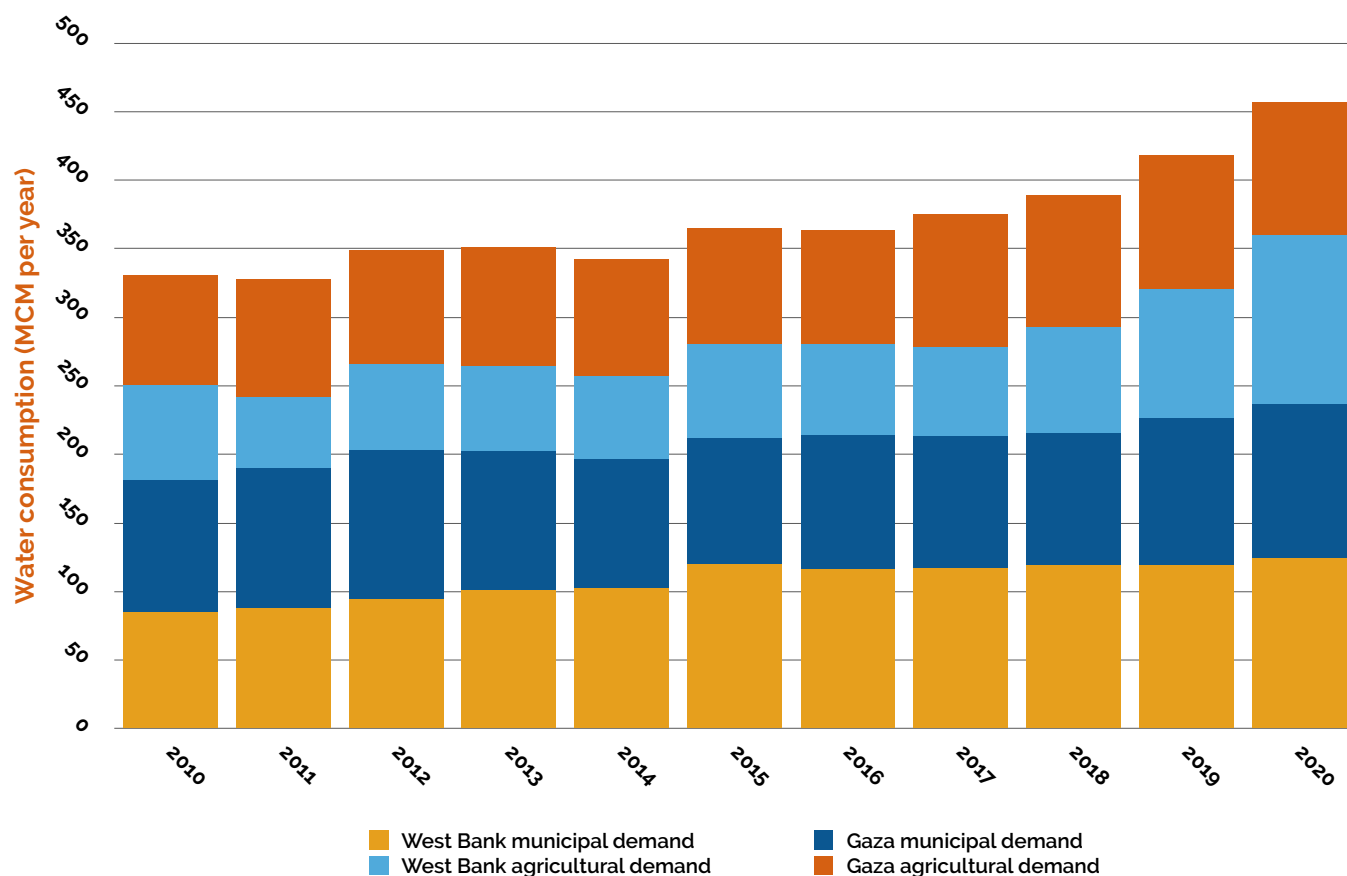
The onset of the conflict in October 2023 had a significant impact on water supply and wastewater facilities in Gaza. An Interim Rapid Damage and Needs Assessment (IRDNA) published in February 2025³ estimated the total reconstruction and recovery needs in Gaza at US\$53 billion, with over 89 percent of water, sanitation and hygiene assets being either destroyed or partially damaged and the recovery and reconstruction needs at US\$2.7 billion. The majority of water systems were heavily affected or were nonoperational due to heavy bombardment causing damage to the water infrastructure needed for production, treatment, and distribution; a lack of fuel due to restrictions on imports; and insecurity and uncertainty that prevented regular operations and maintenance. The PWA reported that damage, coupled with restrictions on water imports purchased from Israel, has reduced capacity to less than 5 percent of the normal daily production. The Water, Sanitation and Hygiene

(WASH) Cluster estimated that each person in Gaza had access to less than three liters of water a day. At the end of 2023, none of the STLV desalination plants were operating, and the Mintar connection point that provided 24,000 cubic meters per day was still closed, while the Bani Suhaila and Bani Sa'ad connection points were providing approximately 1,100 cubic meters per hour (OCHA 2023). One of the five WWTPs had been destroyed and another two damaged, while 36 of the 80 water reservoirs had been damaged (19) or destroyed (17), and at least 114 of the 284 water wells had been impacted (World Bank 2024). As a result, people have been forced to resort to drinking groundwater resources that are unfit and unhealthy for human consumption.

Water Supply

Water consumption in the West Bank and Gaza is characterized by significant suppressed demand due to constraints imposed on, and the water available to, the Palestinian people.⁴ According to PWA records, water consumption has increased by more than 34 percent during the last decade (figure 3.3 and table 3.1), with municipal demand increasing by some 50 percent—equivalent to population increase, meaning that the per capita water demand has remained almost constant. In 2020, an estimated 236.6 MCM of water was supplied for municipal purposes, which includes industrial demands, and 220.6 MCM, for agricultural supply. The total amount of water available to meet this demand includes 366.4 MCM of groundwater resources, of which 190 MCM per year is from the Coastal Aquifer in Gaza. Water from this aquifer is of poor quality and unfit for human consumption, and withdrawals exceed the sustainable yield by an estimated 135 MCM per year. The gap between the supply and demand is met through imports purchased from Israel, which amounted to 90.7 MCM in 2020. When considering the allocations made under the Oslo Accords and discounting the imports required from Israel, the gap between the amount of water supplied in 2020 and the available water resources is estimated to be more than 225 MCM.

Figure 3.3 Agricultural and Municipal Consumption in the West Bank and Gaza, 2010–20



Source: Authors' elaboration based on World Bank data.

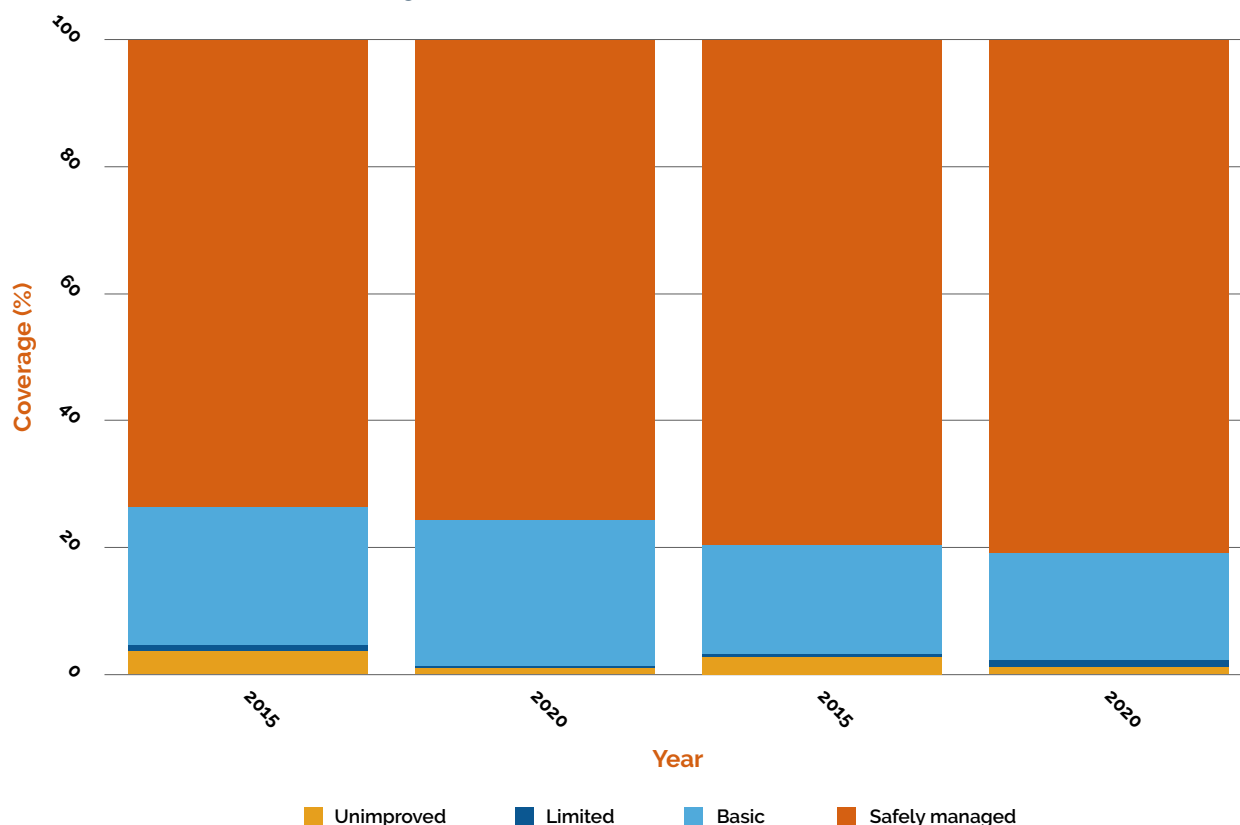
Note: MCM = million cubic meters

The level of access to water supply services in the West Bank and Gaza has historically been relatively high, despite the constraints. Access is mostly provided through an individual household connection to a piped system and is nearly universal (figure 3.4). Collective supply points have been replaced over the last few decades and are no longer cited in official statistics, except in zones where there is no piped water supply. The connection rate (expressed as the number of connections per 100 inhabitants) has been increasing steadily in all urban areas and currently stands at 18–22 connections per 100 inhabitants. Given that the average household is considered to include 6.5 persons (Palestinian Central Bureau of Statistics estimates), service coverage through household connections in urban areas is likely almost complete, and future growth will be directly dependent on the development of new residential areas and the natural expansion of urban areas. The number of household connections and access to services in Gaza were significantly impacted by the conflict that started in 2023, with 53.2 percent of residential buildings having sustained some level of damage (moderate, severe, or completely destroyed) and more than 800,000 people estimated to be without homes at the end of 2023.

The quality of water related services in the West Bank and Gaza face a number of challenges, and most Palestinian localities do not have continuous water supply. The quantity of water reaching customers varies widely from region to region, reflecting local water resource availability as well as water investments (or the lack thereof). Most service providers deliver water only intermittently; only half of West Bank households and one-third of Gaza households receive water daily (World Bank 2018a). The northern and southern parts of the West Bank are particularly affected by a lack of water, mainly due to Israeli restrictions that prevent the drilling of new wells, restrictions on rehabilitation of existing wells, and conveyance of water from one region to another. As a result, a significant number of customers with a connection are without reliable service, and water operators manage to pipe water to each section of the network for only a few hours per day (or a few hours every two or more days). Customers are thus obliged to invest in individual storage facilities and to rely on private tankers to provide additional water. For this reason, most of the houses in the West Bank and Gaza have roof tanks. However, there is insufficient pressure in the network, so many customers also invest in booster pumps, which they use to fill their roof tanks. Because the network lacks pressure, it becomes highly vulnerable to contamination by wastewater infiltration, increasing the incidence of disease and adding additional burdens on consumers.



Figure 3.4 Water Services Coverage, 2015–20



Source: WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP).
<https://washdata.org/data/household#!/>.

The existing level of domestic consumption is well below internationally accepted standards. In July 2010, the United Nations General Assembly declared safe and clean drinking water and sanitation a human right essential to the full enjoyment of life and all other human rights.⁵ The right of every human being to have access to enough water for personal and domestic uses translates to 50–100 liters of safe, acceptable, and affordable water per person per day. For the purposes of planning, the PWA has established a target of 120 liters per capita per day (lcd) for domestic purposes. However, the average per capita consumption for people in the West Bank and Gaza is 86.3 lcd, averaging 82.4 lcd in the West Bank and 91.6 lcd in Gaza. The average consumption in Gaza is higher than that in the West Bank due to higher temperatures and poor water quality that requires higher water consumption rates. These rates range from a high of 141 lcd in Qalqiliya to a low of 51 lcd in Bethlehem and Hebron (table 3.3).

Nonrevenue water (NRW) accentuates issues of water scarcity and provides an important source of water to meet future demand. NRW is estimated at about 31 percent of total water production in the West Bank and 38 percent in Gaza, with an estimated 60 MCM of water lost in 2020 due to non revenue water.^{6,7} The situation has improved since 2013, when NRW was estimated at between 24 and 36 percent in the West Bank and 41 to 46 percent in Gaza (PWA 2013). Although a significant portion of this NRW is reportedly due to commercial losses, transmission and distribution losses are accentuated by intermittent supplies (due to physical shortages and electricity interruptions) and by the complicated topography in the West Bank, which causes the network to deteriorate at a faster rate, as well as by challenges with leak detection and repair due to restrictions on movement and materials (such as pipes) that impact routine maintenance. As demand continues to rise due to population growth and as water production is scaled up accordingly, these physical losses pose an increasing burden on water resources in the West Bank and Gaza, potentially surpassing 200 MCM by 2050 unless significant investments are made. This amount is almost equivalent to projected imports purchased from Israel.

Access to sanitation services are similarly high, but show significant differences between Gaza and the West Bank. Overall access to improved sanitation services is almost universal in the West Bank and Gaza (figure 3.5). However, two-thirds of residents in the West Bank use cesspits and access to sewer connections remains relatively low at around 35 percent, with rates varying widely by governorate, from 0 percent in Tubas to 59 percent in Qalqilya, and household income (World Bank 2018). In Gaza, by contrast, the rate of household connections to the sewer network is estimated at more than 90 percent. The high rates of collection provide a strong foundation for increasing wastewater reuse, while the low connection levels in the West Bank highlight the urgency to increase collection, treatment, and reuse in order to reach the NDC target of 70 percent of TW/W reuse in the West Bank.

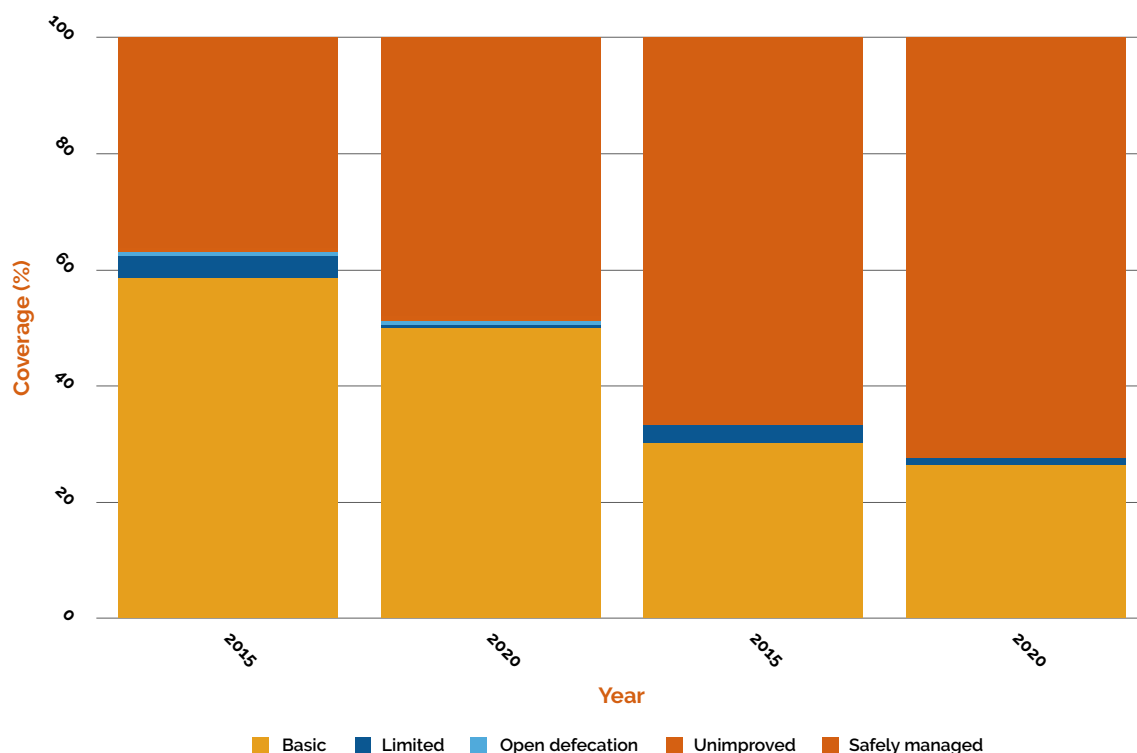
Table 3.3 Municipal Water Supply for the Year 2020

GOVERNORATE	SUPPLY (MCM)	CONSUMPTION (MCM)	LOSSES (MCM)	LOSSES (%)	POPULATION 2020	CONSUMPTION (LITER/CAPITA/DAY)
<i>Jenin</i>	13.9	8.5	5.4	38.85	335,485	<i>69.4</i>
<i>Tubas & Northern Valleys</i>	2.3	1.7	0.6	26.09	65,211	<i>71.4</i>
<i>Nablus</i>	18.1	12.7	5.4	29.83	411,680	<i>84.5</i>
<i>Tulkarm</i>	15.3	9.3	6.0	39.22	197,098	<i>129.2</i>
<i>Qalqilya</i>	8.2	6.2	2.0	24.39	120,357	<i>141.0</i>
<i>Salfit</i>	3.2	3.1	0.1	3.13	81,162	<i>104.6</i>
<i>Jericho & Al-Aghwar</i>	4.2	2.5	1.7	40.48	52,836	<i>129.5</i>
<i>Ramallah & Al-Bireh & Jerusalem</i>	29.4	21.1	8.3	28.23	517,097	<i>111.7</i>
<i>Bethlehem & Hebron</i>	29.5	18.7	10.8	36.61	1,004,727	<i>51.0</i>
<i>Hebron</i>						
<i>West Bank</i>	<i>124.1</i>	<i>83.8</i>	<i>40.3</i>	<i>32.47</i>	<i>2,785,653</i>	<i>82.4</i>
<i>Gaza Strip</i>	<i>112.5</i>	<i>69.6</i>	<i>42.9</i>	<i>38.13</i>	<i>2,082,678</i>	<i>91.6</i>
<i>Total</i>	<i>236.6</i>	<i>153.4</i>	<i>83.2</i>	<i>35.16</i>	<i>4,868,331</i>	<i>86.33</i>

Source: PWA supply reports.

Note: PWA = Palestinian Water Authority; MCM = million cubic meters

Figure 3.5 Sanitation Coverage, 2015–20



Source: WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), <https://washdata.org/data/household#!/>.

Water security is undermined by a range of financial challenges and a lack of sustainability. The value of water in the West Bank and Gaza is not fully costed, and tariffs are a complex issue closely tied to the political and economic situation. Bulk tariffs are set by the PWA/West Bank Water Department (WBWD) and retail tariffs, by the individual water and wastewater service providers, of which there are more than 280.⁸ Consumer tariffs are based on a tiered pricing system, with higher prices for higher levels of consumption, but these prices vary depending on the location and type of water service.⁹ Tariffs are generally higher in the West Bank than in Gaza due to the higher cost of water production and distribution. The average tariff for domestic water is around NIS 5.5 (US\$1.53) per cubic meter in the West Bank and around NIS 3.5 (US\$0.97) per cubic meter in Gaza. The challenges of financial sustainability are compounded by low collection rates. The average collection rate among service providers in the West Bank is between 65–75 percent and 25–50 percent in Gaza.

Water tariffs in the West Bank and Gaza are among the highest in the world but are not sufficient to cover the cost of operation and maintenance. They also make no provision for depreciation. Recognition of the human right to water and sanitation by the United Nations General Assembly in 2010 acknowledges that the costs for water and sanitation services should not exceed 3 percent of a household's income, meaning services must not affect peoples' capacity to acquire other essential goods and services, including food, housing, health services, and education. Due to the scarcity of water, many communities in the West Bank hire water tankers for their supply. This practice is reflected in the average tariff per governorate, which is relatively high in Hebron, Jenin, and Tubas, that is, in governorates where many communities are obliged to use water tankers. Tariffs are NIS 20 (US\$5.60) or more per cubic meter in some communities. The high cost of water services can be a significant burden for households in the West Bank and Gaza, particularly those with low incomes. Many households pay up to 30 percent of their income on water bills. This burden is due to a combination of factors, including limited water resources, inefficient infrastructure, and political instability, with high tariffs contributing to water insecurity and poverty.

Water supply and sanitation services impose a significant fiscal burden on the PA. The combination of tariffs below the levels required to cover operation and maintenance, coupled with low collection rates and high NRW, undermine the financial viability of most service providers. These losses combine with the subsidies on bulk water supplies to impose a significant fiscal burden on the PA. For example, the WBWD purchases water from Israel at around NIS3.6 (US\$1.00) per cubic meter and sells it to the service providers for NIS 2.6 (US\$0.72) per cubic meter, implying a subsidy of nearly 30 percent. This is compounded by the fact that many municipalities do not pay the WBWD, with underpricing by the WBWD and nonpayment by municipalities providing an effective transfer of NIS130 million (US\$35 million) to service providers in 2014 (World Bank 2018a). This “subsidy” goes disproportionately to the service providers with the biggest arrears, effectively rewarding the worst performers. Additionally, many local government units (LGUs) rely on revenues from water services to help cover their general expenditures not specific to water. This practice deprives the water operator of needed finances and has led many LGUs to simply not pay WBWD for bulk water (box 3.1).

Box 3.1

THE POLITICS OF PAYING FOR WATER IN THE WEST BANK AND GAZA

Domestic water supply in West Bank and Gaza primarily comes from groundwater resources and water imports purchased from Israel. The imported water is purchased from the Israeli company Mekorot through the West Bank Water Department (WBWD) at an agreed price and quantity. As part of the net lending system, the Israeli government deducts the revenues of water from the taxes collected on behalf of the Palestinian Authority.

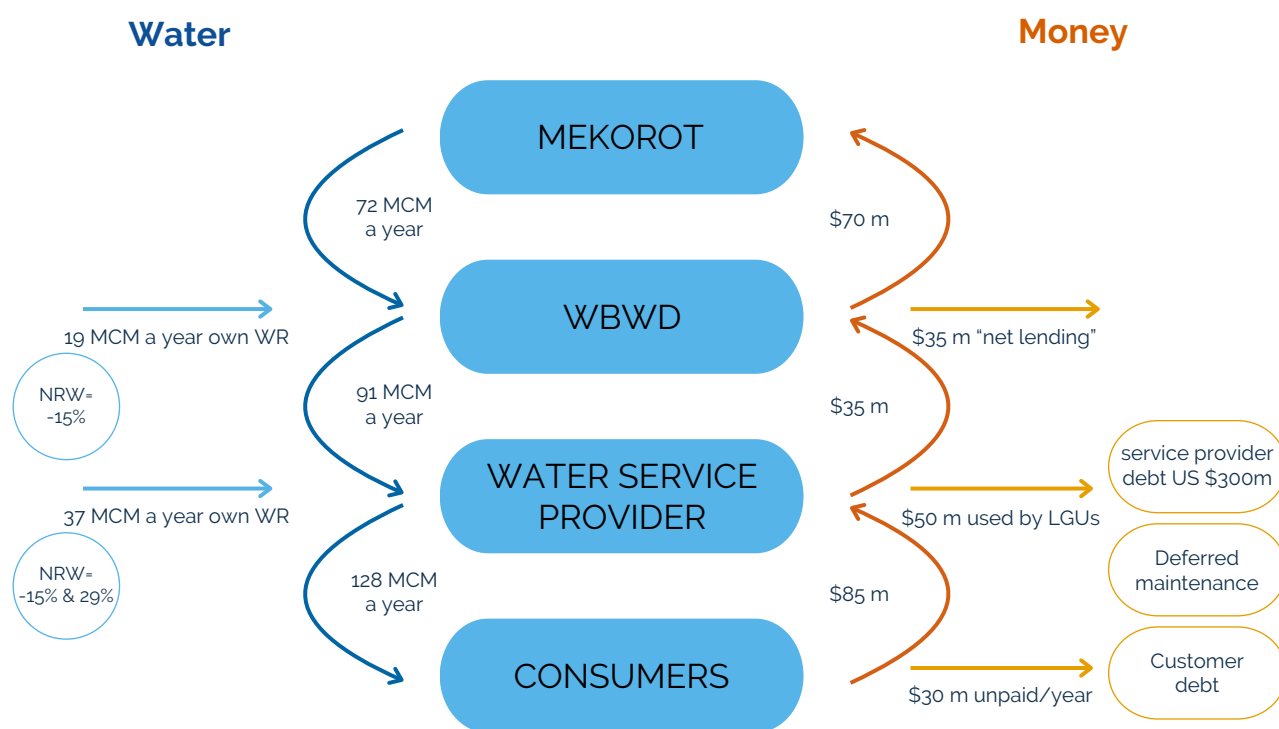
Municipal service providers have to pay for the water received from the WBWD. However, collection rates for water are as low as 20 percent for some service providers. Moreover, some service providers use these revenues for other municipal services. In most cases, the WBWD is not paid in full, creating a debt to WBWD that totaled NIS 1.8 billion (~US\$500 million) by 2023. In response, the WBWD, in cooperation with the Ministry of Local Government (MoLG), is forced to establish payment scheduling for the service providers in an attempt to reduce the burden of the obligations to Mekorot on the Palestinian Authority.

The low collection rate for water fees is due to a range of factors. These include the typical challenges facing the water sector associated with the quality of service and low levels of satisfaction, the notion that water is a public commodity and should therefore be free, as well as the lack of proper enforcement mechanisms. Not paying for water is also seen by some as an act of political resistance, although others rejected this strategy given that Israel deducts the outstanding amounts to Mekorot from the taxes it collects on behalf of the PA under the net lending system.

Issues of affordability are less of an issue, with the average-income household reportedly able to afford to pay NIS 120 per month for water services — the price of a 24 cubic meter equivalent for a family of eight, which is larger than the average family size in the West Bank and Gaza. Some service providers have implemented the use of prepaid water meters. These have resulted in collection rates increasing by as much as 100 percent, and even more in some instances because they allow for collecting a portion of the old debts when charging the meter.

The costs associated with water and wastewater services have important implications for net lending. This is the system by which Israel deducts payment for unpaid dues for electricity, water, and sewage services provided to Palestinian consumers (figure 3.6). For these unpaid dues, Israel makes deductions from the funds it collects on behalf of the PA. The deductions include charges by Israel for the purchase of bulk water imports, wastewater treatment, and costs recovered from service providers and their customers. These amounts for water and sewage increased from US\$51 million in 2008 to more than US\$130 million in 2020; water increased from US\$42 million to just more than US\$100 million, and sewage increased more than three-fold, totaling US\$241.67 million between 2008 and 2020 (figure 3.7). These figures reflect (1) an increase in the volume of water purchased from Israel (from 48 MCM in 2008 to 79 MCM in 2018), (2) an increase in the incremental cost of water purchased (from NIS 2.9 to NIS 3.6 per cubic meter), and (3) an increase in the volume of wastewater flowing from the West Bank that is treated in Israel.¹⁰ In addition, some electricity costs related to water treatment and pumping are also covered by the PA from clearance revenues or other sources. Given existing levels of (in)efficiency, the expansion of nonconventional water sources would translate into a fiscal burden of some US\$400 million a year to keep water supply and sanitation services running. The implicit subsidy is US\$1.45 per cubic meter of water purchased.¹¹ With the need to develop or purchase 250–300 MCM of nonconventional water a year, the fiscal burden would be between US\$363 million and US\$435 million by 2030.¹²

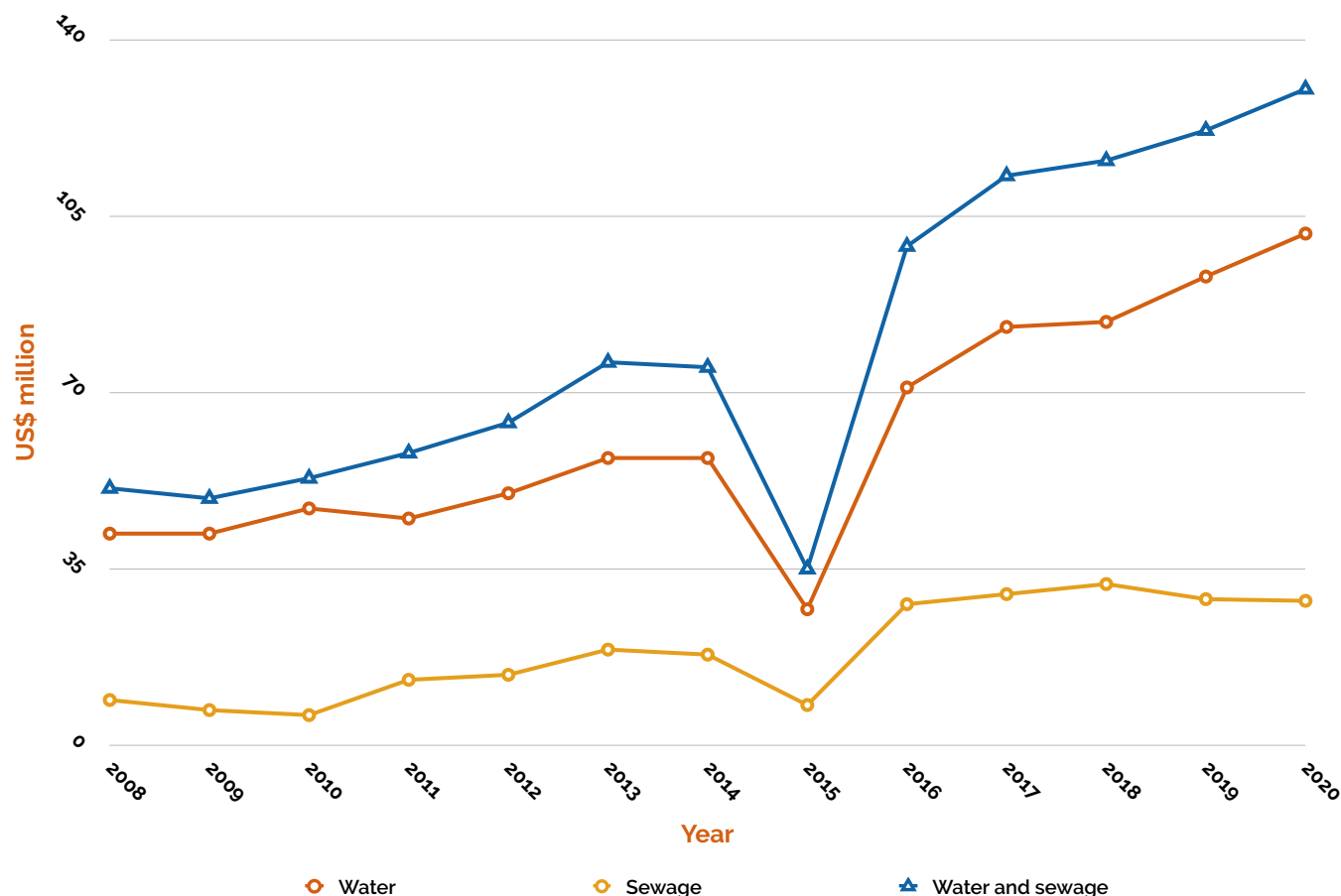
Figure 3.6 Financial Context of the Palestinian Water Sector



Source: World Bank 2018b.

Note: LGU = local government unit; MCM = million cubic meters; NRW = nonrevenue water; WBWD = West Bank Water Department; WR = water source; m = million

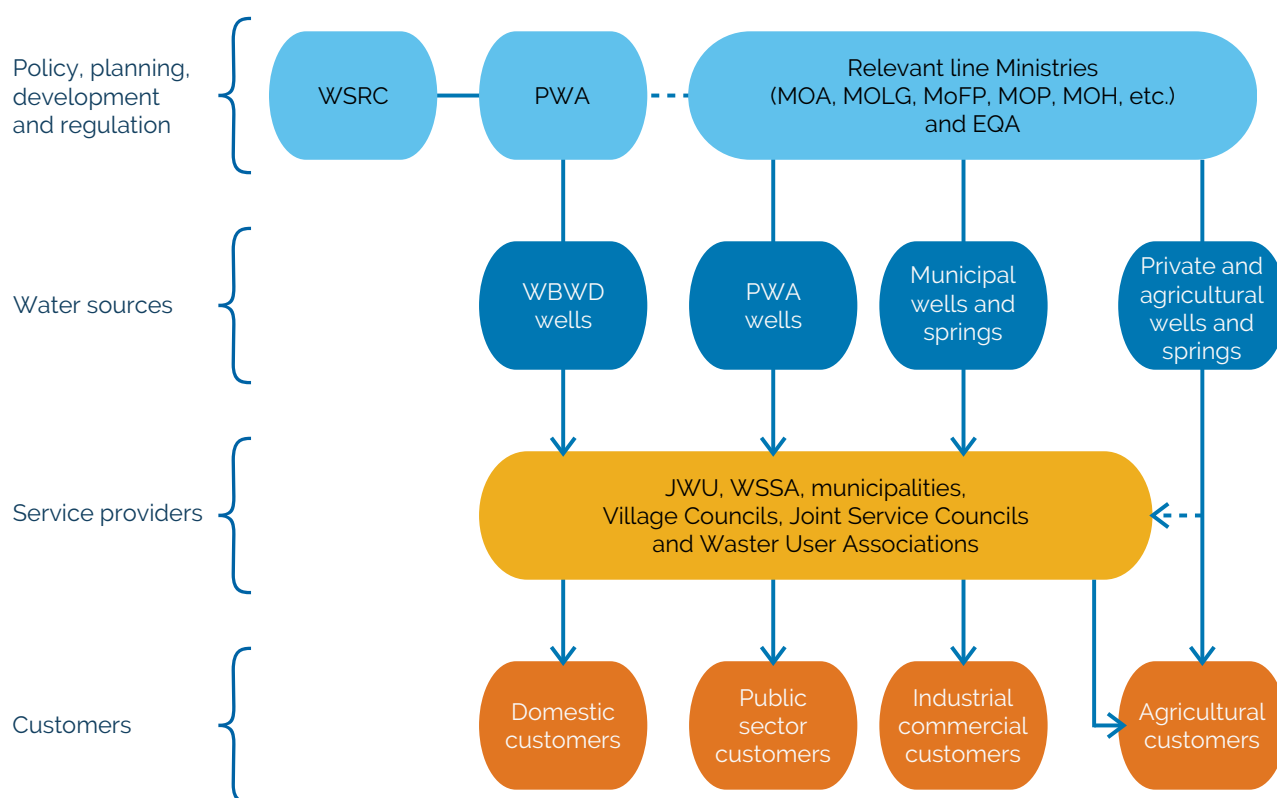
Figure 3.7 Trend in Palestinian Authority Revenues Deducted through Net Lending



Source: Authors' elaboration based on data from the Palestinian Water Authority.

The institutional setup of the water sector has been characterized by fragmentation, weaknesses in accountability, and a lack of coordination among the multiple actors involved (figure 3.8). The institutional arrangements for water sector management in the West Bank and Gaza are invariably influenced by the political context, including the conflict, the resulting restrictions on movement and access, and strong asymmetries in the JWC. This context poses challenges to effective governance and management of the water sector. Historical institutional arrangements and their legal foundations have resulted in jurisdictional issues; in Area C permits are required for the development and management of water. There is a recognized need for an agreed and transparent reform process and related decision-making built on strong sector leadership, institutional and personal willingness to change, and coordination and cooperation, as well as harmonization and alignment of donors and financial institutions.

Figure 3.8 Institutional Arrangements in the Water Sector in the West Bank and Gaza

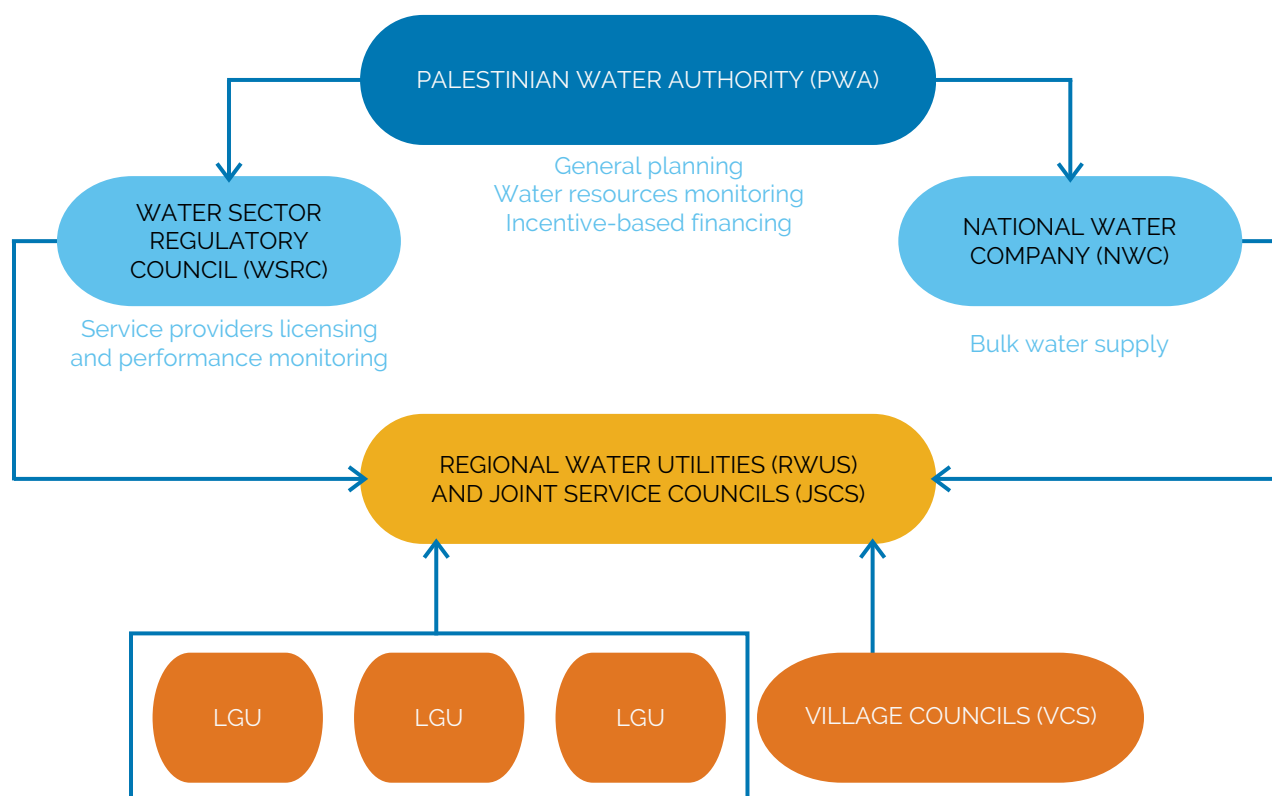


Source: World Bank. 2018. *Toward Water Security for Palestinians: West Bank and Gaza Water Supply, Sanitation, and Hygiene Poverty Diagnostic*. WASH Poverty Diagnostic. World Bank, Washington, DC.

Note: PWA = Palestinian Water Authority; WSRC = Water Sector Regulatory Council; MoA = Ministry of Agriculture; MoFP = Ministry of Finance and Planning; MoH = Ministry of Health; MoLG = Ministry of Local Government; JWU = Jerusalem Water Undertaking; WSSA = Water Supply and Sewerage Authority; EQA = Environmental Quality Authority.

To address the systemic challenges in the water sector, the PA has implemented policies aimed at achieving a transformative and sustainable shift in the sector. In 2014, the PA enacted the Water Law and approved the Strategic Development Plan (SDP) 2022–32. The SDP focuses on enhancing water and wastewater services within a comprehensive framework for developing governance in sector institutions. The activities outlined in the SDP align with the climate change adaptation measures outlined in the PA's NDCs and National Adaptation Plan (NAP). The 2014 Water Law incorporates guiding principles aimed at adjusting and reforming the sector, defining the responsibilities of stakeholders, establishing clear and enforceable accountabilities, and promoting financial independence and self-sufficiency of the service providers (figure 3.9). The focus at the national level is on policymaking, regulation, and bulk water supply. The PWA is responsible for managing water resources in an integrated and sustainable manner and develops general plans, sector policies, and development strategies. The Water Sector Regulatory Council (WSRC), established in August 2014 as an independent legal entity reporting to the Cabinet of Ministers, oversees regulation and monitoring of all matters related to water service providers. The National Water Company is expected to be responsible for bulk water supply. The Water Law calls for consolidation of the existing service providers into regional utilities that are expected to provide water supply and wastewater services at the local level, although these are yet to be established.

Figure 3.9 Institutional Arrangements after Full Implementation of the Water Reform



Source: Author's elaboration based on 2014 Water law (No. 1664)

Note: LGU = local government unit

Future Water Demand

Forecasting future water demand for the West Bank and Gaza is complicated by the complex regional context. Projections must account for the unique socioeconomic characteristics and circumstances of both the West Bank and Gaza, and they must consider the various agreements relating to territorial boundaries and issues relating to land and water access. These agreements and issues determine the PA's entrenched fragility, vulnerability to shocks, and intrinsic dependence on geographical and political factors. Finally, projections need to reflect prospects for improved outcomes due to increased cooperation, which will influence the access to land and water resources, as well as the development, operation and maintenance of water, energy and agriculture related infrastructure.

The *National Water and Wastewater Strategy* is based on planning for a future independent Palestinian state. First published in 2013 and updated in 2023, the strategy assumes that Palestinians will enjoy access and use of land based on the 1967 border and to water resources based on international law. These resources would include surface water from the Jordan River Basin, as well as an additional 200–400 MCM per year of groundwater in the West Bank (320–500 MCM) and the Gaza Strip (70 MCM). The strategy also assumes that the Palestinian people will recover their full access to irrigable land, especially in the Jordan Valley, that the Palestinian administration (at the central and local level) will be fully entitled to plan and implement all necessary water and wastewater facilities in accordance with their own strategic plans, and that there will be no restrictions on the importation of hydraulic equipment (including wells, storage tanks, water and wastewater networks, and wastewater treatment plants). It further assumes that the JWC will be replaced by cooperative mechanisms that will be designed to ensure the sustainable management of transboundary water resources (such as the Jordan River, Wadi Gaza, and groundwater) by a future independent Palestinian state and neighboring

countries (Israel, Jordan, Lebanon, and Syria) based on equitable utilization of the shared water resources. An update of the strategy is expected to be released in 2024.

The strategy recognizes that sustainable management of water resources is vital to the Palestinians' long-term prosperity. It provides the planning and management framework necessary for the protection, conservation, sustainable management, and development of water resources and for the improvement and sustainable management and provision of water supply and wastewater services and related standards in the Palestinian territories. In doing so, it aims to reinforce the PA's approach to sustainable water resources management by ensuring that all agencies work together in the pursuit of shared water resources management goals. It also aims to establish a framework for the coordinated development, regulation, and financial sustainability of water supply and wastewater services to ensure concerted efforts toward improved water systems management, rehabilitation, and maintenance.

Reconciling the projected demand for, and supply of, water in the West Bank and Gaza presents a major challenge for the resilience of the Palestinian people and the economy. Based on the assumptions, the strategy estimates future water demand for water in 2050 at 1,091.2 MCM (table 3.4). This figure represents a significant gap between the current water resources available to the Palestinian people of 462.2 MCM per year. Excluding imports from Israel in 2020, this gap is further increased to 717.7 MCM per year. The 2030 and 2040 forecasts for water demand are based on progressive realization of a fully independent Palestinian state, with additional demand to account for population growth and an increase in agricultural use. If no agreement with Israel is reached on the final status of the West Bank and Gaza, the strategy recognizes that its long-term objectives cannot be achieved and that the constraints imposed by water scarcity will have a significant impact in the West Bank and Gaza, leading them to be designated as water disaster areas.

Table 3.4 Projected Water Demand Based on the National Water and Wastewater Policy and Strategy.

	WATER DEMAND	2010	2020	2030	2040	2050
<i>West Bank</i>	<i>Municipal</i>	85.0	124.1	272	348.0	435.0
	<i>Agriculture</i>	68.8	123.6	127	247.2	367.2
	<i>Total</i>	153.8	247.7	399	595.2	802.2
<i>Gaza</i>	<i>Municipal</i>	97.2	108.5	116	149.0	191.0
	<i>Agriculture</i>	87.0	97.0	98	98.0	98.0
	<i>Total</i>	184.2	205.5	214	247.0	289.0
<i>Total</i>	<i>Municipal</i>	182.2	232.6	388	497.0	626.0
	<i>Agriculture</i>	155.8	220.6	225	345.2	465.2
	<i>Total</i>	338.0	461.7	613	842.2	1091.2

Source: Authors' elaboration based on the National Water and Wastewater Policy and Strategy.

To account for the combined impacts of climate change and different levels of accessibility to available water resources, three scenarios have been used to assess the social and macroeconomic impacts of water scarcity and climate change in West Bank and Gaza. The scenarios take into account the regional realities and national climate priorities. The assessment identifies the benefits of advancing climate resilience and mitigation interventions that are aligned to the West Bank and Gaza's international climate commitments, specifically, attainment of its NDC and the National Adaptation Plan, as well as the costs to society of climate-related damages and their cascading effects under a hypothetical case of no climate action.¹³ The three scenarios are:

- **Continued Fragility**—This scenario assumes a reference case in terms of restrictions in access to resources in Area C and groundwater resources limited to those specified in the interim arrangements in the Oslo II Accords, along with no adaptation or mitigation interventions.
- **Increased Resilience**—This scenario approximates baseline conditions based on business as usual in 2020 and assumes the PA takes action that is within its capacity and in line with commitments in the NDC (e.g., desalination, reuse of TWV, and reductions in nonrevenue water) under the current political conditions.
- **Toward Sustainability**—This scenario is the most optimistic. It assumes the PA acts within its capacity and in line with commitments in the NDC and that it improves cooperation with neighboring countries. It further assumes there are no restrictions in access to resources within Area C, including allocations equivalent to entitlements from the Jordan River.¹⁴

Estimates of projected municipal water demand includes all domestic demand along with 7 percent for industrial requirements (figure 3.10). Demand projections are sensitive to a number of assumptions, particularly population. For consistency with other World Bank publications and economic modeling tools, this analysis relies on the UN population projections, which are significantly lower than those of the Palestinian Bureau of Statistics. According to the UN projections, the West Bank and Gaza are projected to have a population of 9.2 million people by 2050. However, the Palestinian Bureau of Statistics predicts a population 21 percent larger at approximately 11.8 million, which would equate to an increase in total water demand that is 8 percent greater than that based on UN population projections.

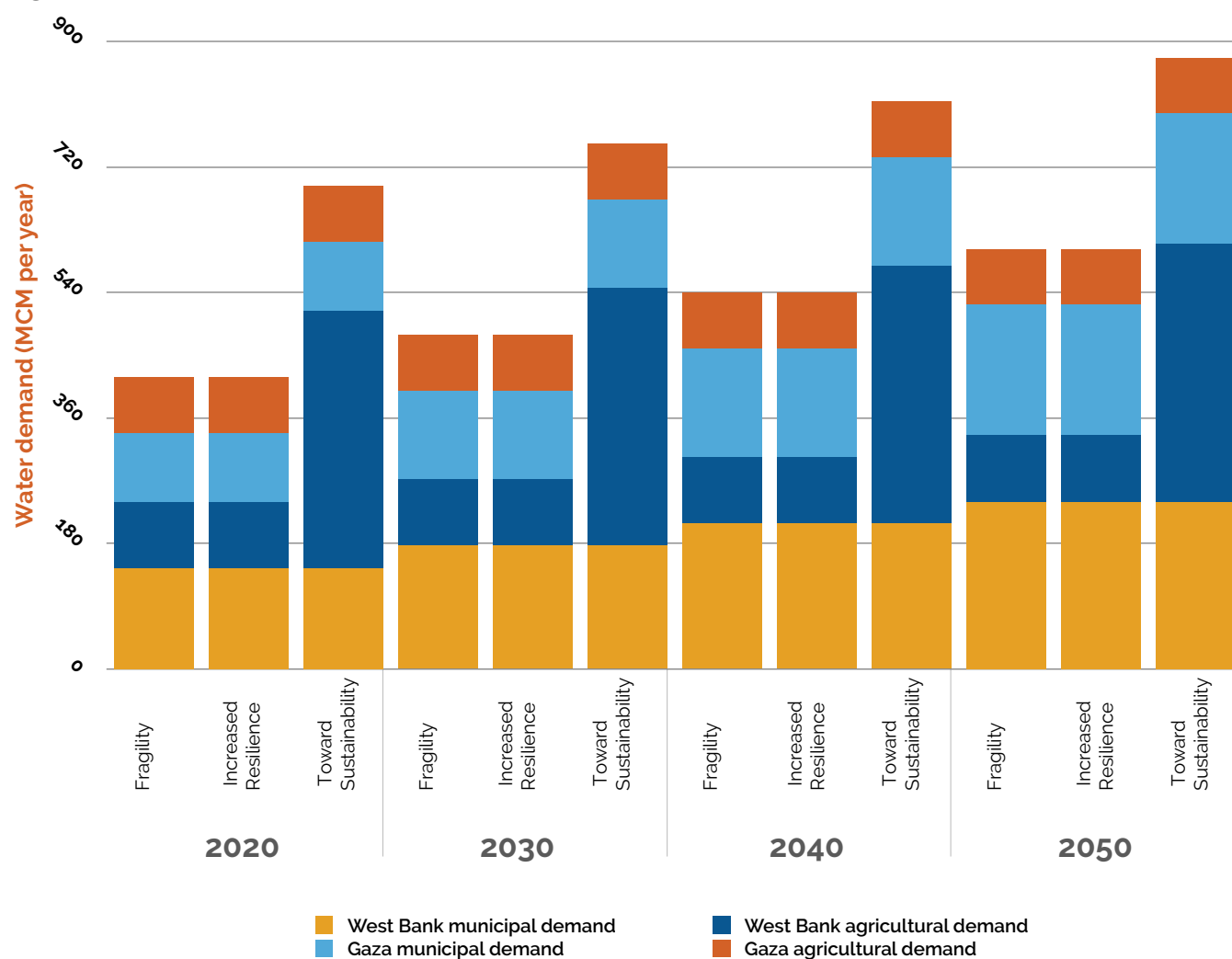
Estimates of municipal demand are equally sensitive to assumptions about per capita consumption. The National Water and Wastewater Sector Strategy and Policy was developed with the objective of providing a basic human right to water of 120 lcd in the West Bank and Gaza. Accordingly, the demand for municipal water in 2020 is estimated to total 239 MCM, including 143 MCM for the West Bank and 96 MCM for Gaza. However, the demand is sensitive to assumptions, and actual water consumption is known to be significantly less, at around 82.4 lcd in West Bank and 91.6 lcd in Gaza, according to PWA data. If per capita consumption is assumed to be 80 lcd, demand in 2020 is reduced to 95 MCM in the West Bank and to 64 MCM in Gaza. If per capita consumption is assumed to be 100 lcd, the estimated demand for 2020 is 119 MCM in the West Bank and 80 MCM in Gaza.

Agricultural water demand includes assumptions about the area of irrigated land and water requirements (figure 3.11). The amount of water required per dunum varies from one place to another and is dependent on rainfall, temperature, quality of soil, and other factors. It also depends on the type of crop being grown and the irrigation technology used (submersion, sprinklers, drip irrigation, and so on). For planning purposes, the Ministry of Agriculture (MoA) recommends an average water requirement of 600 cubic meters per dunum per year (6,000 cubic meters per ha). This requirement reflects the recent and considerable development of drip irrigation (reaching 56 percent adoption). However, to manage water shortages, the MoA supplies only 75 percent of the "normal" water demand (450 cubic meters per dunum per year).



Agricultural water demands are further determined by restrictions on access to land resources. The area of arable land is estimated at 1.2 million dunums (120,000 ha), which amounts to 21 percent of the total area in the West Bank and Gaza. Ninety percent of the arable land is located in the West Bank. Of total agricultural land, the rainfed area accounts for 77 percent and the irrigated area, 23 percent. The MoA estimates that there are 745,000 dunum (equivalent to 75,000 ha) of irrigable land in the West Bank and Gaza, of which 82 percent is in the West Bank. There is little scope for expansion of irrigation in Gaza due to limited land availability and poor water quality. Most of the potential irrigable land in the West Bank is located in Area C, which is fully subject to Israeli military control and only a very small part of which is accessible to Palestinian economic agents. As a result, estimates of irrigated area for the purposes of demand projections in the Continued Fragility and Increased Resilience scenarios are based on current access: 15,800 ha in Area C and 13,500 ha in Gaza. The Toward Sustainability Scenario assumes unrestricted access to Area C, increasing the irrigated area in the West Bank to 61,500 ha. It should be noted that some agricultural wells located inside the residential areas are expected to be taken over for domestic water purposes.

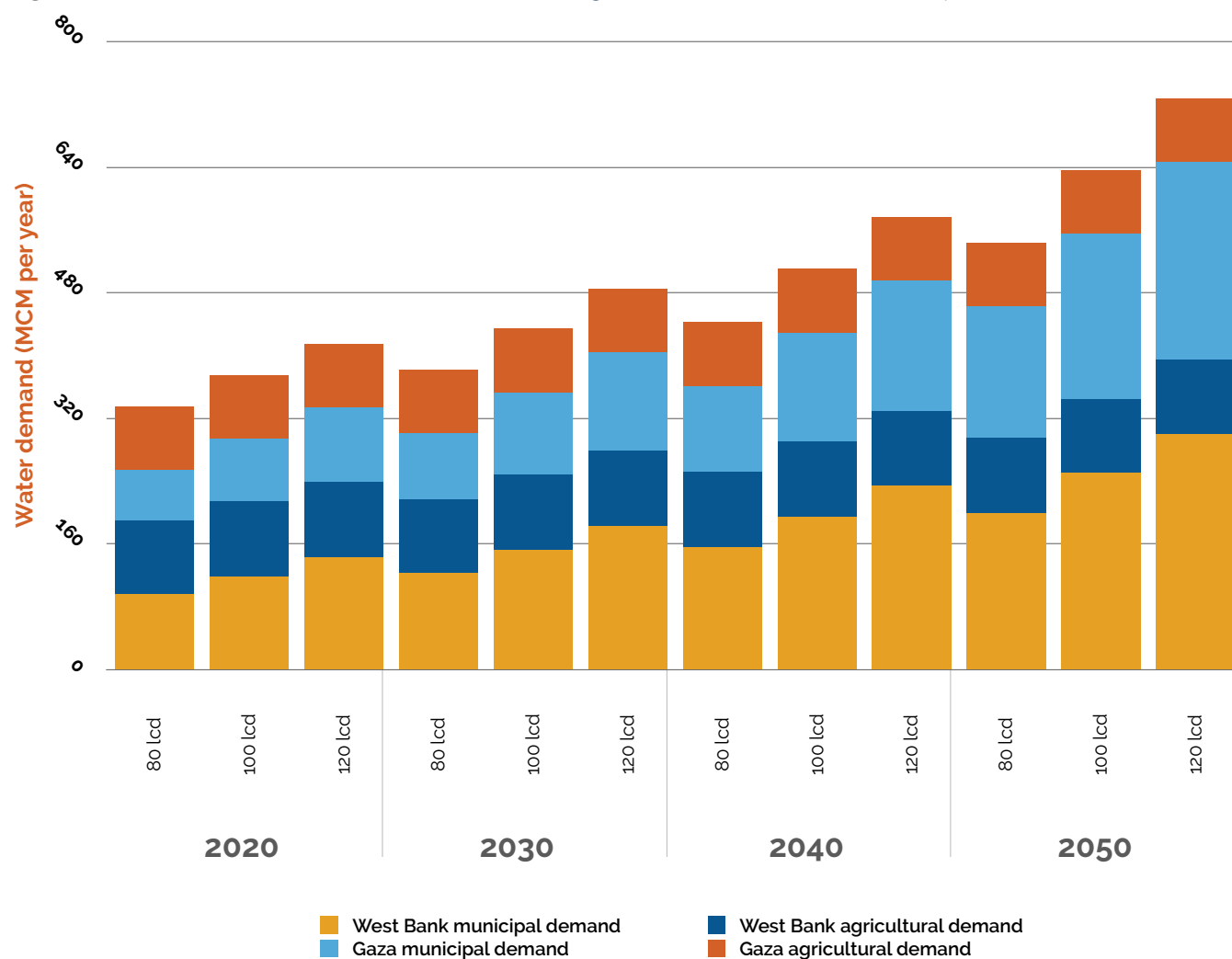
Figure 3.10 Water Demand Projections under Each Scenario



Source: Authors' elaboration based on World Bank data

Note: MCM = million cubic meters

Figure 3.11 Water Demand Projections Reflecting Different Levels of Consumption



Source: Authors' elaboration based on World Bank data.

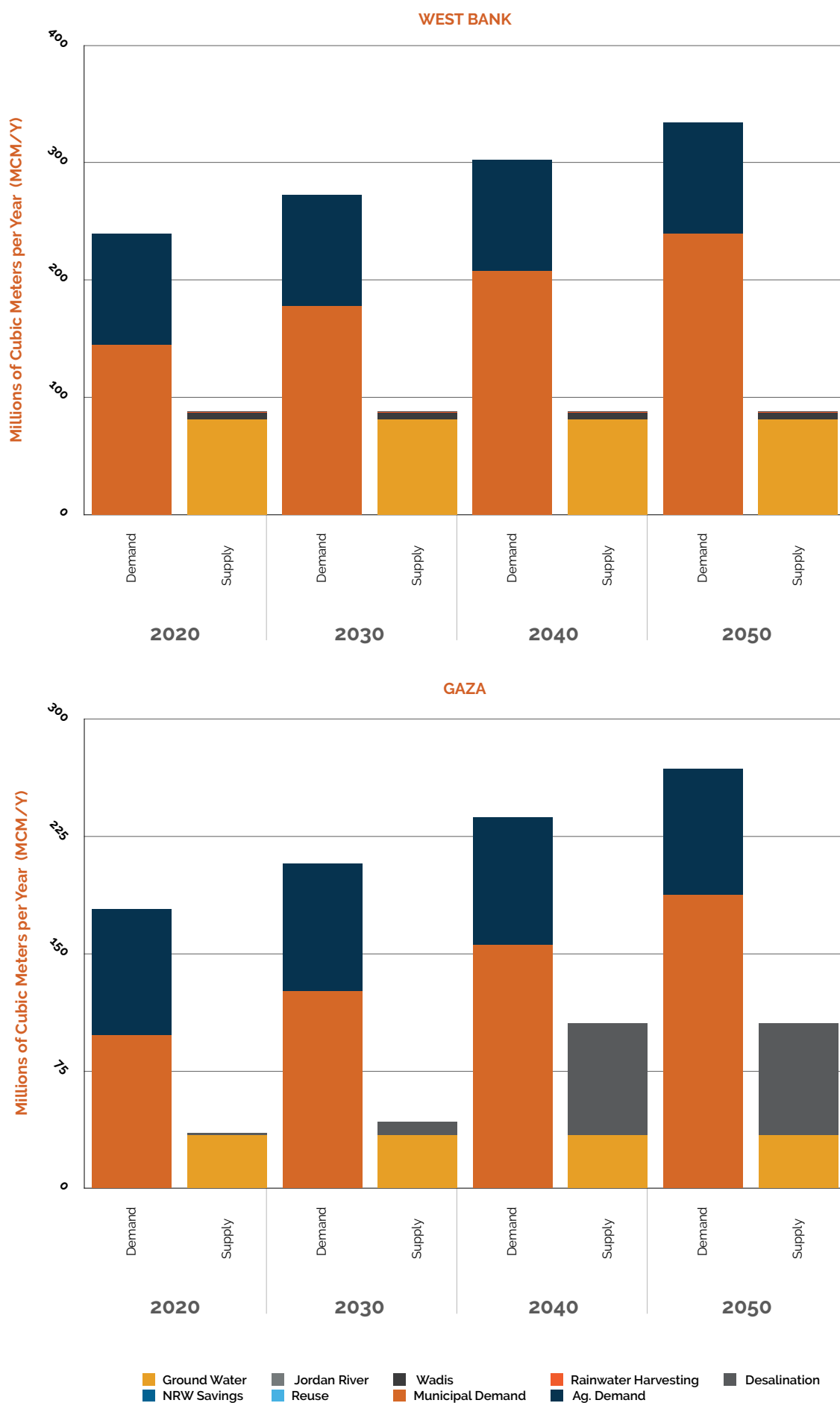
Note: MCM = million cubic meters

Under the Continued Fragility Scenario, where access to water is limited to the interim agreement under the Oslo II Accords (118 MCM of groundwater in the West Bank) and sustainable groundwater yields are assumed in Gaza (55 MCM), the gap between demand and supply is estimated at nearly 300 MCM per year (figure 3.12). This figure is based on the basic human right of 120 lcd, but the gap narrows to some 200 MCM if the per capita consumption is reduced to 80 lcd. The gap is met through a combination of strategies, including over-abstraction of groundwater resources, private suppliers (water tankers, STLV desalination plants, and so on), and imports from Israel.

Considering the projected population growth in the West Bank and Gaza, the demand for water is expected to undergo a significant increase, surpassing 600 MCM per year by 2050. Under the Continued Fragility Scenario, despite efforts to expand Gaza's desalination capacity by 115 MCM per year, there will still be a shortfall of approximately 250 MCM per year in the West Bank and 160 MCM in the Gaza Strip. Within this context, by 2050 Palestinians will be compelled to rely on private vendors and imports from Israel to meet 68 percent of their national water demand. This heavy reliance on external sources will impose a significant economic and financial burden.



Figure 3.12 Water Supply and Demand under the Continued Fragility Scenario



Source: Authors' elaboration based on World Bank data.

Note: MCM = million cubic meters

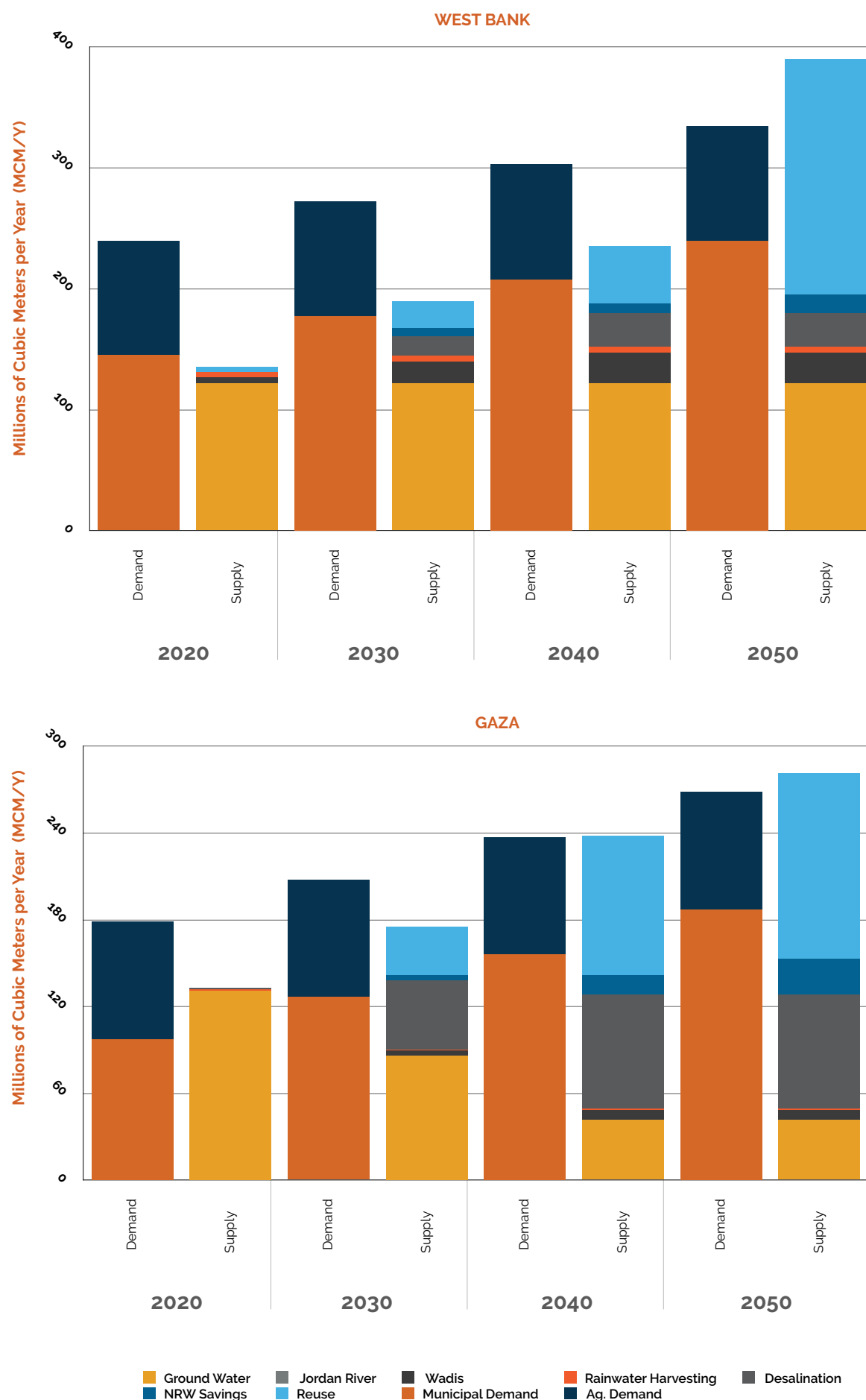
The Increased Resilience Scenario acknowledges the short-term solution to meeting unmet demand through the over-abstraction of groundwater resources, which is sufficient to meet demand under assumptions of low per capita consumption. However, if per capita consumption is assumed to satisfy the basic human needs (120 lcd) and irrigation requirements are met, there is still a gap of roughly 40 percent between demand and supply. This gap is closed through imports from Israel. By 2050, these imports are estimated at roughly US\$96 million.

The forecast for the Increased Resilience Scenario includes a range of actions to increase the production of water, to achieve the goal of sustainable groundwater management and considerably reduce dependence on water imports by 2040 in the West Bank and Gaza (figure 3.13). The actions consider a modest increase in water storage (wadis) and rainwater harvesting capacity in the West Bank, a significant increase of desalination capacity in Gaza, and a large increase in wastewater reuse for agricultural purposes in both regions. It assumes a gradual reduction of the NRW levels in the West Bank and Gaza.

According to the forecast, these actions would significantly reduce the gap between municipal water supply and demand. By 2030, that gap is projected to narrow to 6 percent in the West Bank and be completely eliminated in Gaza. However, by 2040, as groundwater abstraction is reduced to a sustainable level, the municipal gap is expected to widen again. Some 10 percent of demand in the West Bank and 18 percent in Gaza would have to be met by external water resources. By 2050, the increase in municipal water supply would not keep pace with population growth, resulting in a larger gap, which would reach 18 percent in the West Bank and 25 percent in Gaza. Considering the municipal shortage, sufficient development of wastewater reuse schemes would be necessary to meet agricultural demand. However, these schemes are not expected to be sufficiently developed until 2050 in the West Bank and 2040 in Gaza, and the agricultural sector may still face challenges in meeting its water demands until then.



Figure 3.13 Water Supply and Demand under the Increased Resilience Scenario



Source: Authors' elaboration based on World Bank data.

Note: MCM = million cubic meters

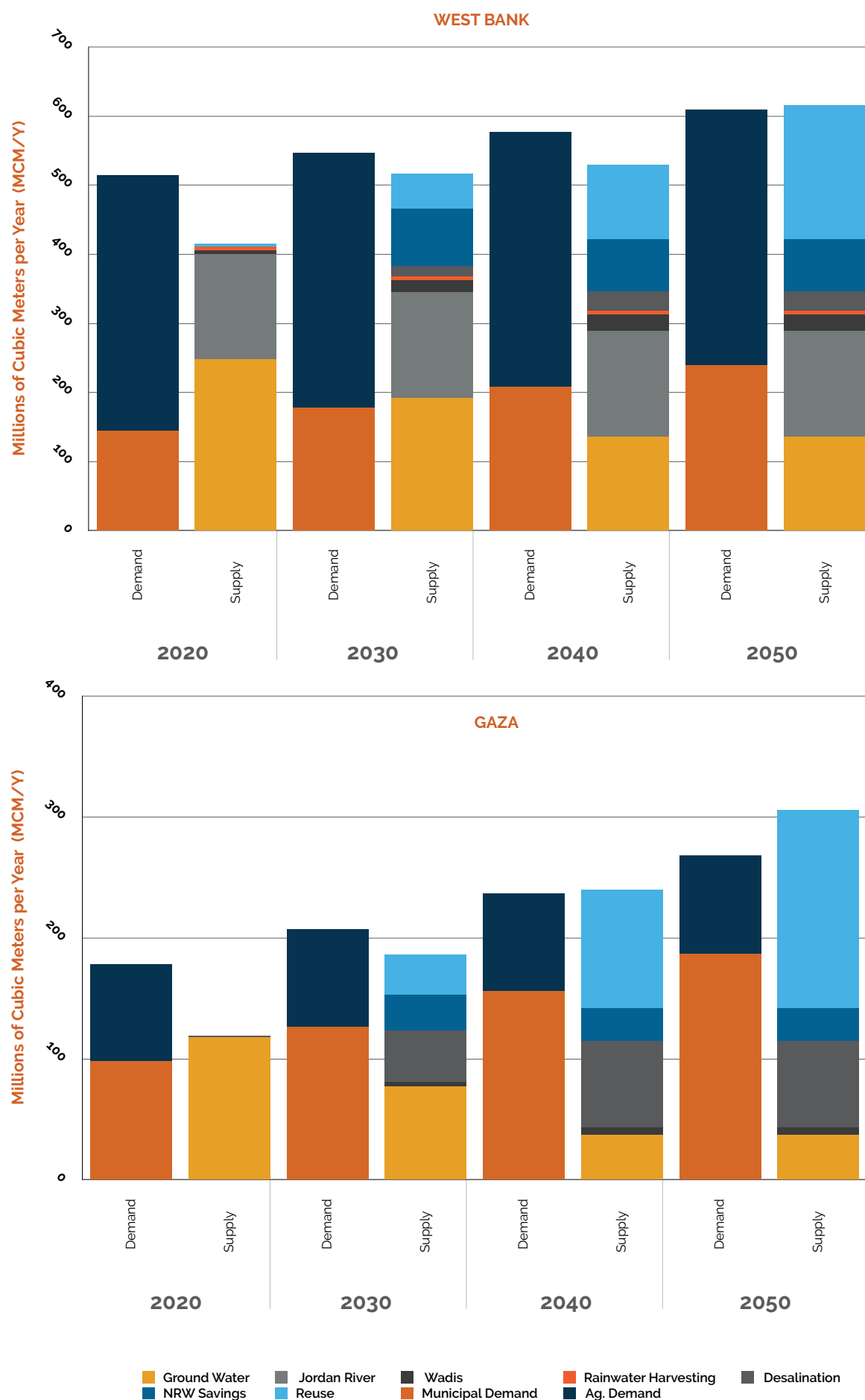
The Toward Sustainability Scenario assumes that the Palestinian people will enjoy access and use of land based on the 1967 border and that they will have access to water resources in accordance with international law (figure 3.14). These resources are assumed to include surface water from the Jordan River Basin (200 MCM per year) as well as groundwater in the West Bank (369 MCM per year) and Gaza (190 MCM per year) until reaching a sustainable yield by 2040. The scenario also assumes that the Palestinian administration will have full authority to plan and implement necessary water and wastewater facilities, allowing for increased water storage (wadis), rainwater harvesting capacity, and desalination as well as wastewater reuse for agriculture. Additionally, the scenario considers a 15 percent reduction in NRW for both the West Bank and Gaza by 2030.

Under these circumstances, the projections for the West Bank indicate that municipal water demand will be met only if access to the Jordan River Basin is allowed and access to the Mountain Aquifer is increased. Under such a scenario, the projected increase in demand by 2050 can be accommodated, and sustainable groundwater abstractions can be achieved by 2040. In Gaza, the initial increase in groundwater access will be enough to meet municipal demand. However, the forecast shows that the increase in desalination capacity and assumed NRW reduction will not fully offset the reduction in groundwater abstraction to the sustainable yield, especially given the demand increase driven by high population growth rates in Gaza. Therefore, by 2040, Palestinians in Gaza would need to rely on external sources to cover 9 percent of municipal demand, increasing to 14 percent by 2050.



Image by Emad El Byed on Unsplash

Figure 3.14 Water Supply and Demand under the Toward Sustainability Scenario



Source: Authors' elaboration based on World Bank data.

Note: MCM = million cubic meters

The Toward Sustainability Scenario assumes access to an additional 48,000 hectares of arable land in Area C, which would have a significant impact on agricultural demand. Despite the increased access to groundwater and the Jordan River Basin, the agricultural demand will not be fully met until 2050, when the increased collection, treatment, and reuse of wastewater will supply approximately 160 MCM per year for agricultural purposes. In Gaza, the same water source will enable agricultural demand to be fully met by 2040.

The total projected water demand increases from 399 MCM per year for the year 2022 to some 688.8 MCM per year for the year 2032. The present demand of 247.7 MCM suggests an additional increase in demand of 441.1 MCM per year, which means an additional supply of this quantity by the year 2032.



Reconciling Supply and Demand and Increasing Resilience

Addressing the gap between projected demand and supply is complicated by uncertainties about future regional circumstances and access to land and water resources. Increasing the access to water resources and addressing demand-side measures would give Palestinians a significantly increased volume of water, which would enable water service improvements (hours of service, pressure, water quality) to be implemented for domestic customers, service coverage to expand to localities not currently connected to the water supply network, and wastewater services to include collection, treatment, disposal, and reuse. Greater access to water resources, coupled with increased access to land, would allow for increased agricultural production and would facilitate the development of economic activities that require water.

Exogenous constraints on access to water resources in the West Bank and Gaza impose serious restrictions on social, political, and economic opportunities. Given that water is an essential input throughout the economy (agriculture, manufacturing, and so on), water scarcity entails multiple cascading and compounding effects. Under the Fragility Scenario, gaps would be closed through a combination of unsustainable strategies, including over-abstraction of groundwater resources, use of private suppliers (water tankers, desalination plants), and imports from Israel. Increasing pressure on access to land and water resources in the West Bank, coupled with deteriorating water availability and quality in Gaza, will continue to undermine the agriculture sector's socioeconomic potential, contributing to very poor growth. Model estimates suggest the cost due to a 25 percent reduction in water availability would range from US\$1.23 billion to US\$1.64 billion per year.¹⁵ Under the Continued Fragility Scenario, the gap between water demand and supply is large and growing, estimated at nearly 300 MCM per year with significant economic cost.

Bridging the gap between demand and supply requires a combination of institutional and regulatory reforms, improved data and information, along with significant infrastructure investments. All future scenarios show the challenges of meeting demand under existing conditions and without considering impacts associated with climate change. Without access to additional water resources envisioned under the Toward Sustainability Scenario, the gap between demand and supply persists. Under such circumstances, there is a risk of over-abstraction and unsustainable use of groundwater resources, suppressing demand among the population and increasing the reliance on imports from Israel. The long-term solution relies heavily on investing in the reduction of nonrevenue water, increasing the collection and treatment of wastewater for reuse in the agricultural sector in the West Bank, and development of desalination in Gaza. These measures need to be coupled with a range of institutional measures, supported by better information, to improve data-driven decision-making.

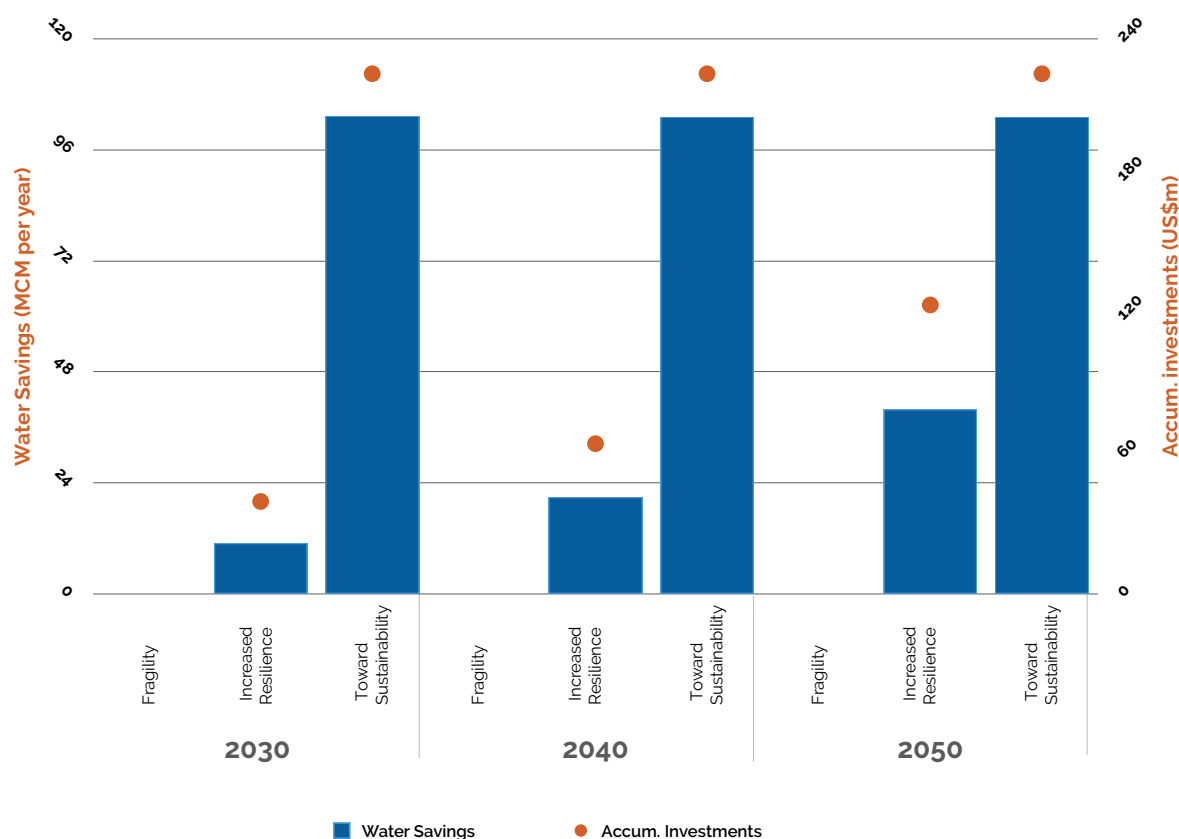
Infrastructure investment requirements are significant but subject to multiple constraints. They include the volatile and evolving regional context, increasing funding constraints, and a lack of sustainable revenues that limit financing opportunities. Given these constraints, there is a need to differentiate the types of investment options available to the PA. First are those investments that rely on access to Area C and require a broader political solution. Second are those that rely on permissions and permits from the JWC and the Israeli administration. Third are those that fall within the control of the PA and that are reflected in the Increased Resilience Scenario. That scenario includes actions that are largely under the control of the PA and that are reflected within the NDC. They include no-regret investments in reducing nonrevenue water and campaigns to reduce consumer demand. These investments need to be coupled with investments in desalination in Gaza and increasing wastewater reuse in the West Bank. However, both of these investments continue to be subject to a number of constraints, including authorizations and permitting during construction, restrictions on movement and supply of materials for operations and maintenance, reliable supplies of electricity, and vulnerability to violent conflict. In the absence of such investments, reconciling the gap between demand and supply will increasingly rely on imports from Israel.

Investments in nonrevenue water provide short- to medium-term options to reduce losses and increase water availability for productive purposes. Notwithstanding the challenges in reducing NRW, the establishment of district metered areas coupled with regular monitoring for leaks and damage can help with early identification and repairs to minimize losses. Water meters need to be installed at strategic points—points informed by water loss management plans—to monitor water supply and demand and to track the system's water flow, pressure, and consumption patterns, allowing identification of potential issues and priority areas to support scheduling for repair and maintenance work.

Intermittent supply and topography present a number of challenges in the West Bank. Pressure management is therefore important to regulate pressure in the network and minimize water losses due to high pressures in the distribution network that can cause water leaks, bursts, and overflows. In those areas with high pressure, pressure reduction stations can be installed to reduce the water pressure and minimize leakage. Implementing smart water management systems, such as Supervisory Control and Data Acquisition, can also help in gathering and analyzing real-time data to monitor and control the flow of water through the distribution network, detect leaks, and reduce NRW by optimizing water use. All of this relies on regular maintenance, including periodic cleaning, inspection, and replacement of parts.

The forecasting exercise for 2050 considers various NRW reduction scenarios and analyzes their potential impact on water supply (figure 3.15). In the Continued Fragility Scenario, which assumes no action is taken and NRW levels remain constant, 33 percent of the water produced in the West Bank and Gaza will continue to be lost. The Increased Resilience Scenario assumes gradual investment of US\$60 million over 30 years to reduce NRW to 25 percent by 2050. This reduction, combined with the planned actions to increase water production, would result in water savings of 10 MCM per year by 2030, 20 MCM per year by 2040, and 40 MCM per year by 2050. The Toward Sustainability Scenario assesses the impacts on the water supply of a 15 percent reduction in NRW by 2030, which would save more than 100 MCM of water annually, assuming the West Bank and Gaza has full access to its water resources. The reduction of NRW in this scenario would require investments of US\$225 million by 2030 to enable the West Bank and Gaza to fully capitalize on the potential savings from reducing NRW. The long-term strategy to meet the growing demand must include actions to reduce NRW. However, the Palestinian experience has shown that these actions can be capital-intensive, particularly when dealing with old networks lacking leak detection systems. The PWA estimates that reducing NRW by one percentage point requires an investment of US\$10 million in the West Bank and US\$5 million in Gaza.

Figure 3.15 Potential Water Savings and Investment Needs for Nonrevenue Water Reduction



Source: Authors' elaboration based on World Bank data.

Note: MCM = million cubic meters.

Investments in new sources of supply are limited and further constrained by regional realities. These challenges are further compounded by the need to reduce the abstraction of groundwater resources to within sustainable levels. In Gaza, the only feasible long-term option relies on the development of desalination capacity. There were multiple short-term, low-volume desalination plants and plans for two-phased development of larger desalination capacity (Gaza Central Desalination Plant—GCDP), which would cover future water demand and relieve pressure on the groundwater resources of the Coastal Aquifer. However, the conflict that started in October 2023 resulted in significant damage to existing infrastructure and introduced considerable uncertainty about more significant investments in the near term. In the West Bank, increased harvesting of surface water resources could yield an estimated 45 MCM per year from the 33 main wadis (table 3.5). There are also plans to augment supply in the West Bank through desalination, but these opportunities remain limited, and the pace of project implementation has been slower than expected during the last 10 years. These plans would need to be complemented with investments in conveyance infrastructure with sufficient hydraulic capacity to transport water to end consumers. Additional storage is also needed to buffer against exogenous shocks.

New sources of supply will have significant socio-economic impacts and implications on financial sustainability of the sector. Desalination is a costly process which is vulnerable to increases in energy prices. Its high cost may lead to increased water prices for consumers, which can further exacerbate issues of water affordability and accessibility. Estimates suggest that in Gaza it can cost up to US\$1.20 per cubic meter of water produced. This high cost has significant implications for the financial sustainability of desalination projects, particularly in Gaza, where the economy is struggling due to political instability and conflict. The cascading implications of these impacts from electricity and water prices, coupled with general inflationary pressures and the compounding impacts of the price of basic staples, can accentuate the social equilibrium if not properly managed. Therefore, it is

important to carefully consider the financial implications of desalination projects and energy–water interdependencies. These need to be weighed against the cost of inaction, which could have severe consequences for public health and well-being given that more than 90 percent of the water is unfit for human consumption and lack of access to clean water has led to waterborne diseases, malnutrition, and other health issues.

Table 3.5 Estimated Available Resource from Wadis in the West Bank

WADI	PROPOSED HARVESTING QUANTITY MCM/YEAR	PURPOSES
<i>Qilt</i>	3.0	Domestic and agriculture
<i>Auja</i>	3.5	Agriculture and artificial recharge
<i>Fara'a</i>	5.0	Agriculture and artificial recharge
<i>Al Mukalak</i>	3.0	Agriculture and domestic
<i>Al Khudera</i>	9.0	Agriculture and domestic
<i>Qana</i>	9.0	Agriculture and domestic
<i>Sarida</i>	9.0	Agriculture and domestic
<i>Al Moqata'a</i>	3.0	Agriculture and domestic

Investments in wastewater reuse and a circulate economy approach will be essential to improving water security in the West Bank and Gaza. The transition from a linear water cycle focused on production, consumption, and discharge to a circular water economy that emphasizes reuse of TW/W will help increase resilience to climate uncertainties and exogenous shocks. Circular economy principles offer an opportunity to recognize and capture the full value of water, to foster sustainable and responsible use of water and energy, and to support the increased productivity of climate-smart agricultural practices. The high network coverage in Gaza prior to October 2023 provided the foundation for furthering investments in upgraded treatment capacity to enable reuse and aquifer recharge, although the damage inflicted during the conflict will require significant investments in rehabilitation and reconstruction. In contrast, the relatively low level of coverage in the West Bank emphasizes the need to focus investments on collection networks, development of treatment plants, and the institutional mechanisms to facilitate the necessary approvals. These resources will help unlock the potential of the agriculture sector by reducing water constraints. In addition, the improved collection and treatment of wastewater in the West Bank will reduce deductions by Israel for untreated wastewater.

Complementary investments in institutional and regulatory reforms are needed to improve the sector's performance and leverage synergies across the nexus. The geographic fragmentation of the West Bank and Gaza is reflected in the many service providers and opaque lines of reporting and responsibilities, resulting in operational and financial inefficiencies that undermine service quality and sustainability as well as water security. Continued support from development partners is needed for institutional measures to improve the sector's overall performance and to develop more effective regulation that can deliver quality services and increase water security. Without improvements in the sector's financial performance, rising demand for water will increase pressure on already-compromised services, affecting the willingness of consumers to pay and adding to the arrears to be recovered through net lending. Strengthening capacity for negotiations and rebalancing asymmetries

in coordination mechanisms will help reduce dependencies on Israel for water, both through purchases from Mekorot and approvals required from the JWC and other Israeli state apparatus. This effort involves establishing a clear framework within the West Bank and Gaza to move toward a more holistic and comprehensive water-energy-food nexus approach.

Improving regional cooperation is increasingly urgent to ensure equity and empower effective collaborative mechanisms that can facilitate robust, sustainable outcomes. The international development community has an important role in supporting these efforts. The interim agreement put in place as part of the Oslo Accords is outdated and no longer fit for purpose. It is time to reassess and renegotiate a more realistic and equitable agreement that is suitable for a post conflict context. Strengthening the PA and PWA to negotiate more equitable and efficient coordination mechanisms and restructuring the joint governance system established under the Oslo Accords could address historical asymmetries and facilitate the rational planning and development of water resources infrastructure. In the interim, the functioning of the Joint Water Committee (JWC) could be enhanced and an independent, third-party arbitrator may help to accelerate decision-making, improve efficiency, and promote equity.

Improved information and data are needed to strengthen decision-making under increasing uncertainty, foster greater awareness, and improve social accountability. Shifting demographic patterns and rapidly changing economic conditions in the West Bank and Gaza, coupled with increasing variability of climate and weather systems, evolving social expectations, and rapidly changing regional conditions, make for a high degree of uncertainty. Thus, data-driven decision-making will become increasingly important to address systemic risks and exogenous constraints to the development, operation, and management of water. These risks and constraints can result in cascading and compounding impacts across sectors, with significant social and economic consequences. Reliable information systems, coupled with real-time communication systems, can strengthen the social compact, increasing consumers' awareness of the value of water and increasing service providers' accountability (box 3.2).

Box 3.2**THE ROLE OF PUBLIC AWARENESS IN THE CONSERVATION OF WATER RESOURCES**

Given continued population growth in the West Bank and Gaza, water consumption will significantly increase. However, the limited availability of water resources in the region has inculcated a strong cultural awareness of the need for water conservation, and consumption per capita is extremely low. The Palestinian Water Authority (PWA) estimates that the average Palestinian consumes approximately 80 liters of water per day, which falls below the basic human right recommendation of 120 liters per capita per day (lcd). Nonetheless, the population in West Bank and Gaza can still play a crucial role in water conservation.

To achieve this goal, the World Bank-funded Water Security and Resilience Program promotes water conservation. It will provide financial support for a public awareness campaign (PAC)

1. Emphasizing the importance of responsible water use to enhance resilience against droughts and other climate-related impacts;
2. Highlighting the connections among health, hygiene, water, and wastewater;
3. Providing information on the roles of the PWA and local government units in delivering safe water services; and
4. Emphasizing the significance of timely bill payments for the maintenance and expansion of these services.

The PAC will particularly target youth and explore opportunities to increase women's involvement in public awareness and communication efforts. By cultivating a culture of water conservation, public awareness can help reduce water wastage, increase bill collection rates in the water sector, and curb nonrevenue water levels.

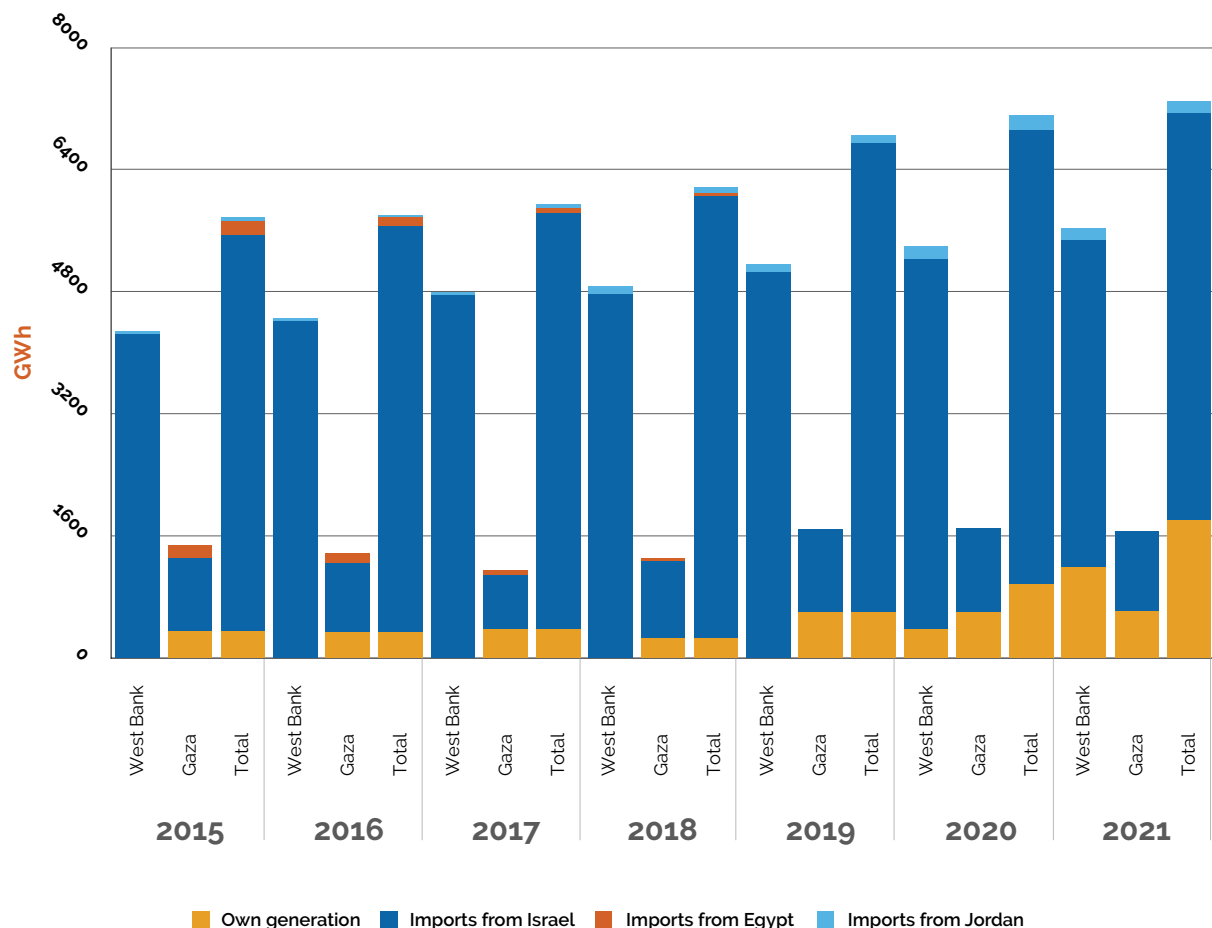


THE ENERGY SECTOR

The energy sector in the West Bank and Gaza is characterized by underserved demand and a reliance on imports. All areas across the West Bank and Gaza suffer from power shortages, with poor quality of available supply and increasingly frequent load shedding. The limited power supply is rationed through rolling blackouts, which have increased in duration in Gaza, where the available power supply meets less than half the demand, and in frequency in the West Bank, where power shortages have been experienced during peak winter and summer months (Badieli et al. 2017). These shortages have significant implications for energy, water, and agriculture in the West Bank and Gaza, where access to energy and water is limited and often unreliable, and compounded by constraints on land resources. The interdependence of these resources means that any changes in one can have significant impacts on the others, making it essential to address the energy-water-agriculture nexus in an integrated and sustainable manner.

The severe deficiency of power supply is rooted in the energy sector's deep dependence on Israel. This dependence is exacerbated by increasing demand, coupled with insufficient investment, institutional and financial challenges, various restrictions, and a lack of regular maintenance. In the West Bank, electricity demand has grown to nearly 1,300 megawatts (MW), more than 95 percent of which is provided by Israeli imports. In Gaza, demand routinely exceeded 500 MW prior to the onset of the conflict in October 2023, while supply was typically 180–200 MW. Domestic electricity supply in Gaza is provided primarily by the diesel-fired Gaza Power Plant, which has a capacity of 140 MW (normal operation is at 60–80 MW due to fuel constraints), and by imports from Israel Electric Corporation (IEC), which provides up to 120 MW. Consequently, electricity is available for only 5–15 hours per day. In addition, Egypt supplies 17 MW of electrical power to Gaza; 20 MW is supplied to Jericho by Jordan's state utility firm (figure 3.16).

Figure 3.16 Main Sources of Electricity in the West Bank and Gaza, 2015–21



Source: Original based on Palestinian Bureau of Statistics data.



Image by Ahed Izhiman

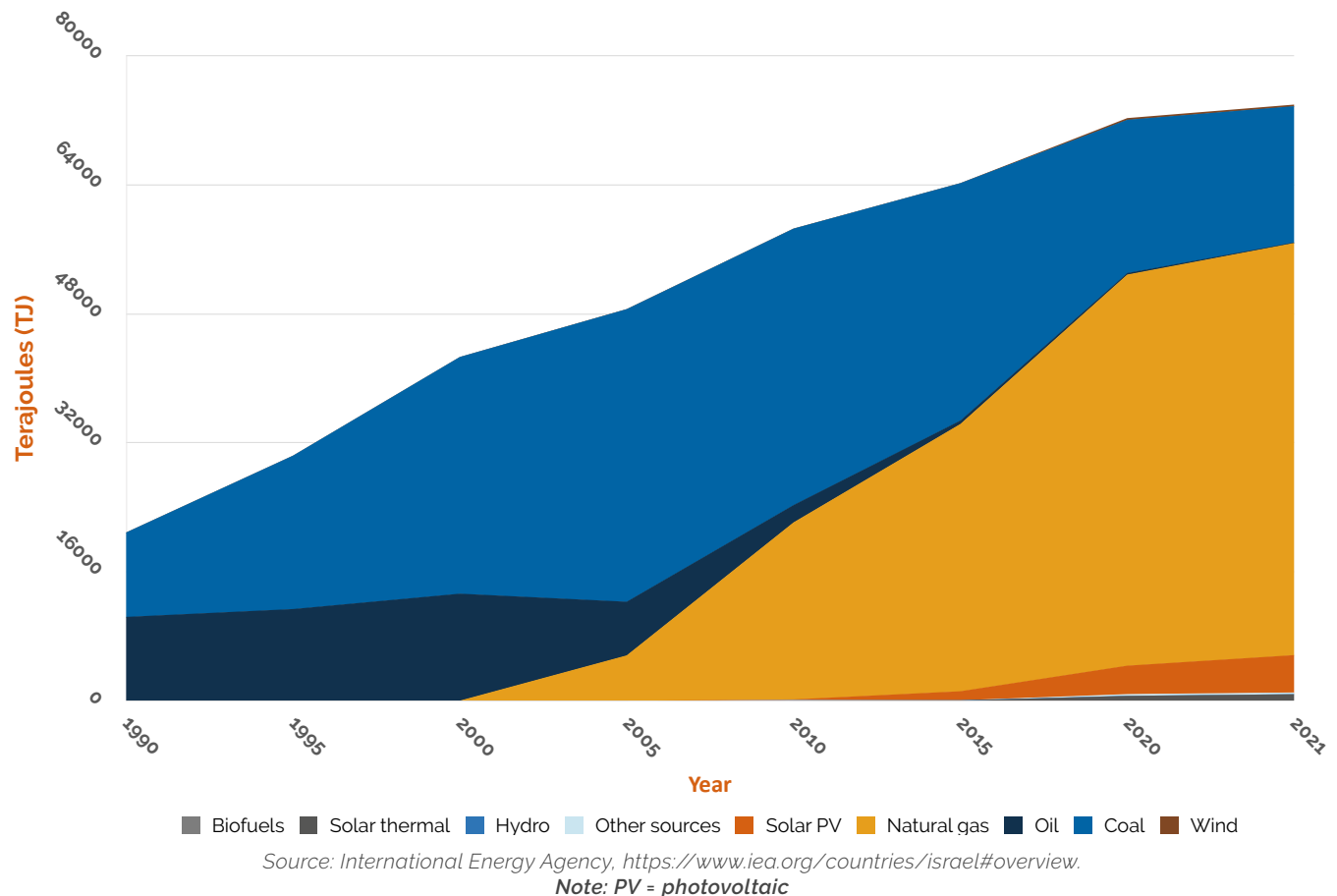
The West Bank and Gaza not only imports most of its electricity from Israel but also uses the same transmission infrastructure. Until 2020, Israeli power was provided by 270 low- and medium-voltage connection points between Israel and the West Bank, with a total contracted capacity of 890 MW. In Gaza, 10 connection points with Israel provide 120 MW of capacity. These points provide electricity through distribution companies (DISCOs) and LGUs, and each connection point is billed directly to the relevant DISCO or LGU. In addition, a few connection points directly serve private, mostly industrial, customers who are also billed directly. The supply is entirely managed by IEC, with minimal commercial and service quality agreements, and the Palestinian Electricity Transmission Company (PETL) along with the DISCOs/LGUs having limited ability to monitor and manage the quantity and quality of supply. These technical challenges, coupled with constraints in transmission and distribution, result in frequent localized power interruptions.

The energy sector also suffers from financial and operational challenges that accentuate the energy supply challenges. Geographical, operational, and financial fragmentation across the electricity supply chain continues to hinder sustainability. Electricity costs for Palestinians are among the highest in the region, and the energy sector in the West Bank and Gaza faces significant challenges due to limited access to resources, infrastructure, and funding. With domestic electricity production fulfilling only 7 percent of consumption in the West Bank and Gaza, the NDC focuses on energy distribution, energy efficiency, and renewable energy production (primarily from solar photovoltaic [PV]). All of these efforts have significant adaptation co-benefits. Although the overall collection rate from general consumers (residential, commercial, and industrial) is high at between 80 percent and 90 percent, there have been persistent challenges in addressing the energy needs of and recovering costs from nonpaying consumers (e.g., people in refugee camps); the collection rate for these consumers can be as low as 18 percent. There are significant opportunities to scale up renewable energy distribution to improve supply security and independence, mitigate climate impacts, and improve services at lower cost to economic sectors and residents.

Energy Resources

Existing energy resources available to the West Bank and Gaza are heavily dependent on Israel for energy generation, the vast majority of which comes from fossil fuels (figure 3.17). More than 90 percent of the 73,960 gigawatt hours (GWh) generated in 2020 derived from power stations fueled mostly by gas (67 percent) and coal (26 percent) (IEA n.d.). Renewable energy accounted for a minor share of electricity production; installed solar PV capacity was roughly 3,525 GWh in 2020. For domestically generated power, the West Bank and Gaza also relies heavily rely on fossil fuels; only 80 MW are generated from renewable (solar) energy in the West Bank.

Figure 3.17 Electricity Generation by Source in Israel, 1990–2021

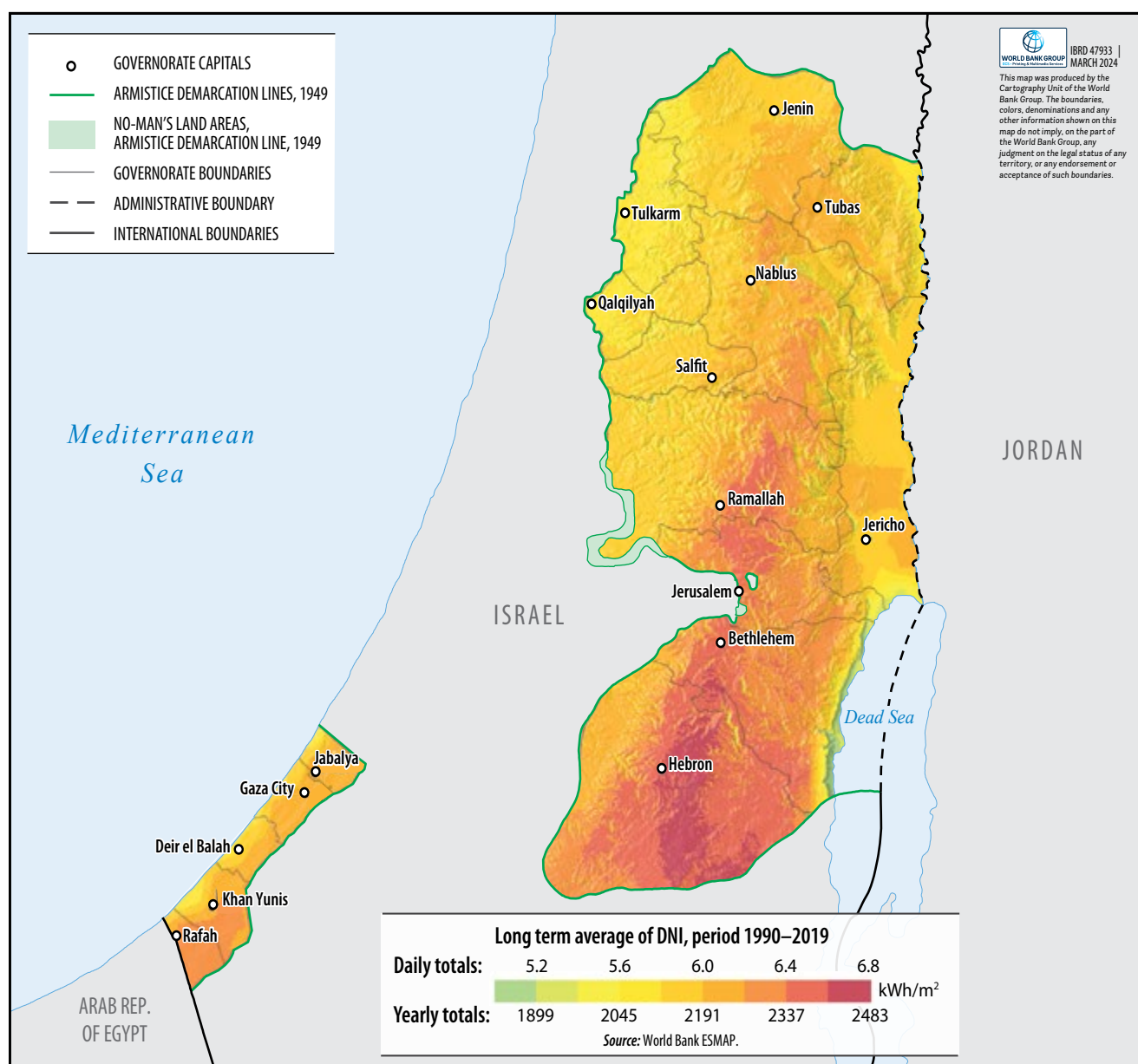


Renewable energy resources have the potential to play a significant role in addressing the power deficit while increasing its energy security and reducing the cost of generation. The National Renewable Energy Action Plan for the period 2020–30 aims to increase the contribution of renewable energy to electricity generation in the West Bank and Gaza to 10 percent. Of this amount, 80 percent is projected to come from solar PV, 10 percent from wind energy, and 10 percent from biogas/biomass. To meet this strategic target, 500 MW of renewable energy must be installed by 2030.

The NDC identifies a number of important actions relating to the energy transition, including upgrading the grid to enable distribution of renewable energy, primarily from solar PV, by 2030; improving energy efficiency by 20 percent (versus business as usual) across all sectors by 2035; and ensuring 20–33 percent of electricity is generated from renewable energy by 2040, primarily from solar PV. The Renewable Energy and Energy Efficiency Law of 2015 (Decree No. 14) outlines the mandates of the Palestinian Energy and Natural Resources Authority (PENRA), Palestinian Electricity Regulatory Council, and Palestine Electric Company (PEC). It defines PENRA as the policymaking institution responsible for preparation and implementation of the energy strategy. PENRA, with the technical support of PEC, is responsible for identifying areas of high renewable energy and energy efficiency potential, which will be prioritized for development of renewable energy installations and energy efficiency measures.

Renewable solar energy provides the most significant opportunity to bridge the deficit and increase resilience to exogenous constraints. The West Bank and Gaza is estimated to receive about 3,000 hours of sunshine every year, an average of 8.2 hours daily (map 3.4). This sunshine makes it suitable for investing in solar energy (Hamada and Ghodieh 2021). The technical potential in the West Bank is estimated to be 530 MW of rooftop solar PV⁵ and at least 100 MW of utility-scale solar in Area A and Area B. In contrast, Area C has vast potential for solar energy development that could be unlocked through enhanced regional cooperation (see box 3.3). If only 3 percent of the land in Area C was used for utility-scale solar production, more than 3,000 MW could be built. The technical potential in the West Bank is estimated to be 530 MW of rooftop solar PV; the technical potential of utility-scale solar in Area A and Area B is estimated at a minimum of 100 MW. Area C terrain is relatively flatter than Area A and Area B terrain, which is mountainous; Area C terrain is suitable for 3–10 MW of ground-mounted solar PV-based power generation. Nevertheless, the significant challenges associated with securing approval, permits, and clearances for the design through construction stages of solar and other infrastructure projects in Area C poses significant challenges to using this resource in a cost- and time-effective manner. This is a significant lost opportunity for increasing independence, diversification, and energy security for the West Bank and Gaza energy sector.

Map 3.4 Normal Direct Irradiation in the West Bank and Gaza



Source: World Bank ESMAP.

The West Bank and Gaza have significant potential for wind power generation. The West Bank has several areas with high wind speeds, including the northern and central mountain ranges, the Jordan Valley, and the eastern slopes of the Hebron Hills, with an estimated potential of 1,200 MW of wind power. Gaza has high wind speeds due to its proximity to the Mediterranean Sea; its estimated wind power potential is 120 MW, according to PENRA. But development of wind power in the West Bank and Gaza has been limited due to regional conditions, lack of investment, and limited infrastructure. There are ongoing efforts to promote renewable energy development, including wind power, to improve energy security and reduce dependence on imported fossil fuels.

Box 3.3

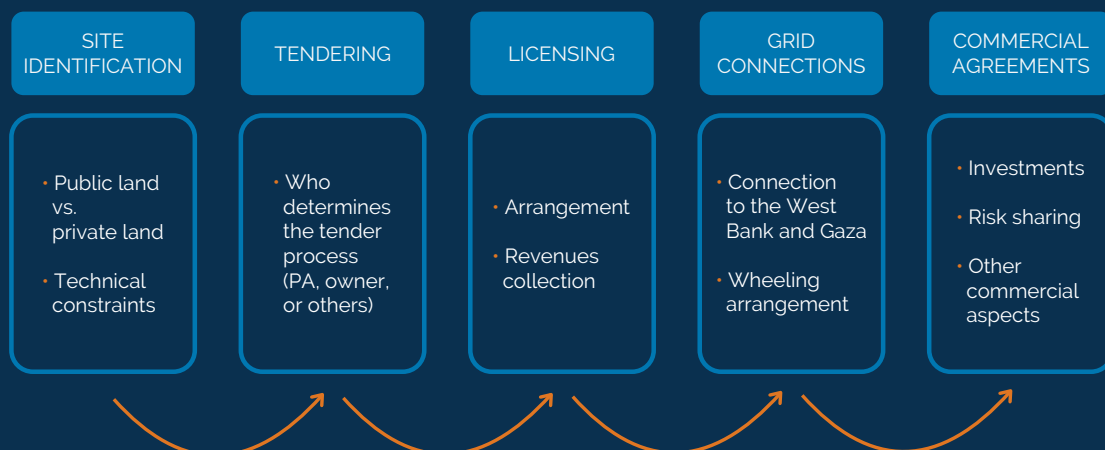
UNLOCKING RENEWABLE ENERGY POTENTIAL IN AREA C

Enhanced regional cooperation could unlock Area C's vast potential for solar energy development. Over 3,000 MW of generating capacity could be built on just 3 percent of the land in Area C, while Areas A and B have the technical potential to generate about 530 MW from rooftop solar panels and at least 100 MW from utility-scale solar plants. Area C's terrain is also flatter than in Areas A and B, making it suitable for medium scale 3-10 MW ground-mounted solar PV generation. Nevertheless, the significant political challenges associated with securing approvals, permits, and clearances from the design through the construction stages inhibit investment in solar and other infrastructure projects in Area C that would increase the independence, diversification, and security of the energy sector in the West Bank and Gaza.

The PA submitted a permit application in 2022 for a number of solar PV sites located in Area C. Around the same time, a Gol survey identified 23 sites in Area C that would be viable for Israeli use, including use by the Israeli settlements in Area C. The uncertain and lengthy processing times for PA permit applications, combined with Israel's intention to develop energy resources in Area C poses a number of challenges to the water-energy-food nexus in the West Bank.

Following a practical and scalable approach would help to identify and address project-specific challenges. The draft International Community Common Position Paper for Developing the Renewable Energy Sector in the West Bank proposes a set of parameters for investment projects. However, this approach does not deal with the more binding higher-level challenges involving regulations and permitting, highlighting the crucial importance of dialogue and negotiations.

Parameters for practical and scalable approach at project level



Energy Demands

The interdependence of energy, water, and agriculture will continue to drive the projected increase in demand for electricity. The Palestinian Central Bureau of Statistics and the Master Plan for Electricity Generation and Transmission for the West Bank show that demand for electricity in the West Bank is projected to increase by 3.5 percent annually, reaching an estimated 8,779 GWh by 2035 (table 3.6). Projected growth in Gaza was higher prior to the conflict, at about 8 percent, due to the growing population, reconstruction efforts after the damage in 2014 and 2021, and expansion of economic activities (table 3.7). The projected demand is expected to reach 6,050 GWh (peak load of 1,063 MW) by 2035; this demand reflects provisions to meet projected (energy-intensive) desalination capacity. With demand for electricity in the West Bank and Gaza expected to double by 2035, the interdependence of energy, water, and agriculture is increasingly recognized as a key challenge for policymakers.



Table 3.6 Energy Demand Forecast for Areas of Service in the West Bank

AREA	JENIN AND TUBAS	TULKARM AND QALQILYA	NABLUS, SALETT, ATARA, AND RAMALLAH	JERICO	BETHLEHEM AND AL-EIZARIYA	HEBRON, HEBRON 2, AND TARQUMIYA	WEST BANK
YEAR	DEMAND						
	GWH	GWH	GWH	GWH	GWH	GWH	GWH
2022	733	545	1,613	175	813	1,106	4,985
2023	766	562	1,687	184	858	1,153	5,209
2024	800	581	1,764	193	906	1,203	5,447
2025	698	720	1,865	204	957	1,257	5,700
2026	728	738	1,919	209	985	1,310	5,890
2027	762	758	1,990	292	954	1,367	6,124
2028	1,063	785	1,833	303	994	1,430	6,408
2029	1,109	806	1,904	316	1,036	1,497	6,668
2030	1,158	829	1,902	457	1,029	1,569	6,944
2031	1,217	858	1,991	479	1,081	1,650	7,276
2032	1,280	889	2,084	502	1,134	1,736	7,265
2033	1,373	920	2,154	527	1,191	1,826	7,991
2034	1,444	952	2,255	552	1,250	1,922	8,375
2035	1,520	985	2,359	579	1,312	2,024	8,779

Source: Palestinian Bureau of Statistics

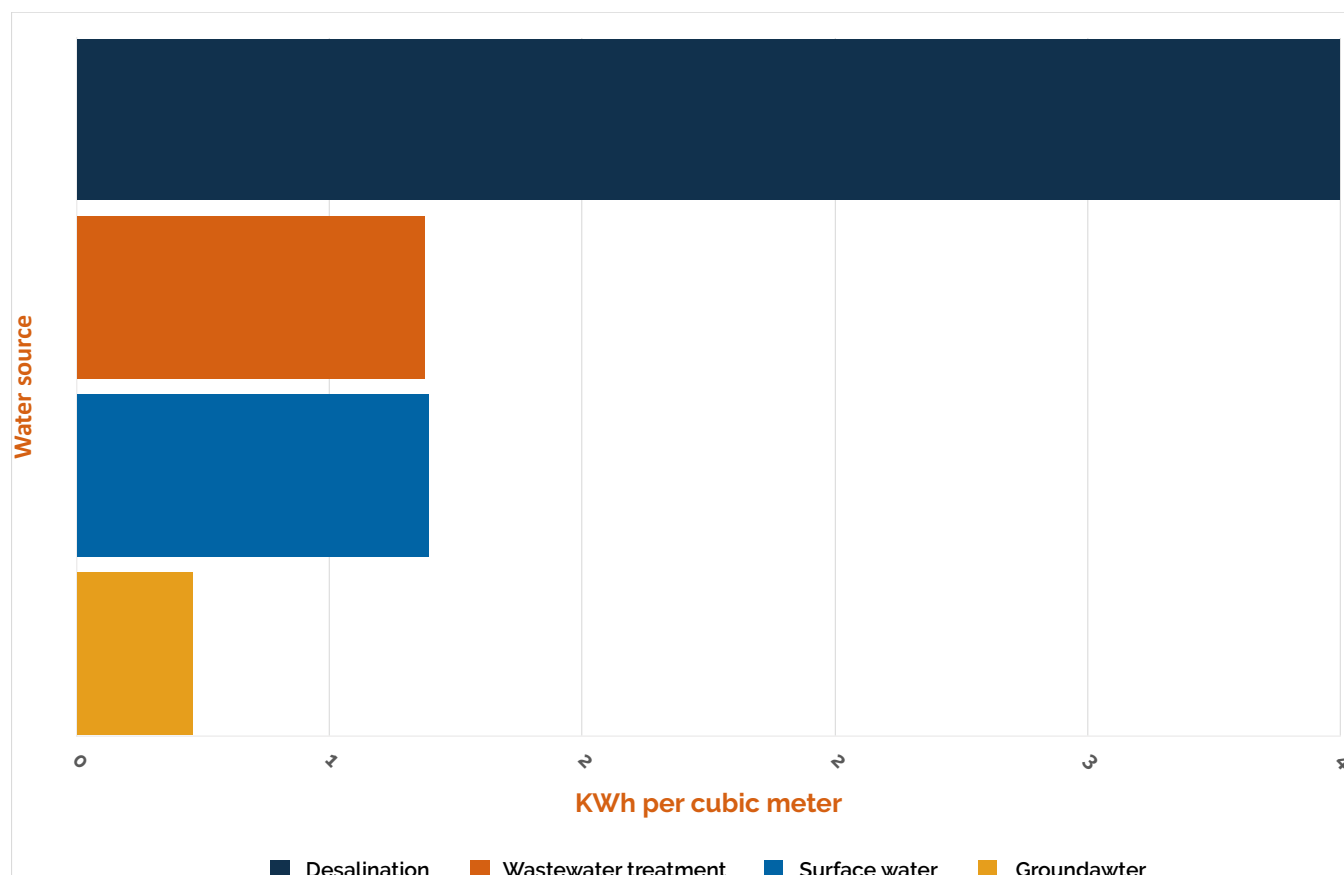
Table 3.7 Energy Demand Forecast in Gaza

GAZA	PEAK LOAD (MW) MEDIUM FORECAST		DEMAND (GWH) MEDIUM FORECAST	
2017	Peak demand (MW)	550	Energy (GWh)	2,650
2035	Peak demand (MW)	1,063	Energy (GWh)	6,050

Source: Palestinian Bureau of Statistics

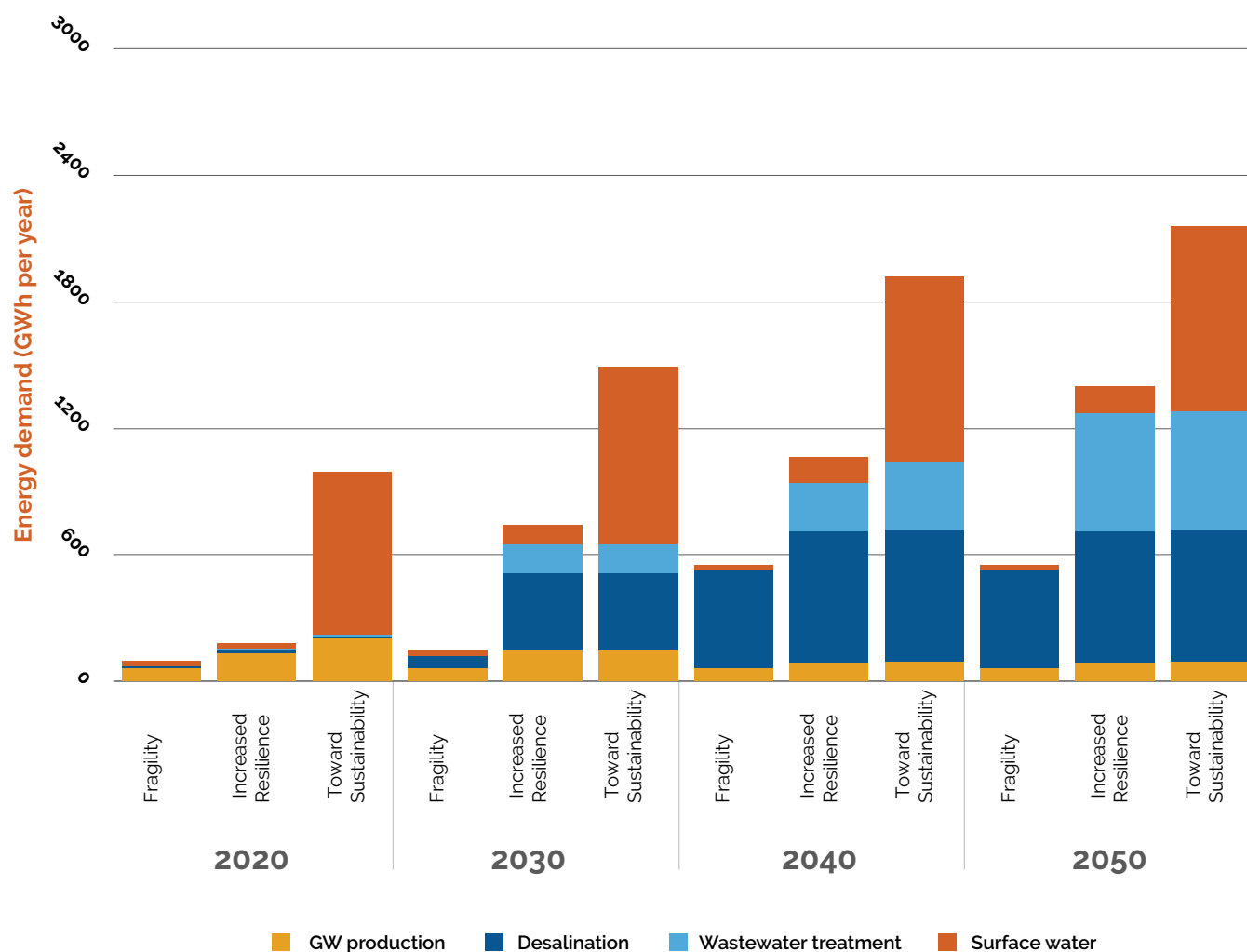
Understanding the key drivers of energy demand and interdependence of energy, water, and agriculture allows for identification of opportunities for energy savings and strategies to improve the efficiency and sustainability of the nexus. For example, the water sector is a significant consumer of energy, with energy consumption accounting for a significant portion of the sector's operating costs. The energy required to abstract, treat and distribute water depends on the source of water and technology employed (figure 3.18). By understanding the key drivers of energy consumption in the water sector, it is possible to identify opportunities for energy savings and to develop strategies to improve the efficiency and sustainability of water systems. Similarly, it is possible to identify opportunities for energy savings and to develop strategies to improve the efficiency and sustainability of agricultural systems. For example, the introduction of solar PV can reduce the costs of and increase access to groundwater resources, while reducing the carbon footprint of agricultural systems, although they need to be properly regulated to avoid driving an increasing abstraction. Drip irrigation systems can also significantly reduce energy demand by delivering water directly to the roots of plants, thus reducing the need for pumping. The total energy requirements for each scenario were assessed based on projected sources of water to explore opportunities across the nexus (figure 3.19).

Figure 3.18 Energy Required to Produce One Cubic Meter of Water



Source: Authors' elaboration based on World Bank data.

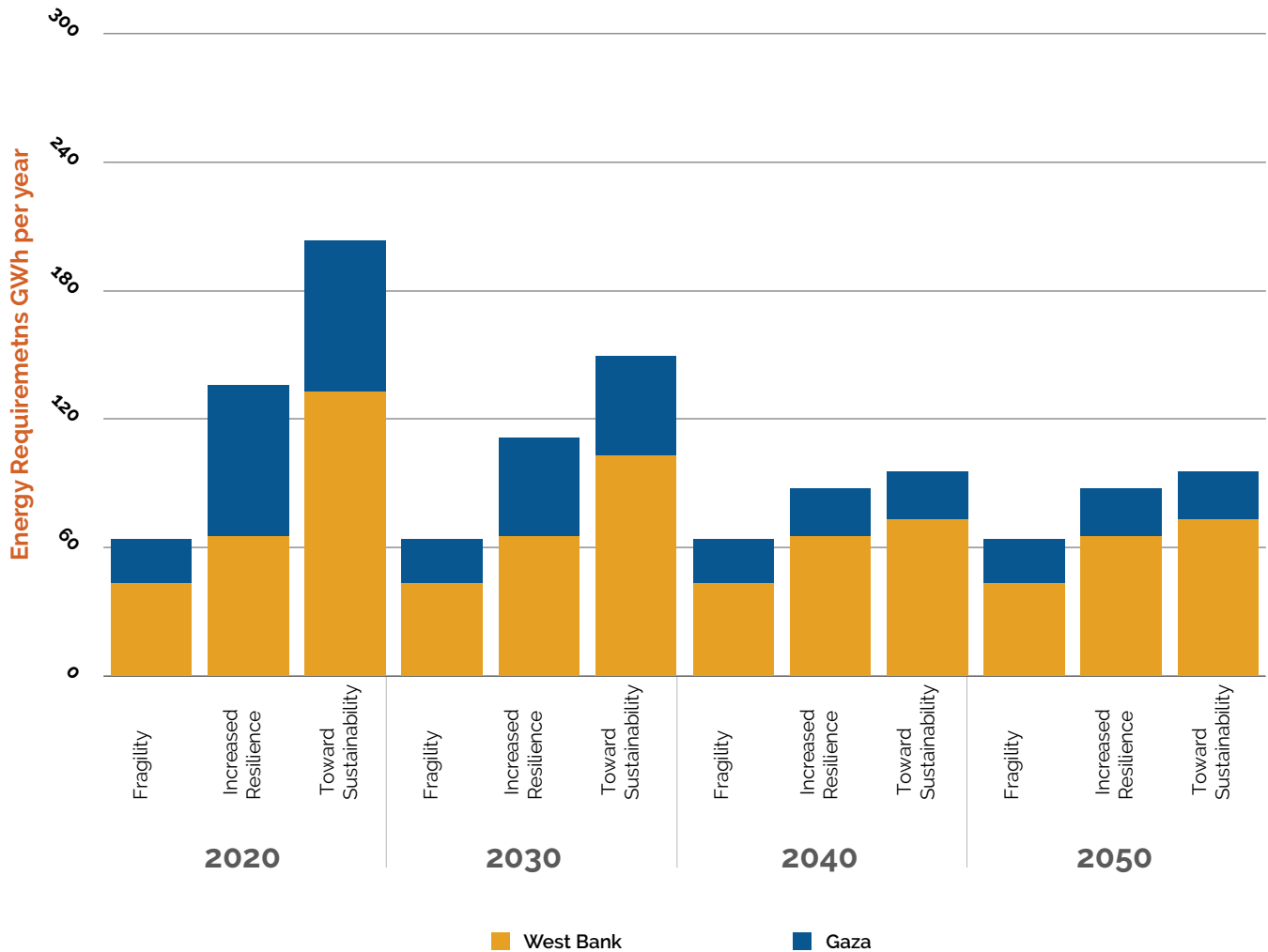
Figure 3.19 Energy Demands of Water Production by Scenario.



Source: Authors' elaboration based on World Bank data.

One of the major drivers of energy demand is reliance on groundwater abstraction. The amount of electricity used in groundwater abstraction depends on various factors, including the depth of the well and the water table, along with the amount of water needed and the size and efficiency of the pump. On average, a typical residential well pump uses between 500 watts and 2,500 watts of electricity; larger commercial pumps can use 10,000 or more watts. The total amount of electricity used in groundwater pumping also depends on the frequency and duration of pumping, which can vary depending on water demand and groundwater availability. The energy requirements and pumping costs for groundwater can be significant, particularly as water tables continue to decline and the need to pump from deeper levels increases. Additionally, pumping from deeper levels can lead to increased salinity and contamination of groundwater, which can have negative impacts on the environment and human health. Therefore, it is important to carefully consider the cost of pumping groundwater for agriculture and to explore alternative solutions, such as rainwater harvesting and conservation measures, that can reduce demand for groundwater and make its use more sustainable in the long term. Based on energy consumption associated with groundwater abstraction in 2020, the projected demand for electricity associated with groundwater abstraction is estimated to increase to 87.5 GWh per year by 2050 under the Increased Resilience Scenario (figure 3.20).

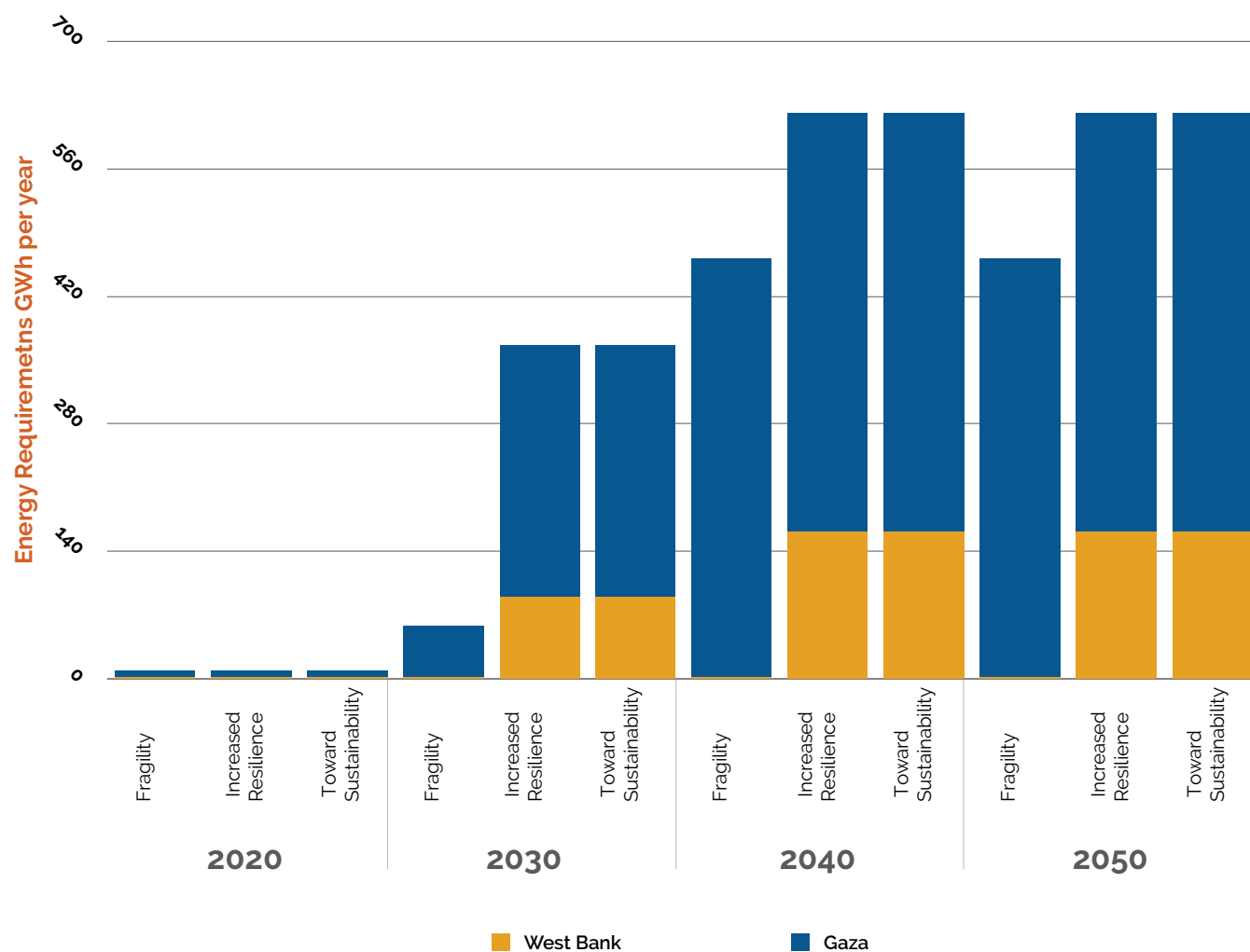
Figure 3.20 Energy Requirements of Groundwater Abstraction



Source: Authors' elaboration based on World Bank data.

Desalination will be an increasingly important and a key driver of energy demand in Gaza. The process of removing salt and other minerals from seawater or brackish water to produce freshwater requires significant amounts of energy, particularly in the case of advanced treatment processes. The amount of electricity used depends on the type of desalination technology used, the size of the plant, and the salinity of the source water. On average, desalination plants consume 3–4 kilowatt-hours (kWh) of electricity per cubic meter of water produced. A typical large-scale desalination plant that produces 100,000 cubic meters of water per day would consume 300,000–400,000 kWh of electricity per day. However, the energy requirements of desalination can be minimized through the use of energy-efficient technologies, such as reverse osmosis membranes, and the integration of renewable energy sources, such as solar and wind power (box 3.4). Additionally, investments in water infrastructure and conservation measures can help reduce the demand for desalination and make it more financially sustainable in the long term, with the use of energy recovery devices, such as pressure exchangers, able to reduce the energy consumption to 1–2 kWh per cubic meter of water produced. If the plans for development of desalination are realized, the projected demand for electricity is estimated to increase to 622 GWh per year by 2050 under the Increased Resilience Scenario (figure 3.21).

Figure 3.21 Energy Requirements of Desalination



Source: Authors' elaboration based on World Bank data.

Box 3.4



FLOATING PHOTOVOLTAIC SOLAR GENERATION FOR DESALINATION

As part of the 2011 national strategy to integrate renewable energy as an alternative electricity source, the Palestinian Authority explored the feasibility of using floating marine photovoltaic (PV) cells to provide electricity for the three short-term low-volumes (STLV) desalinization plants in Gaza. The panels would supply power to ensure round-the-clock operation of the desalination plants at full capacity.

In 2021, the Arab Water Expert Network, in collaboration with the Palestinian Water Authority, completed a prefeasibility assessment for this technical solution. The assignment considered site-specific factors such as STLV plant locations, power consumption, topography, meteorological conditions, and marine activity zones to develop design criteria in accordance with international standards for similar projects. The feasibility analysis covered technical, financial, and environmental and social perspectives.

The study determined that the three STLV desalination plants have sufficient space for installing floating solar PV systems away from wave-breaking zones. Depending on the exact location, the floating PV cells would range from 2,200 kWp to 7,800 kWp. Accurate data, soil testing, detailed environmental and social impact assessments, and simulation software would be necessary for precise design and estimation of system potential.

From a financial perspective, the project was deemed feasible, with a positive net present value and internal rate of return and an acceptable payback period. The study suggested that profitability ratios would remain positive throughout the cells' projected 20-year economic life. The average annual energy production, costs, revenue, and profit are summarized in the table below. However, challenges such as component reliability, technical expertise, and political stability would need to be addressed to ensure the project's long-term success.

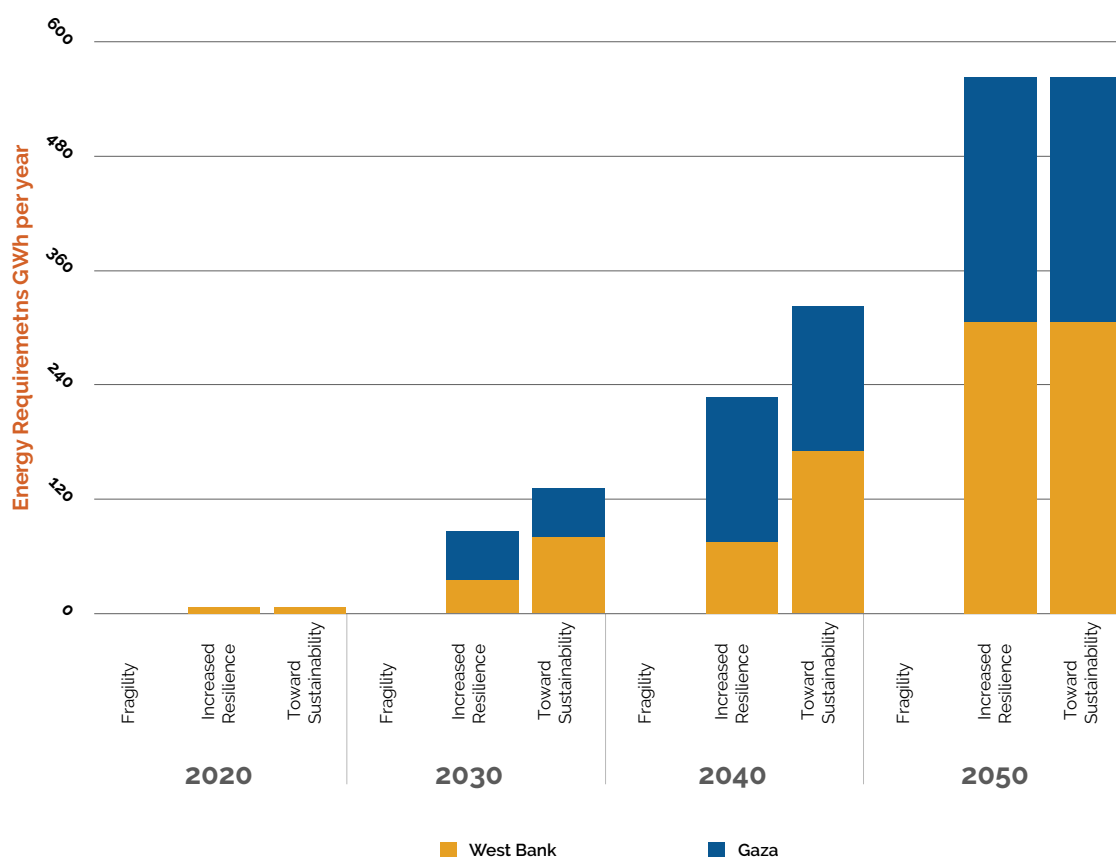
	AVERAGE GENERATION (KWH/YEAR)	AVERAGE ANNUAL COST (US\$/YEAR)	AVERAGE ANNUAL REVENUE (US\$/YEAR)	AVERAGE GENERATION (KWH/YEAR)
<i>Gaza STLV</i>	6,164,000	616,400	1,140,340	523,940
<i>Deir Al Balah STLV</i>	3,669,000	366,900	678,765	311,865
<i>Southern STLV</i>	13,043,000	1,304,300	2,412,955	1,108,655

Source: Arab Water Expert Network. *Prefeasibility Assessment to Improve Electric Power Supply for The STLVs by Installing Offshore Floating Solar PV Mounting System*. 2021.

Increasing water supplies to meet the demands of a growing population will have significant implications for energy demand. The treatment of water to make it safe for human consumption and the process of transporting it from its source through distribution networks to demand centers requires significant amounts of energy, particularly in areas where water must be pumped over long distances or to higher elevations, such as in the West Bank. The distribution of water through pipelines and other infrastructure requires energy to maintain pressure and flow rates, in the absence of which intermittent supplies result in network leakages that can result in significant losses of both water and energy because pumps must work harder to maintain pressure and flow rates. Based on energy consumption associated with the treatment, conveyance, and distribution of water supplies in 2020, demand for electricity is estimated to increase significantly by 2050 under the Increased Resilience Scenario.

The reuse of TWW provides significant opportunities for water security in the West Bank and Gaza but will impose significant demand for energy. The treatment of wastewater to remove pollutants and contaminants requires significant amounts of energy, particularly in the case of advanced treatment processes such as biological nutrient removal. The amount of electricity used in wastewater treatment depends on the size of the treatment plant, the treatment processes used, and the efficiency of the equipment. On average, a typical WWTP consumes 0.5–1.5 kWh of electricity per cubic meter of wastewater treated. A plant that treats 10,000 cubic meters of wastewater per day would consume 5,000–15,000 kWh of electricity per day. However, more efficient treatment technologies such as membrane bioreactors and anaerobic digestion can reduce energy consumption to 0.2–0.5 kWh per cubic meter of wastewater treated. Additionally, some WWTPs use renewable energy sources such as solar, wind, or biogas to generate electricity, which can further reduce their energy consumption and carbon footprint. Based on energy consumption associated with wastewater treatment in 2020, demand for electricity is estimated to be 562.6 GWh per year by 2050 under the Increased Resilience Scenario.

Figure 3.22 Energy Requirements of Wastewater Treatment



Source: Authors' elaboration based on World Bank data.

Irrigation is the primary driver of energy demand in the water-agriculture nexus. The pumping of water from its source to irrigation systems requires significant amounts of energy, particularly in areas where water must be pumped over long distances or to higher elevations, such as in the West Bank. The amount of electricity used in irrigation depends on the type of irrigation system used, the size of the farm, and the efficiency of the equipment. On average, a typical irrigation system consumes around 0.5–1.5 kilowatt-hours (kWh) of electricity per cubic meter of water applied. A farm that irrigates 10,000 cubic meters of water per day would consume 5,000–15,000 kWh of electricity per day. However, more efficient irrigation technologies such as drip irrigation and precision irrigation can reduce energy consumption to 0.2–0.5 kWh per cubic meter of water applied. The harvesting and processing of crops also require energy, particularly in the case of crops that require refrigeration or other forms of processing, as does their transportation from the farm to the market. In addition, fertilizer application requires energy, particularly in the case of synthetic fertilizers that are produced using fossil fuels. The use of renewable energy sources can reduce energy demand and the carbon footprint. Based on energy consumption associated with irrigation in 2020, demand for electricity is estimated to increase significantly by 2050 under the Increased Resilience Scenario.



Image by Ahmed Zaqout / World Bank

Bridging Supply and Demand

The nexus between water, energy and agriculture in the West Bank and Gaza is complex and multifaceted, with many interrelated factors that affect the availability of resources. The interdependence of these resources means that any changes in one can have significant impacts on the others, making it essential to address the nexus in an integrated and sustainable manner. Ensuring sufficient energy is available and bridging the gap between supply and demand requires both supply-side and demand-side measures.

Energy efficiency should be viewed as the "first fuel." Implementation of energy and water efficiency measures could improve the sustainability of infrastructure, which is particularly important given the political constraints on significantly increasing generation capacity in the immediate future. Water facilities could achieve significant cost savings by increasing the efficiency of electrical and mechanical equipment at a water or WWTP. Demand-side management tactics, such as shifting energy use away from peak hours, could help manage energy shortages.

Energy efficiency programs in the water sector typically involve a range of measures aimed at reducing energy consumption and improving the efficiency of water systems. Some key elements of energy efficiency programs in the water sector are undertaking energy audits to identify areas where energy is being wasted and to identify opportunities for energy savings, upgrading equipment, such as pumps, motors, and lighting to more energy-efficient models, optimizing operations to reduce energy consumption, such as reducing pumping times and optimizing water treatment processes, and adopting water-saving irrigation techniques.

Energy efficiency programs in the agriculture sector can reduce demand and increase profitability. Energy consumption accounts for a significant portion of the agricultural sector's operating costs; reducing energy demand can increase the sustainability and efficiency of agricultural systems. Interventions to reduce energy demand include the adoption of efficient irrigation systems, such as drip irrigation and micro-sprinklers, that can help to reduce water consumption and energy demand for pumping water; the use of precision agriculture technologies, such as GPS-guided tractors and drones, that can help to optimize crop management practices, reducing energy consumption and improving yields; and the adoption of crop diversification practices to reduce the energy demand associated with monoculture farming, as well as improve soil health and reduce the risk of pests and diseases. The adoption of conservation tillage practices, such as no-till farming, can further reduce the energy demand associated with traditional tillage practices, as well as improve soil health and reduce erosion, while the use of efficient machinery, such as tractors and harvesters, can reduce energy consumption and improve the efficiency of agricultural operations. These interventions can promote economic development and improve the livelihoods of communities that depend on agriculture.

The gains from energy efficiency programs can be substantial. A rapid assessment of the energy efficiency of pumping stations in Jenin (ARCOWA 2020) suggests that well-pump energy efficiencies can be significantly improved. If operated at industry standards, a minimum saving of 1.6 MWh per year can be made, translating to a minimum saving of US\$176,120 per year in operating costs. Similar inefficiencies for the booster pump systems could increase the potential savings by at least a factor of 2. Thus, the savings could be doubled and reach more than US\$320,000 per year.

**Box 3.5****THE ASSOCIATED WORKS PROJECT**

The energy needs of the water sector in Gaza were significant prior to the conflict (figure 3.23). In response to the water crisis in Gaza, the Palestinian Authority (PA), in collaboration with the World Bank Donor Partnership (Sweden, Portugal, United Kingdom, Norway, the Netherlands, Denmark, Italy, Australia, Finland, and France), has supported a number of initiatives prior to the conflict in an attempt to restore the Coastal Aquifer and promote sustainable groundwater management.

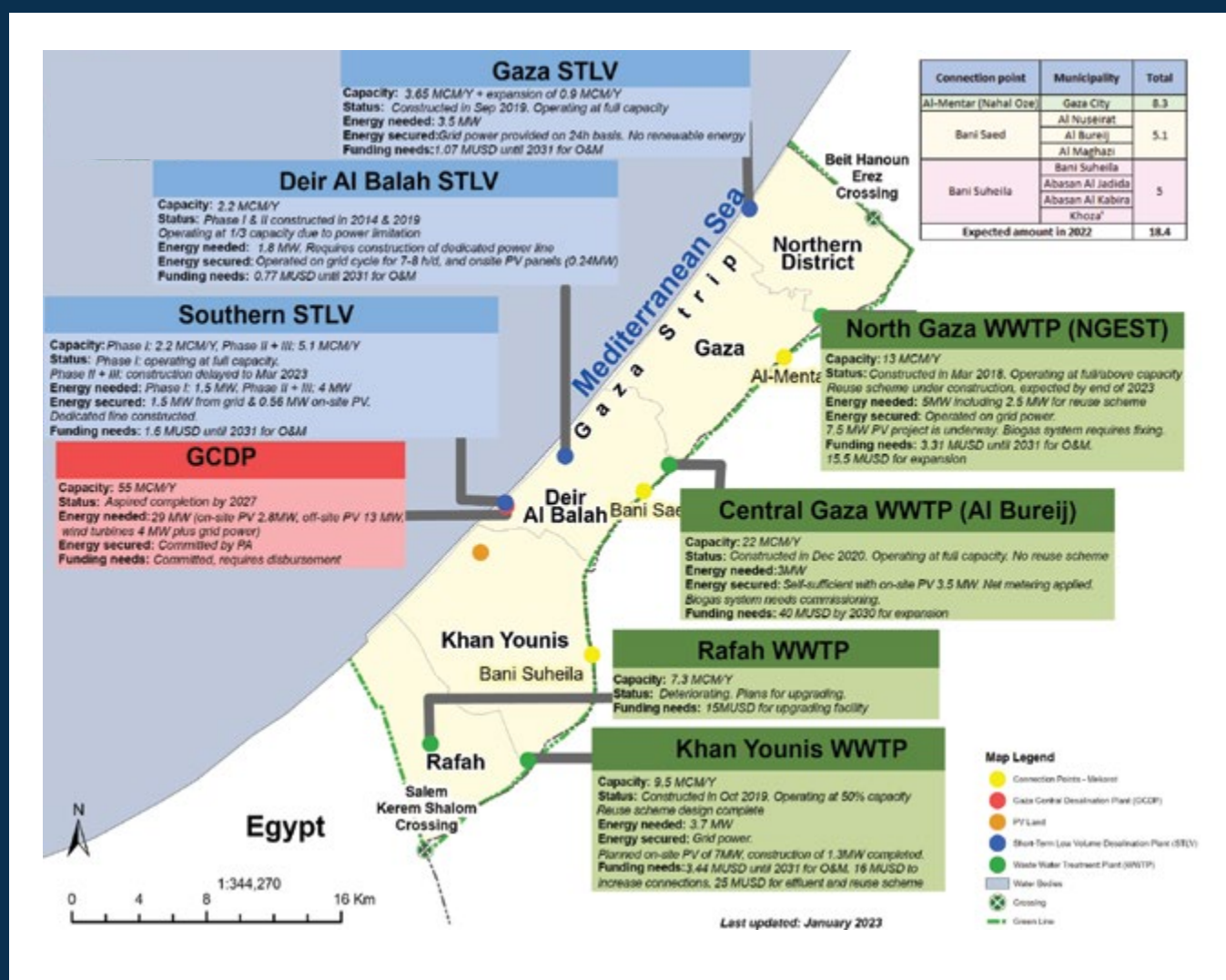
The PA's plan to reduce dependence on groundwater in Gaza relies heavily on scaling up desalination capacity. Doing so entails significant energy requirements. Estimations based on the small to large-scale desalination plants (STLV plants) in Gaza suggest that producing one cubic meter of water may require up to 4 kWh of energy. Given the challenging situation in Gaza's energy sector, which heavily relies on imports from Israel, it is unrealistic to expect an increase in desalination capacity without a corresponding increase in energy generation capacity.



The PA intends to address this challenge by incorporating photovoltaic plants into the design of future STLV plants—an approach requiring significant capital investments. Recognizing the potential synergies between the energy and water sectors, the PA, with multi-donor support that includes the World Bank Donor Partnership, the Kuwait Fund for the Arab Economic Development, and the European Union, has initiated the Gaza Central Desalination and Associated Works Program (GCDAWP). The program aims to achieve a balanced water supply by blending the outputs of desalination, groundwater, and imports. This scheme ensures that water quality standards are met while operating the system in the most sustainable and efficient manner.

The World Bank's contribution to the GCDAWP is the Associated Works Project (AWP), which focuses on enhancing water supply systems and includes measures such as rehabilitating and constructing necessary infrastructure for the blending scheme. These measures aim to reduce water losses and improve access to clean and reliable water sources, further supporting sustainable water and energy management in Gaza. The

Figure 3.23 Energy Needs of the Water Sector in Gaza



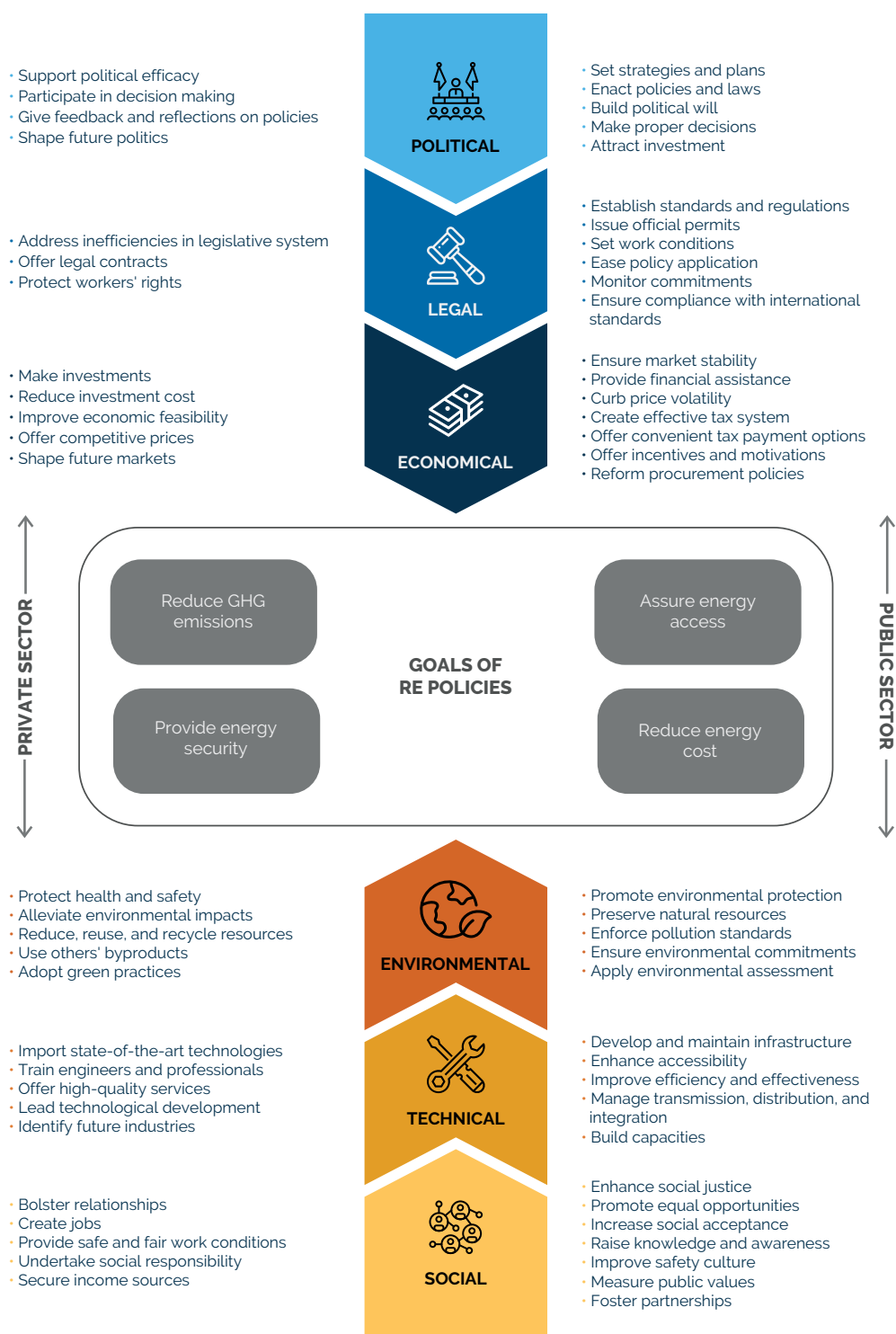
Source: Office of Quartet/UNICEF.

Note: STLV = short term low volume; GCDP = Gaza Central Desalination Plant; WWTP = wastewater treatment plants

AWP has important linkages with the energy sector. Recognizing these linkages allows for a holistic approach to address the challenges in Gaza. By exploring and capitalizing on potential synergies, the AWP can contribute to the sustainable management of water resources and energy efficiency, ultimately benefiting the livelihoods and well-being of the local population.

The development of renewable energy sources can reduce the region's dependence on imported fuel and electricity, while reducing greenhouse gas emissions (GHG) and increasing resilience to external constraints. To meet increasing demand for electricity, renewable energy sources should be growing at about 5–10 percent per year (Juaidi et al. 2022). However, there are barriers to entry, and the energy sector remains highly vulnerable because of its reliance on imports from Israel, which controls energy types, quantities, and prices. Given opportunities for renewable energy, a framework that links policy targets with the roles of various sectors with the goals of energy security, energy access, energy cost, and GHG emissions reduction has been proposed (figure 3.24). Renewable energy has become more vital in Gaza since the onset of the conflict in October 2023 and the restrictions on the entry of fuel.

Figure 3.24 Renewable Energy Framework Proposed by Juaidi et al. (2022)



Source: Juaidi et al. 2022.

Note: RE = renewable energy

Raising awareness through education and outreach programs can reduce demand for electricity. Increasing awareness about the importance of energy conservation and the impact of excessive electricity consumption can help people understand the need to reduce their energy consumption and promote the use of renewable energy sources. Coupled with incentives, such as rebates for energy-efficient equipment, can encourage people to adopt energy-efficient practices and reduce their energy consumption.

Regional cooperation could diversify sources of supply and increase resilience to exogenous constraints. Although the amounts of electricity imported from Jordan into the West Bank and from Egypt into Gaza are modest, increasing power imports from both countries provides a medium-term option. The viability of this option depends on the domestic power sector situation in each of these neighboring countries, as well as on the relative costs of their power export tariffs compared with Israeli and domestic Palestinian options (Badiei et al. 2017). Expanding imports from either of these countries would also entail significant upgrades to cross-border transmission infrastructure, which is quite limited, and would require various levels of political and governmental approvals to allow permitting for construction and so is not without challenges. Such regional ventures have been promoted for some time and hold significant benefits but have proven elusive (box 3.6).



Box 3.6

THE GREEN BLUE DEAL

The Green Blue Deal is aimed at promoting cooperation and sustainable development in the water and energy sectors between Israel, Jordan, and the West Bank and Gaza. This trilateral framework recognizes the shared challenges and interdependencies among the three parties in managing their water resources and advancing their environmental goals. By leveraging mutual interests and fostering collaboration, the Green Blue Deal has five objectives aimed at creating a more secure and prosperous future for all:

- **Water Resource Management:** This objective emphasizes the sustainable use and management of shared water resources, promoting equitable allocation, conservation, and efficient infrastructure development to ensure reliable access to clean water for all communities and ecosystems.
- **Renewable Energy Integration:** This objective recognizes the crucial role of energy in water management. It encourages the adoption and integration of renewable energy to reduce dependence on fossil fuels, mitigate climate change impacts, and enhance energy security.
- **Environmental Conservation:** This objective underscores the significance of preserving and restoring ecosystems, including rivers, lakes, and coastal areas, by encouraging joint efforts to protect biodiversity, enhance ecosystem services, mitigate the impact of climate change on the environment, and work together to safeguard the natural heritage for future generations.
- **Infrastructure Development:** This objective focuses on the construction and enhancement of water and energy infrastructure. The agreement promotes collaborative projects that improve water supply networks, wastewater treatment systems, desalination plants, and renewable energy installations. These initiatives aim to enhance resource efficiency, reduce losses, and support sustainable economic development.
- **Research and Innovation:** This objective recognizes the importance of research, technology transfer, and innovation in addressing water and energy challenges. It encourages joint research programs, knowledge exchange, and the development of innovative solutions for sustainable water and energy management. By fostering innovation, the parties can benefit from shared expertise, cutting-edge technologies, and best practices.

The Green Blue Deal represents a milestone in regional cooperation, highlighting the potential for joint action and dialogue to address pressing environmental issues. By transcending political boundaries, it offers a framework for building trust, fostering stability, and creating shared benefits for Israel, Jordan, and the West Bank and Gaza. Through collaborative efforts, the parties aspire to forge a more sustainable and resilient future, demonstrating that cooperation can lead to positive change in the region.

Source: Bromberg, Majdalani, and Abu Taleb (2020).

THE AGRICULTURE SECTOR

Agrifood Sector Overview by Production System

The agriculture sector has historically played a significant role in terms of food security, employment, and GDP in the West Bank and Gaza. While the value added by the agriculture, forestry, and fishing sector has increased in absolute terms, from US\$611 million in 1994 to US\$938 in 2022, the sector's relative contribution to overall GDP has decreased from 13.3 percent in 1994 to 6.3 percent in 2021.¹⁶ The fisheries sector is important in Gaza, but most of the agricultural land (92 percent) is located in the West Bank and held by 82 percent of the total holders. Livestock and crops represent about 50 percent each of gross value add, with the bulk of the crops supported by irrigation (Palestinian Central Bureau of Statistics 2020). An estimated 95 percent of cropland in Gaza is irrigated, compared with an estimated 42 percent in the West Bank. With an estimated 138,339 agricultural holders managing a total area of 120,930 hectares (Palestinian Central Bureau of Statistics 2020), The West Bank and Gaza has one of the smallest average farm sizes in the world, with 0.4 hectares per holder in Gaza and about 1 hectare per holder in the West Bank. Of the more than 30 crops planted, olives dominate in the West Bank and vegetable crops, in Gaza.

Historically, the West Bank has relatively food secure and Gaza, highly food insecure. The World Food Programme (WFP) estimates that, as of August 2023, some 1.84 million people (nearly one-third of the Palestinian population) were food insecure and some 1.1 million people were severely food insecure; of the latter, roughly 1 million people (90 percent) are in Gaza (WFP 2023). Following the conflict that started in 2023, food insecurity increased with restrictions on the entry into Gaza of basic food, along with fuel, water, and other goods. Food insecurity is reportedly high among women; an estimated 36 percent of families headed by women experience food insecurity; in Gaza, 63.3 percent of women-headed households suffer food insecurity (WFP 2023). Poorly diversified diets are also causing overlapping nutritional problems; national surveys by WFP report that nearly 50 percent of those assessed had very low levels of essential minerals and vitamins. Food insecurity will continue to be negatively affected given rising poverty and unemployment rates and continued disruptions to food imports and domestic production.



© Image by Arne Hoel / World Bank

The agriculture sector has experienced significant changes over the past few decades. Overall, productivity is estimated to have decreased by roughly half between 1994 and 2021 due to limited availability of arable land; shifting land uses and land conversion, primarily the result of urbanization and population growth; water scarcity and restrictions, which limit the availability of water for irrigation and hamper the growth and productivity of the agriculture sector; and fragmentation of land ownership that is typically collectively held by extended families. Access restrictions imposed by Israel on Area C of the West Bank impose further constraints, limiting the ability of Palestinian farmers to cultivate their lands and develop agricultural infrastructure. These restrictions hinder the expansion of rainfed and irrigated agriculture and negatively impact the overall productivity of the agricultural sector, including livestock production (B'Tselem 2011; World Bank 2014). In response to these challenges, there has been a significant shift toward vegetable production, with only a small overall increase in total cropped area (~6 percent) between 2010 and 2020 (table 3.8). During this period, field crops decreased by approximately 10 percent and the area for vegetables increased by about 47 percent in West Bank, while Gaza saw an approximately 24 percent decrease in the area dedicated to fruit trees, a 22 percent decrease in the area of field crops, and an increase of 82 percent in the area of vegetables.

Table 3.8 Evolution of Areas (ha) of Agricultural Crops in the West Bank and Gaza, 2010–20

AGRICULTURAL CROPS	VEGETABLES		FRUIT TREES		FIELD CROPS		TOTAL 2010	TOTAL 2020
	2010	2020	2010	2020	2010	2020	2010	2020
<i>West Bank</i>	9,584	14,079	61,265	64,089	22,088	19,810	92,937	97,978
<i>Gaza</i>	3,375	6,149	4,725	3,597	2,453	1,911	10,553	11,657
<i>Total</i>	12,959	20,228	65,990	67,686	24,541	21,721	103,490	109,635

Source: Palestinian Central Bureau of Statistics.

Livestock production is an important component of the agricultural sector, contributing to food security, income generation, and employment opportunities. The sector consists mainly of small ruminants (sheep and goats), poultry, and some cattle, which are most significant in the West Bank, where the majority of sheep and goats are raised in extensive grazing systems on natural pastures. Small ruminant production contributed about US\$45 million to the West Bank and Gaza economy in 2020 (World Bank 2014). Higher temperatures and reduced precipitation due to climate change will lead to a decline in the quality and quantity of natural pastures, impacting the availability of forage for small ruminants (Thornton et al. 2009), while also increasing exposure to heat stress and the potential for more frequent disease outbreaks, reducing productivity and increasing mortality rates (Baylis and Githeko 2006; Nardone et al. 2010). Livestock also has important implications for water, with vulnerabilities influenced by the type of livestock, the production system, and feed and forage requirements. Increasing the resilience of the livestock sector and reducing its impacts on water resources can involve adopting water-saving technologies in animal husbandry, such as water recycling systems and water-efficient feed and forage production practices.



© Image by Arne Hoel / World Bank

Rainfed agriculture, which is the dominant production system in the West Bank, is particularly vulnerable to changes in the availability and distribution of water (map 3.5 and 3.6). Production is determined by a variety of agro-ecological conditions, including altitude, proximity to sea, and soils. The area's rainfed crops include olives, grapes, various field crops, and cereals. Olive trees are the primary rainfed crop and are well-adapted to the region's Mediterranean climate with an ability to withstand prolonged droughts. The area under cultivation for olives covers approximately 48 percent of the total agricultural land in the West Bank, accounting for some 70 percent of fruit production. Olive oil exports generate significant earnings and account for 25 percent of agricultural GDP (FAO 2018); total olive production reached 207,000 tons and generated an estimated income of US\$200 million in 2020 (PCBS 2020). However, olive yields have been variable, with fluctuations in annual production due to climatic factors, pests, and diseases, with rainfed agriculture particularly vulnerable to variations in rainfall. Increased temperatures, reduced and more variable precipitation, and more frequent extreme weather events are likely to negatively affect rainfed agriculture by altering the growing season, reducing water availability and soil moisture, and increasing evapotranspiration rates (IPCC 2014). In particular, olive trees may become more vulnerable to pests and diseases as temperatures rise (Giorgi and Lionello 2008). Furthermore, climate change can lead to a decline in pollinator populations, which could adversely affect the pollination of olive trees and other fruit crops.

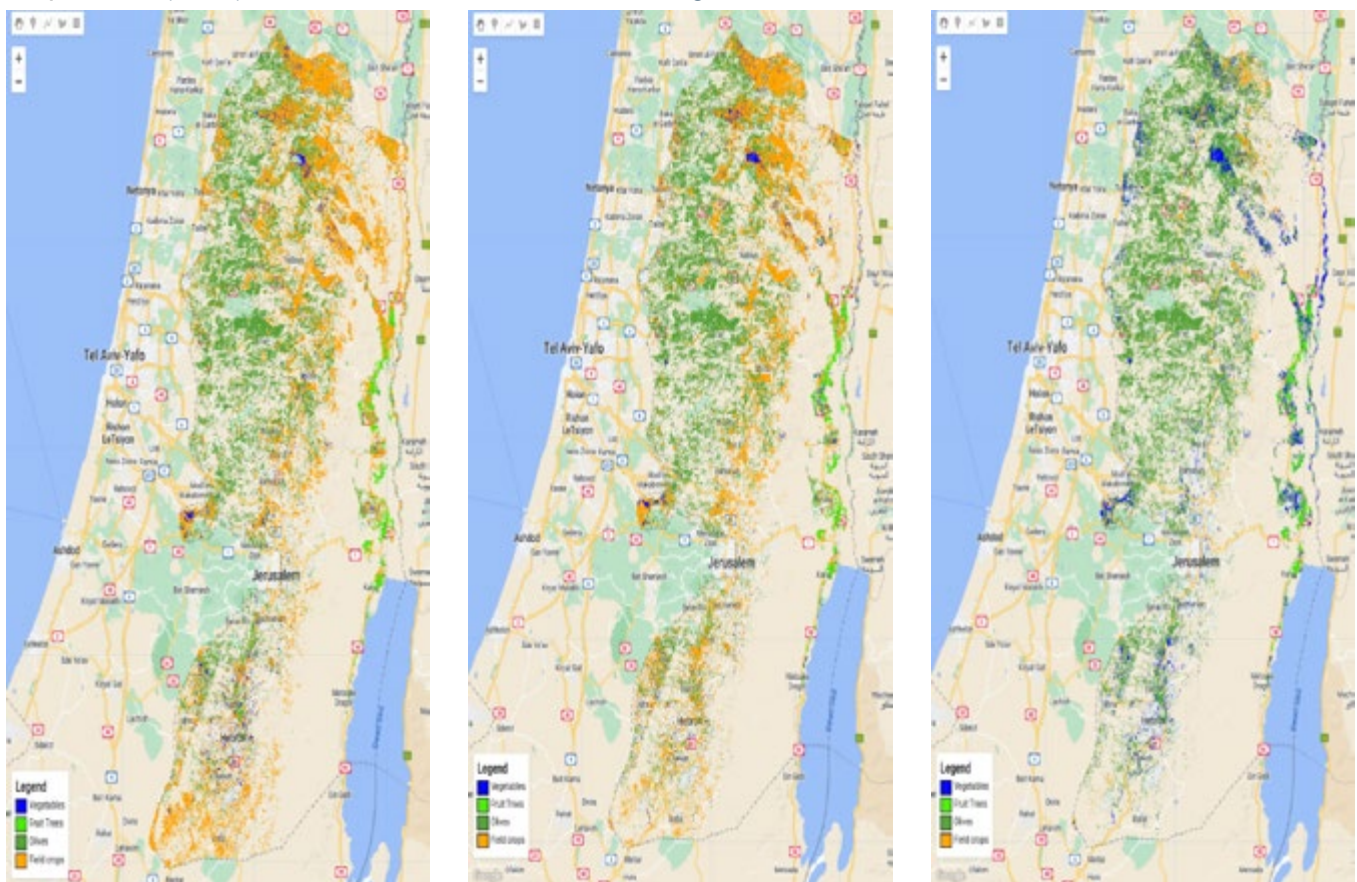
The irrigation sector is essential for maximizing crop yields, ensuring food security, and building resilience to the impacts of climate change. With limited rainfall and water resources, irrigation allows farmers to control the amount of water supplied to their crops, ensuring optimal growth and productivity, increasing crop yields, and improving food security. It also enables farmers to cultivate a wider range of crops, extend the growing season beyond the limitations of rainfed agriculture, and improve resilience to the projected impacts of climate change. Irrigated agriculture accounts for 95 percent of agricultural production in Gaza and an estimated 42 percent in the West Bank. Adoption of more efficient irrigation systems—such as drip irrigation—has increased over the past two decades, with the area equipped with modern irrigation systems increasing from about 18 percent in 2000 to around 58 percent in 2018 (PCBS 2020). Cereals are less frequently irrigated due to the cost of doing so with groundwater. Irrigation is used mostly for horticulture and fruit trees; the horticulture sector accounts for approximately 40 percent of total agricultural production in the West Bank and Gaza. It plays a significant role in providing employment opportunities, particularly for women and young people, providing direct and indirect employment to 18,000 workers in the West Bank and an estimated 7,000 people in Gaza (Giorgi and Lionello 2008) and generating an estimated US\$120 million in 2020 (PCBS 2020).

Map 3.5 Crop Map for Gaza in 2020 (Relatively Wet Year, 688 mm) and 2021 (Relatively Dry Year, 500 mm)



Source: Original for this publication.

Map 3.6 Crop Map for the West Bank in 2022 (Average Rainfall Year, 628 mm)



Source: Original for this publication.

The Water and Energy Footprints of Agriculture

Significant investments are required to meet growing demand and ensure food security for the Palestinian people. As the population increases, concerns about food security are expected to escalate, particularly for Palestinians residing in Gaza. In an already-undernourished region, where more than a third of Palestinians fell below the food insecurity line prior to the onset of the conflict that started in 2023, shifting demographic patterns were already intensifying pressure on the agrifood sector. The situation is particularly critical in Gaza, where the population is projected to nearly double in the next three decades and the conflict has decimated the agricultural sector and food security. Prior to October 2023 the WFP was planning to provide food assistance to 440,500 of the most vulnerable and food-insecure people via in-kind food rations and cash based transfers in the form of electronic

food vouchers to 2028. The conflict has since driven more than half the population of Gaza to the brink of famine and the entire population has experienced acute food insecurity and malnutrition. Given these circumstances, the PA must take immediate action to ensure the ability to provide food for more than 9 million people, including 4 million residents of Gaza, by 2050.

The potential for increasing agricultural production is hindered by limited access to land. In the West Bank, farmers face significant obstacles as they have restricted access to 61 percent of arable land in Area C that is under Israel's administrative control. In 2010 it was estimated that almost half a million dunums of land suitable for agriculture in Area C were not cultivated by Palestinians (Land Research Center 2010) because of access restrictions (World Bank 2010) and lack of water. At the time, it was estimated that 187,000 dunums (18,700 ha) were cultivated or occupied by Israeli settlements, a figure that has increased, and that another 1 million dunums that could be used for rangeland or forestry also was subject to restrictions.

Access to land poses a long-term constraint on agricultural production, but the immediate challenge is the availability of water resources. The overall volume of freshwater withdrawals by the agriculture sector has grown from about 156 MCM in 2010 to 221 MCM in 2020 and is projected to reach more than 450 MCM in 2050. However, the proportion of annual freshwater withdrawals by the agriculture sector has declined, from roughly 60 percent in 2000 to around 48 percent in 2020.¹⁷ This decline can be attributed to increased water use in other sectors and efforts to improve water use efficiency in agriculture. The source of water for agricultural use has also been changing; TWW is increasingly viewed as a sustainable source of supply. Negligible in 2000, reuse of TWW for agriculture reached 10 MCM in 2019, when it accounted for approximately 11 percent of total agricultural water use.

Improvements in agricultural water management can help maximize benefits while reducing water use. There are typically three options for capturing the additional water needed to meet the requirements of future food production: (1) increasing water productivity by reducing losses, (2) improving the use of rainfall and expanding rainfed agriculture, and (3) pursuing virtual water options. Restrictions on land limit the options for expanding rainfed agriculture, while promoting the import of water-intensive, low-valued crops can help optimize the allocation of scarce water resource, particularly when promoting the production and export of high-value crops. Decision-making processes at the farm level are influenced by various factors, including cultural considerations, risk aversion, and social networks, potentially leading to suboptimal choices regarding adoption of more efficient irrigation technologies. While opportunities are limited in Gaza, improving the optimization of cropping patterns in the West Bank has been shown to reduced water use and increase the value added in crop production. There are also opportunities to increase the area under irrigation and improve water productivity through adoption of more efficient irrigation technologies, such as drip irrigation or precision sprinklers, that can promote precision agriculture, hydroponics, aquaponics, and vertical farming methods that optimize water and energy use in agriculture while maximizing yields.

There are a number of barriers to reducing agricultural water use and adopting more efficient water use technologies. These include perceived high levels of risk, high upfront costs, lack of technical knowledge, and limited access to finance (Koundouri, Nauges, and Tzouvelekas 2006). Two other important barriers in the Palestinian context are the access restrictions imposed by Israel on land in Area C and Area B, which reduce the attractiveness of investments in modern production technologies, and the implicit lack of awareness of water scarcity reflected in the commonly held view that there is the right to use water free of restrictions. These barriers are compounded by institutional challenges, such as water pricing policies, property rights, and regulatory enforcement, that impact the adoption of water-saving technologies and practices (Hernández-Mora et al. 2014). In many cases, inefficient water pricing and weak enforcement of water regulations can discourage farmers from adopting more efficient irrigation technologies, further impeding water use reduction efforts. Water prices differ by sources and region, but overall, they do not reflect the cost of production or the externality of using scarce groundwater resources—thereby creating perverse incentives for farmers and other agents.



Image by Joe Catron from Flickr

Progress in achieving food security in the West Bank and Gaza hinges on its ability to enhance its capacity for reusing TW/W. The demand for municipal water is anticipated to grow at a faster pace than conventional supply, further exacerbating the limited water available for agriculture. The most viable solution to bridge the agricultural water deficit is transitioning from a linear water cycle focused on production, consumption, and discharge to a circular water economy that emphasizes reuse. The National Water Policy recognizes the need to treat all produced wastewaters to a quality sufficient to meet national standards for safe and productive reuse TW/W for agricultural, recharge, and aquaculture purposes. Wastewater reuse for irrigation is regulated by Instruction No. 3 of 2012 on the reuse of TW/W in agriculture. The instruction establishes requirements for four classes of water (A–D)—TW/W must meet class A—and it prohibits the use of low-quality wastewater for watering cattle and poultry, cultivating vegetables, direct groundwater recharge, and aquaculture. The Ministry of Health and Environmental Quality Authority have identified crops for which irrigation with TW/W is permitted. The list excludes vegetables, which is one of the most profitable agricultural activities in certain areas; in these areas, there is no demand for TW/W.

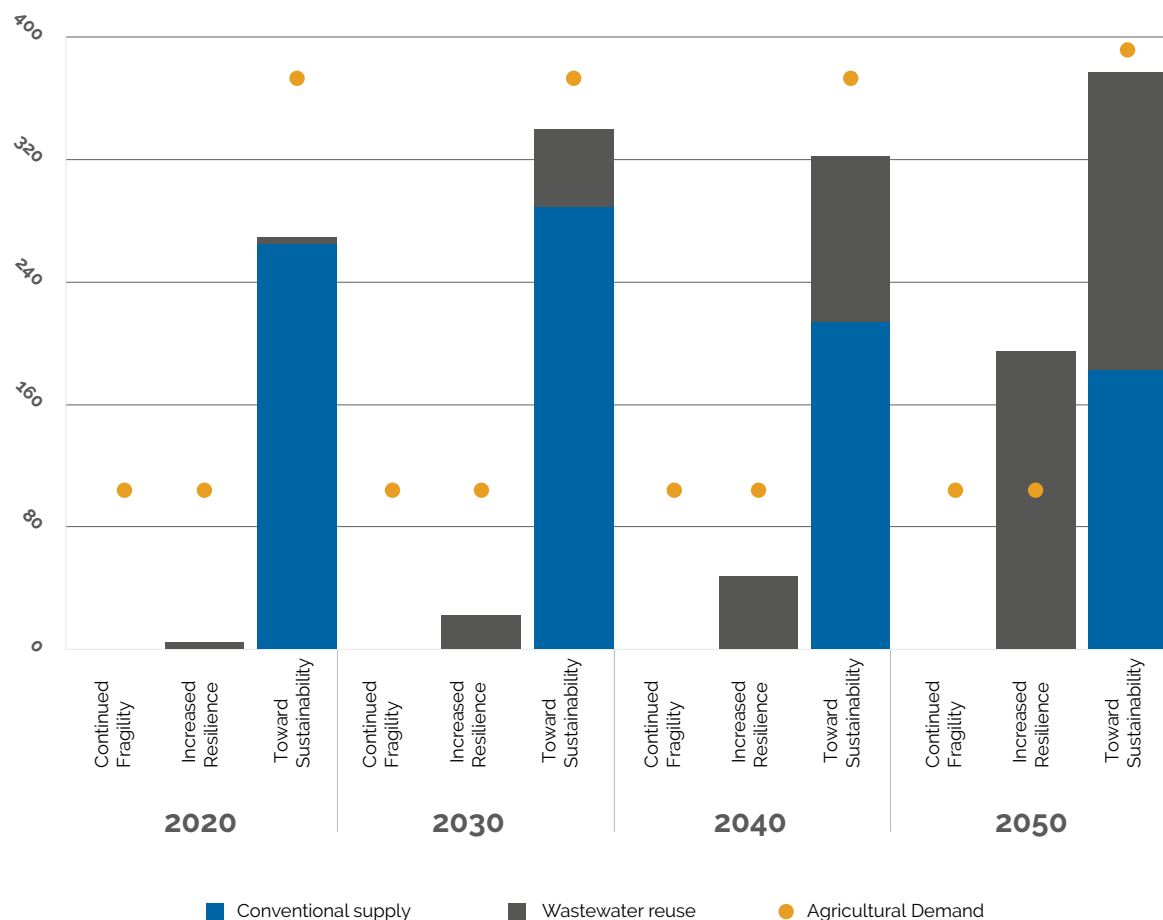
Projected increases in the capacity for reusing TW/W would be sufficient to meet agricultural water demand. There are already a number of existing reuse projects, with several schemes having been piloted in Gaza since 2013, including a large-scale reuse project near the North Gaza WWTP designed to use 40,000 cubic meters per day of TW/W to irrigate 15,000 dunums. The West Bank has also been piloting schemes since 2020, with reuse projects under implementation or development in Jericho, North-West Nablus, Tayaseer, and Auja areas. During the next 20 years, the new strategy aims to increase TW/W reuse from 3 MCM to 78 MCM per year.

The forecasting exercise evaluated the significance of wastewater reuse for agricultural purposes between 2020 and 2050. To determine the water demand in agriculture, an estimate of 600 cubic meters per dunum per year was used. This estimate was based on the current available land in the Continued Fragility and Increased Resilience scenarios, and it reflects full access to the arable land in Area C in the West Bank in the Toward Sustainability Scenario. The results indicate that a substantial increase in wastewater reuse capacity would be sufficient to meet the agricultural water demand in the Increased Resilience and Toward Sustainability Scenarios. However, in the latter scenario, the increase in capacity needs to occur at a faster pace to minimize the short-term gap resulting from irrigating a larger area, including Area C.

Realizing the full potential of agriculture through the reuse of TWW requires significant and sustained investments until 2050. Capacity to increase the volume of TWW for reuse in the short term is limited by the quantity of water supplied through the system and by the volume of wastewater that is subsequently generated, collected, and treated. Based on estimations, it is anticipated that, even under the most optimistic scenarios, the amount of TWW for reuse in the agricultural sector will not meet growing demand until 2040 in Gaza and 2050 in the West Bank (figure 3.25 and figure 3.26). The availability of this resource will be subject to significant investments in the water supply network and reduction of nonrevenue water, as well as wastewater network and treatment capacity (figure 3.27). These investments must be coupled with improvements in irrigation and energy efficiency, increasing storage capacity to facilitate the blending of TWW with other sources. Complementary institutional measures and regulatory reforms will be needed to facilitate integration of TWW into the water and energy sectors and to increase awareness among the population of the benefits.

Cultural concerns related to wastewater reuse will significantly increase overall investment requirements. Farmers in the West Bank and Gaza have traditionally been reluctant to use TWW in agriculture due to cultural reasons (Hamdan, Abu-Awwad, and Abu-Madi 2021). Awareness campaigns to overcome this reluctance might span several years and have uncertain outcomes. Alternatively, addressing the concerns of farmers could involve infiltrating the TWW into groundwater reserves, to be then extracted for reuse. This practice is already being implemented in Gaza and has proven effective not only in mitigating farmers' opposition to reuse but also in significantly improving water quality in the Coastal Aquifer (box 3.7). However, implementing this practice would entail additional investment. According to estimates by the PWA, constructing a WWTP with a capacity of 1,000 cubic meters per day could cost US\$1 million in capital expenditure—building the associated infiltration and reuse system could double the required investment.

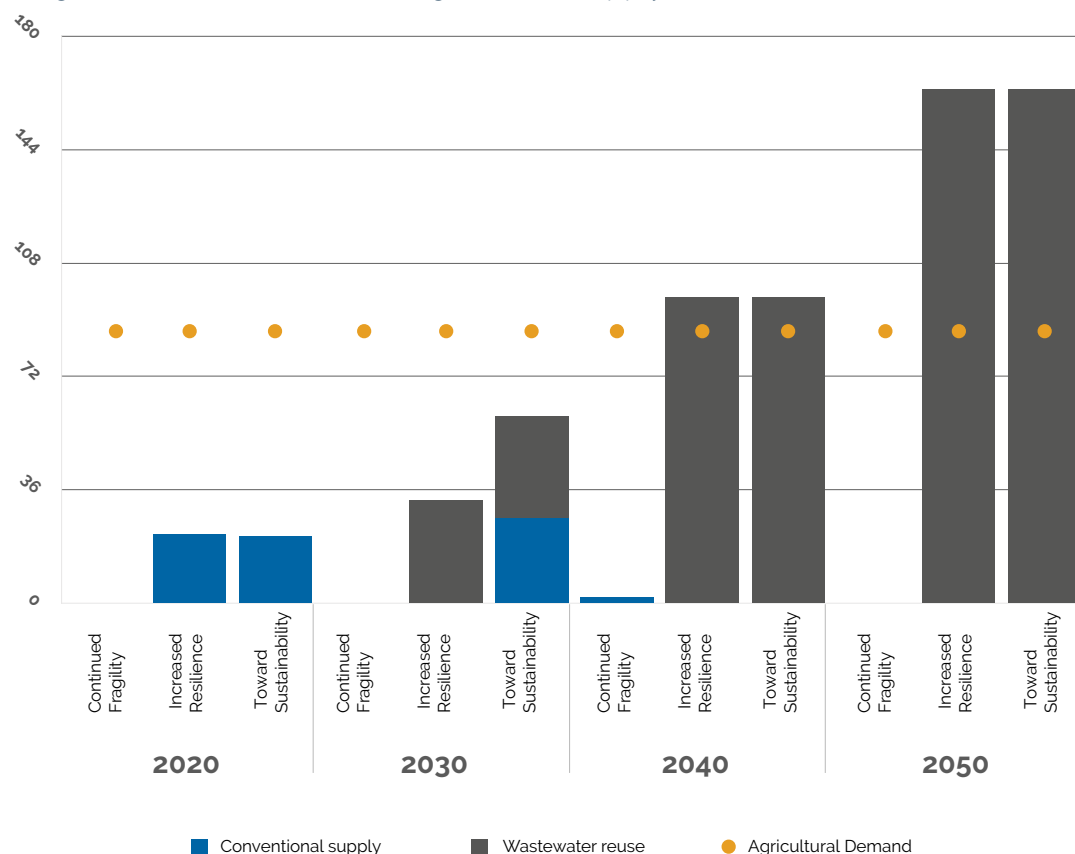
Figure 3.25 Agricultural Demand versus Agricultural Supply in the West Bank



Source: Authors' elaboration based on World Bank data.

Note: MCM = million cubic meters.

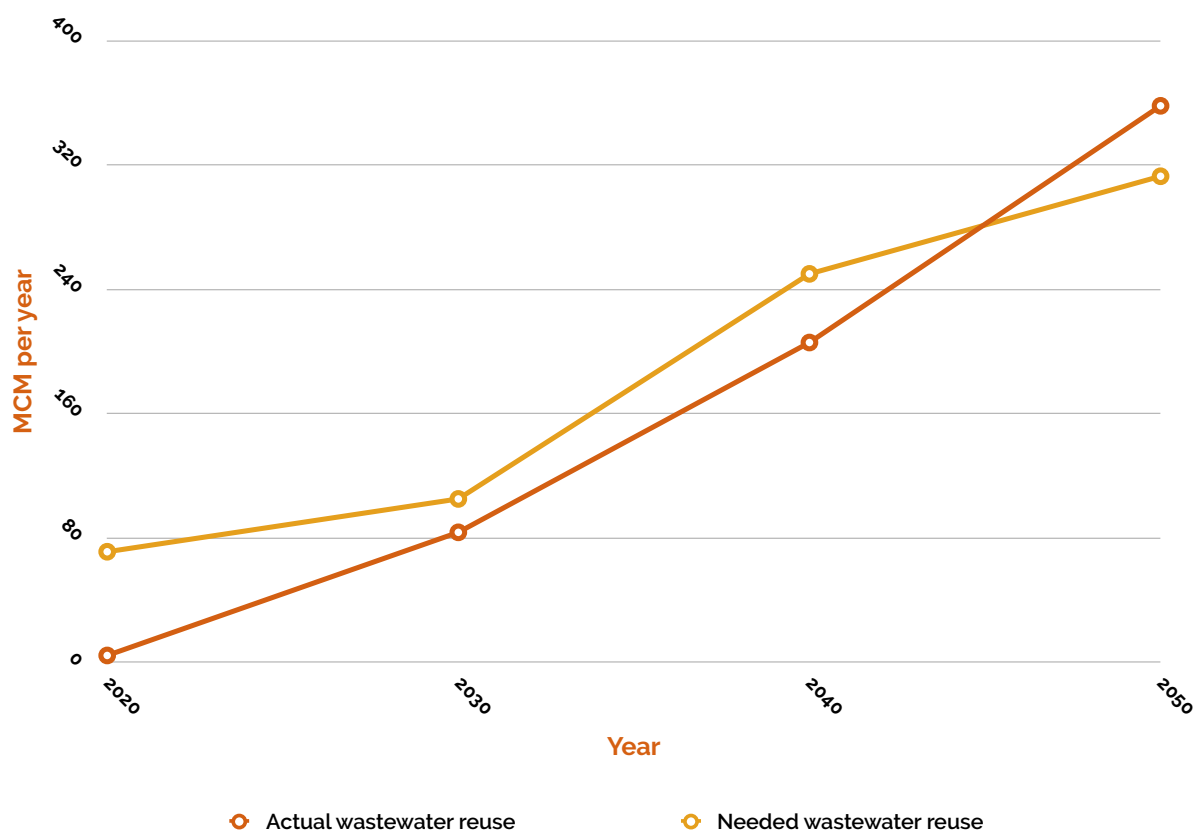
Figure 3.26 Agricultural Demand versus Agricultural Supply in Gaza



Source: Authors' elaboration based on World Bank data.

Note: MCM = million cubic meters.

Figure 3.27 Expected Wastewater Reuse versus Reuse Needed to Meet Demand in the Toward Sustainability Scenario

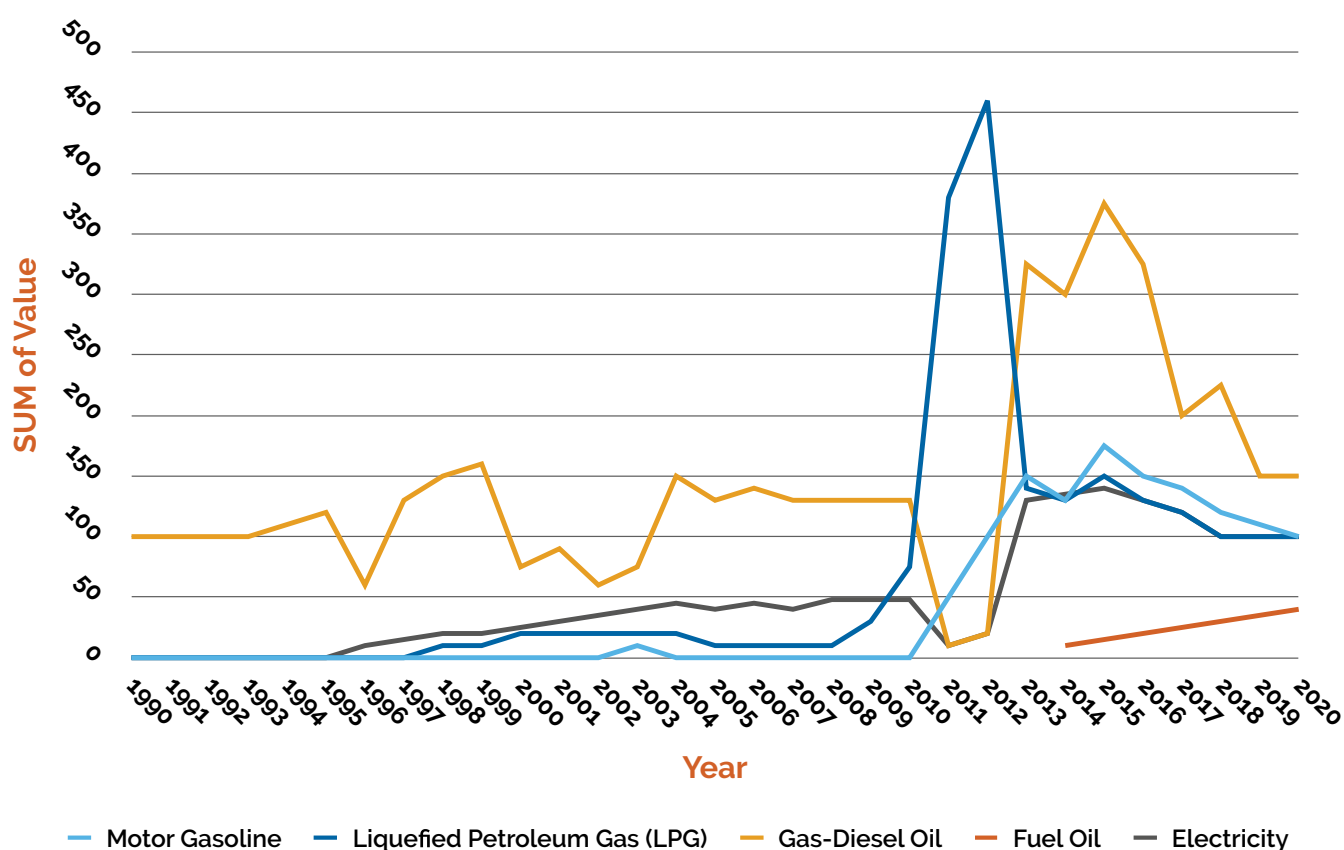


Source: Authors' elaboration based on World Bank data.

Note: MCM = million cubic meters

The agriculture sector has a significant energy footprint—and opportunities to improve efficiency. Although not highly energy-intensive, the agriculture sector requires energy for activities such as irrigation, transportation of agricultural products, and processing and storage of crops. Actual consumption depends on a range of factors, such as the type of agricultural practices, irrigation methods, and the use of machinery and equipment. In the West Bank and Gaza, energy is derived mostly from diesel generators and Israeli-supplied electricity from the grid (figure 3.28). Diesel is commonly used as a fuel for agricultural machinery and vehicles, such as tractors and water pumps, although consumption in the agriculture sector has fluctuated due to changes in fuel prices, availability, and the adoption of more energy-efficient technologies. Electricity is the second-most used source of energy in agriculture sector. Growing interest in using solar energy in the agriculture sector in the West Bank and Gaza is driven by a desire to reduce dependency on imported energy sources and to promote sustainable development. Solar-powered irrigation systems, water pumping, and heating/cooling systems have been increasingly adopted but continue to represent a minor share of the overall energy mix. Efforts to improve energy efficiency in the agriculture sector can contribute to sustainable agricultural practices and can reduce overall energy consumption.

Figure 3.28 Mix of energy sources in the agriculture sector in the West Bank and Gaza.



Source: FAOSTAT 2023.

The development of agri-photovoltaics (APV) provides significant opportunities to increase resilience. Combining solar energy production with agricultural activities, such dual-use approaches, can reduce reliance on imported energy sources and increase energy security. In the West Bank and Gaza, the potential of APV is significant, with an average of 3,000 hours of sunshine per year. Installation of solar panels over croplands or in areas with less productive land means APV technology can also help maximize land use efficiency by generating solar energy without compromising agricultural production. APV systems can also help reduce water evaporation from the soil because solar panels provide shade to crops and could be adapted to harvest rainwater. Such investments allow farmers to generate additional income by selling surplus solar energy to the grid or by providing energy to local communities.

Building the Agrifood Sector's Resilience to Climate Change

Farmers and other agents in the agriculture and food sectors can deal with the impacts of climate change in several ways. In rainfed systems, farmers may shift to drought- (and heat-) tolerant crops and varieties, such as millets, sorghum, or certain legumes; adopt early-maturing varieties to reflect shortening growing seasons; and diversify crops to reduce the risks of crop failure. In irrigated systems, farmers may switch to higher-value crops to increase the value generated from each unit of water; deploy more efficient irrigation systems enabled by the economic value generated from the higher value crops; switch to less water-intensive crops overall; and adjust planting and harvesting dates, depending on the specific climate trends observed in their region.

Several of these adaptive behaviors can be observed in the West Bank and Gaza and can be attributed, in part, to climate change. Decreases in the production of traditional cereal crops such as wheat and barley likely reflect the increased risk of droughts, making rainfed agriculture less reliable. The increase in irrigated fruit and vegetable production likely represents an adaptation action as well as a shift to maximize the value per unit of water utilized (water use efficiency). These crops have become more profitable as access to adoption of drip irrigation systems, in particular, has expanded, reducing the cost of pumping water. Expansion of olive cultivation may also reflect climate change, given olive trees' high degree of adaptation to dry conditions and relatively low water requirements. Finally, data from the Palestinian Central Bureau of Statistics data show a diversification of cropping systems, with farmers growing a wider range of crops, including nontraditional crops such as greenhouse vegetables and cash crops like herbs and medicinal plants. This diversification helps farmers increase their income and reduce the risks associated with climate change.

Other potential adaptation pathways to minimize impacts include water conservation practices, such as mulching, contour plowing, and terracing, to help reduce soil erosion and to enhance water infiltration and retention (Haddadin 2002) as well as selection of drought-tolerant crop varieties, implementation of crop rotation practices, and use of drip irrigation (FAO 2018).

There continues to be large potential to optimize the crop mix to reduce water use and increase higher levels of water use efficiency. Optimization of the land used for the largest five crops could reduce irrigation water consumption by 10 percent (4 percent of all agricultural water use) and increase the total value added in irrigated agriculture by 3.8 percent, equivalent to 4 percent of the entire agricultural sector (Nazer et al. 2010). Programs combining policy elements and promoting investments, taking both a carrot and a stick approach, have the potential to achieve such a transformation.

Major advances in agricultural water productivity could be realized, particularly in olive, eggplant, tomato, and cucumber production (Gilmont et al., 2017). Switching from flood (furrow) to drip irrigation can lead to water savings of 40–56 percent (Richter et al. 2017), while subsurface drip irrigation can save 32–57 percent. Deficit irrigation of fruits could save 19–60 percent of water use without significant impact on yields. Irrigation scheduling and soil moisture monitoring and irrigation timing should also be considered (Richter et al. 2017). In addition, advanced irrigation sensor technology, including technology based on the Internet of Things, can lead to further water savings of 20–30 percent. Improved irrigation needs to be coupled with complementary water-saving policies and incentives to avoid reverse effects (Jevon's paradox).

Cover for vegetable production could be scaled up to increase water productivity. Despite a water-saving potential of some 20 percent at plot level, less than 25 percent of all vegetable production is covered to date. The use of protected cultivation systems such as greenhouses or screenhouses equipped with artificial intelligence systems presents a sustainable option for improving water productivity.¹⁸

Suboptimal crop mix and adoption rates are in large part due to the incentives set by the current water pricing regime. Water prices are below the resource's economic value or its cost of production. They therefore set distortive economic incentives for farmers. However, irrigation water prices are already perceived as high and comprise a large portion of total farming expenses via the cost of energy for pumping. Therefore, when combined with the cultural attitudes described above, attempts to increase irrigation water prices are likely to meet strong political resistance. Nevertheless, many farmers would continue farming even if water prices were increased beyond their willingness-to-pay threshold (Abu-Madi 2009). Preconditions for improved water pricing would be effective monitoring of groundwater use and strengthened enforcement. Remote sensing technologies could aid both.

Scale-up of climate-smart agriculture (CSA) practices offers further opportunities to build resilience to climate change in rainfed systems. In rainfed olive and barley production, these practices include contouring, terracing, and the use of appropriate plows, polymers, and organic matter to improve crops' infiltration and soil storage capacity. In agropastoral goat and sheep production, land degradation can be offset by integrated land restoration programs and breeding practices that increase productivity and expand markets. Realizing the potential of CSA practices requires strengthened extension services and increases in farmers' adaptive capacity.

Developing rainwater harvesting (RWH) systems and reducing groundwater overdraft will increase resilience to water scarcity and droughts. RWH systems are effective interventions for adapting to increasing water variability. RWH has been widely used to supply water for irrigation, improve soil moisture deficits, and recover degraded landscapes. Groundwater, if managed well, can also provide a supplemental source of water for crops, livestock, and drinking during droughts. The West Bank and Gaza must reduce unsustainable use of groundwater to ensure that this water source can sustainably support water needs during increasingly frequent drought periods.

Deploying solar water pumps offers opportunities but comes with high sustainability risks in the absence of effective policy frameworks for water governance. Solar water pumps reduce the costs of irrigation and increase access to cheap groundwater for farmers. Given severe water scarcity, a scale-up of solar water pumps requires integrated policies and solutions. Promising solutions include increased groundwater monitoring, water-saving technologies, metering, low-power water pumps, and social learning interventions. An equally effective intervention is the buy-back of solar electricity from farmers connected to the grid (feed-in tariff). The additional revenue stream from solar energy creates an incentive for efficient farm irrigation, hence reducing the risk of over-pumping. Scaling up this intervention will require investments in smart grid technologies and grid resilience solutions, enabling the grid to absorb decentralized renewable energy reliably and safely.

Box 3.7

GAZA'S COASTAL AQUIFER

The Coastal Aquifer serves as the primary source of drinking water for Palestinians in Gaza. Over the past two decades, excessive abstraction and reduced recharge rates due to changes in rainfall have resulted in saline intrusion and significant deterioration of water quality. Contamination has been exacerbated by the presence of poorly managed farms, open-air landfills, and inadequate sewage networks, resulting in the introduction of additional pollutants. As a result, the primary source of drinking water in Gaza is unsuitable for human consumption, and the people of Gaza are forced to rely on bottled water, private suppliers (such as water tankers and small-scale desalination plants), and water imports from Israel to meet their needs.

In an attempt to restore the Coastal Aquifer and promote sustainable groundwater management, the World Bank-funded North Gaza Wastewater Treatment Plant (NGWWTP) is effectively transforming sewage water into a valuable source of water. The NGWWTP serves more than 400,000 residents and treats approximately 13 million cubic meters of wastewater annually. After undergoing treatment, the wastewater is infiltrated back into the aquifer. This treated wastewater is then used for irrigation purposes by some 4,200 farmers in the northern part of Gaza. By reusing TWW for irrigation, the project not only mitigates pollution risks but also enhances agricultural productivity and supports the local farming community.



Infiltration basins at the NGWWTP in Northern Gaz

NOTES

¹ The Oslo Accords include two agreements between Israel and the Palestine Liberation Organization. The Oslo I Accord was signed in Washington, D.C., in 1993, and the Oslo II Accord was signed in Taba, Egypt, in 1995, marking the start of the process aimed at achieving a peace treaty based on Resolution 242 and Resolution 338 of the United Nations Security Council and fulfilling the right of the Palestinian people to self-determination.

² The figures are from an assessment of rainwater harvesting for domestic water supply.

³ World Bank, European Union, and United Nations (2025) Gaza and West Bank Interim Rapid Damage And Needs Assessment. <https://thedocs.worldbank.org/en/doc/133c3304e29086819c1119fe8e85366b-0280012025/original/Gaza-RDNA-final-med.pdf>

⁴ Historical water demand in the West Bank and Gaza is divided into agricultural and municipal water demand. Municipal water demand includes both domestic and industrial demand; separate records are not available for specific industrial requirements, which is usually taken as a percentage of the domestic water demand.

⁵ Resolution A/RES/64/292. The Human Rights Council subsequently adopted Resolution 16/2, in April 2011, guaranteeing access to safe drinking water and sanitation as a human right: a right to life and to human dignity.

⁶ The strategy defines NRW as including unaccounted for water (UFW) and water that has been accounted for but not billed (e.g., water used at mosques and camps and for firefighting). NRW is generally slightly higher than UFW and it is expressed as a percent. UFW is calculated as the difference between water produced and water billed to customers and is mostly expressed as percent of water production. This figure aggregates leakages in the network (transmission and distribution losses) and water that is stolen. UFW estimates are based on production metering and customer metering, as well as on estimation where metering is difficult or inaccurate.

⁷ Figures are based on PWA data.

⁸ They include water and wastewater utilities, undertakings, authorities, water departments within municipalities, village, joint service council's, cooperative associations, and private sector providers.

⁹ The first block is up to 10 cubic meters; the second block, 10–20 cubic meters; the third block, 20–30 cubic meters; and the last block, more than 30 cubic meters.

¹⁰ The cost of treating wastewater that crosses the Green Line is deducted by Gol [IAQ: pls spell out] from the PA's clearance revenues. The practice of treating wastewater entering Israel started in 2003. However, there is no agreed mechanism for measuring these flows, and there is a lack of transparency in the charges, quality of treated wastewater, quality of effluent, and use of the effluent.

¹¹ This subsidy includes both the cost of purchasing water from Mekorot and the wastewater treatment costs deducted from clearance revenues.

¹² Without additional electricity-related implicit subsidies for water pumping deducted from clearance revenues.

¹³ The PA approved an update to its First Nationally Determined Contributions to the United Nations Framework Convention (UNFCCC) on Climate Change on October 2021. The update set a target of a 26.6 percent reduction in greenhouse gas (GHG) emissions relative to a business-as-usual (BaU) case by 2040 under so-called independence scenarios. A status quo scenario sets a target of a 17.5 percent reduction in GHG emissions relative to a BaU scenario by 2040. The NAP was approved by the PA and submitted to UNFCCC in August 2016.

¹⁴ Cooperation is based on management of water resources in the West Bank and Gaza and approval of proposed projects through the Joint Water Committee, which was established through the Oslo II Accords signed in 1995. The agreement was intended to be temporary, yet after more than 25 years no final agreement has been reached.

¹⁵ Model estimates are based on adaption of estimates of water scarcity on the Jordanian economy using Taheripour et al. 2020. Prospects for Growth and Jobs in the Palestinian Economy: A General Equilibrium Analysis (World Bank 2017) suggests that Jordan is the most relevant comparator in the Middle East and North Africa region to benchmark economic performance of the West Bank and Gaza because they are both quite similar in terms of their basic resource base and are part of similar favorable trade agreements with other trading partners.

¹⁶ Constant 2015 US\$. See <https://data.worldbank.org/indicator/NV.AGR.TOTL.KD?locations=PS>.

¹⁷ See <https://data.worldbank.org/indicator/ER.H2O.FWAG.ZS?locations=PS>.

¹⁸ Analysis conducted as part of the Climate-Smart Agriculture Action Plan for Jordan in 2021 indicates that greenhouses for vegetables can increase yields from 5,000 kg per dunum to 15,000 kg per dunum while reducing water use from 500 cubic meters per dunum to 375 cubic meters per dunum, increasing water productivity fourfold from 10 kg to 40 kg per cubic meter. Transforming open-field vegetables to hydroponic vegetables can increase yields to 30,000 kg per dunum while reducing water use to 150 cubic meters per dunum, increasing water productivity to 200 kg per cubic meter. But not all cropping systems are suited for covered production due to increased factor costs and changes in micro-climatic conditions.

REFERENCES

- Abu-Madi, M. 2009. Farm-level perspectives regarding irrigation water prices in the Tulkarm district, Palestine. *Agricultural Water Management*, 96 (9): 1344-1350. <https://doi.org/10.1016/j.agwat.2009.04.007>.
- Badiei, Sara, Vivien Foster, Ewuah Oguu, Samuel Kwesi, and Roger Coma Cunill. 2017. *Securing Energy for Development in the West Bank and Gaza: Main Report*. Washington, DC: World Bank Group.
- Baylis, M. and A.K. Githeko. 2006. The effects of climate change on infectious diseases of animals. Report for the Foresight Project on Detection of Infectious Diseases, Department of Trade and Industry, UK Government. https://webarchive.nationalarchives.gov.uk/ukgwa/20121206154035/http://www.bis.gov.uk/assets/foresight/docs/infectious-diseases/t7_3.pdf
- Bromberg, G., N. Majdalani, and Y. Abu Taleb. 2020. *A Green Blue Deal for the Middle East*. EcoPeace Middle East. Amman, Ramallah, and Tel-Aviv. <https://ecopeaceme.org/wp-content/uploads/2021/03/A-Green-Blue-Deal-for-the-Middle-East-EcoPeace.pdf>
- B'Tselem. 2011. *Dispossession and Exploitation: Israel's Policy in the Jordan Valley and Northern Dead Sea*. <https://www.btselem.org/publications/summaries/dispossession-and-exploitation-israels-policy-jordan-valley-northern-dead-sea>.
- FAO. 2018. *West Bank and Gaza Strip: Country Programming Framework 2018–2022*. <https://www.fao.org/3/I8489EN/i8489en.pdf>.
- Friedman, T. L. 2014. "Whose Garbage Is This Anyway?" *New York Times*, Opinion, February 8th, 2014. <https://www.nytimes.com/2014/02/09/opinion/sunday/friedman-whose-garbage-is-this-anyway.html>
- Gilmont, M., Rayner, S., Harper, E., Nassar, L., Tal, N., Simpson, M. and Hilmi Salem. 2017. *Decoupling*

National Water Needs for National Water Supplies: Insights and Potential for Countries in the Jordan Basin. WANA Institute, Royal Scientific Society in Amman, Jordan. https://wanainstitute.org/sites/default/files/publications/Publication_DeliveringFoodAndWaterSecurity_0.pdf

- Giorgi, F., and P. Lionello. 2008. "Climate Change Projections for the Mediterranean Region." *Global and Planetary Change* 63 (2–3): 90–104.
- Haddadin, M. J. 2002. "Water Issues in the Middle East Challenges and Opportunities." *Water Policy* 4 (3): 205–22.
- Hamada, S., and A. Ghodieh. 2021. "Mapping of Solar Energy Potential in the West Bank, Palestine Using Geographic Information Systems." *Papers in Applied Geography* 7 (3): 256–73.
- Hamdan, M., A. Abu-Awwad, and M. Abu-Madi. 2021. "Willingness of Farmers to Use Treated Wastewater for Irrigation in the West Bank, Palestine." *International Journal of Water Resources Development* 38 (3): 497–517. doi:10.1080/07900627.2021.1908236.
- Hernández-Mora, N., L. Del Moral, F. La Roca, A. La Calle, and G. Schmidt. 2014. "Interbasin Water Transfers in Spain: Interregional Conflicts and Governance Responses." In *Water Scarcity, Security and Democracy: A Mediterranean Mosaic*, edited by C. A. Scott, S. Vicuña, and D. Blanco, 71–100. Global Water Partnership-Mediterranean. https://link.springer.com/chapter/10.1007/978-94-007-7323-3_13.
- IEA (International Energy Agency). "Energy System of Israel." <https://www.iea.org/countries/israel#overview>.
- IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp. https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf
- Juaidi, Adel, Fathi Anayah, Ramiz Assaf, Afif Akel Hasan, Sameh Monna, Luqman Herzallah, Ramez Abdallah, Patrick Dutournié, and Mejdi Jeguirim. 2022. "An Overview of Renewable Energy Strategies and Policies in Palestine: Strengths and Challenges." *Energy for Sustainable Development* 68: 258–72.
- Koundouri, P., C. Nauges, and V. Tzouvelekas. 2006. "Technology Adoption Under Production Uncertainty: Theory and Application to Irrigation Technology." *American Journal of Agricultural Economics* 88 (3): 657–70.
- Land Research Center. 2010. Land Suitability for Reclamation and Development in the West Bank. Hebron. https://rec.lrcj.org/Other_Files/Land_Suitability.pdf
- Nardone, A., B. Ronchi, N. Lacetera, M. S. Ranieri, and U. Bernabucci. 2010. "Effects of Climate Changes on Animal Production and Sustainability of Livestock Systems." *Livestock Science* 130 (1–3): 57–69.
- Nazer, D.W., Tilmant, A., Mimi, Z., Siebel, M.A., Van der Zaag, P. and Gijzen, H.J. 2010. Optimizing irrigation water use in the West Bank, Palestine. *Agricultural Water Management*, 97(2): 339–345. <https://doi.org/10.1016/j.agwat.2009.10.006>
- Niksic, Orhan, Nur Nasser Eddin, and Massimiliano Cali. 2014. Area C and the Future of the Palestinian Economy. World Bank Studies. Washington, DC: World Bank.
- OCHA (United Nations Office for the Coordination of Humanitarian Affairs). 2023. The Number of Hours per Day the Pipelines Are Operational Was Not Reported. <https://www.ochaopt.org/content/hostilities-gaza-strip-and-israel-reported-impact-day-69>.

- OXFAM. 2024. "Timeline: The Humanitarian Impact of the Gaza Blockade." <https://www.oxfam.org/en/timeline-humanitarian-impact-gaza-blockade>.
- PCBS (Palestinian Central Bureau of Statistics). 2020. Agriculture Statistics. Ramallah. <https://www.pcbs.gov.ps/>
- PWA (Palestine Water Authority). 2000. Gaza Coastal Aquifer Management Program (CAMP). Gaza, 2000.
- PWA (Palestine Water Authority). 2013. National Water and Wastewater Strategy for Palestine: Toward Building a Palestinian State from Water Perspective. <https://faolex.fao.org/docs/pdf/pal180062.pdf>
- Richter, B. D., J. D. Brown, R. DiBenedetto, A. Gorsky, E. Keenan, C. Madray, M. Morris, D. Rowell, and S. Ryu. 2017. "Opportunities for Saving and Reallocating Agricultural Water to Alleviate Water Scarcity." *Water Policy* 19 (5): 886–907.
- Shuval, H., and H. Dweik. 2007. *Water Resources in the Middle East: Israel-Palestinian Water Issues—From Conflict to Cooperation*. Berlin: Springer.
- Taheripour, F., Tyner, W.E., Sajedinia, E., Aguiar, A., Chepeliev, M., Corong, E., de Lima, C.Z., Haqiqi, I. 2020. *Water in the Balance: The Economic Impacts of Climate Change and Water Scarcity in the Middle East*. World Bank, Washington, DC. <http://hdl.handle.net/10986/34498>
- Thornton, P. K., J. van de Steeg, A. Notenbaert, and M. Herrero. 2009. "The Impacts of Climate Change on Livestock and Livestock Systems in Developing Countries: A Review of What We Know and What We Need to Know." *Agricultural Systems* 101 (3): 113–27.
- United Nations. 1996. Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip (a.k.a. "Oslo II"). <https://www.un.org/unispal/document/auto-insert-185434/>.
- World Bank. 2010. *The Underpinnings of the Future Palestinian State: Sustainable Growth and Institutions*. Washington, DC: World Bank.
- World Bank. 2014. *Area C and the Future of the Palestinian Economy*. Washington, DC: World Bank.
- World Bank. 2017. *Prospects for Growth and Jobs in the Palestinian Economy: A General Equilibrium Analysis*. Washington, DC: World Bank.
- World Bank. 2018a. *Toward Water Security for Palestinians: West Bank and Gaza Water Supply, Sanitation, and Hygiene Poverty Diagnostic*. Washington, DC: World Bank.
- World Bank. 2018b. *Securing Water for Development in West Bank and Gaza*. Washington, DC: World Bank.
- World Bank. 2019. *Economic Monitoring Report to the Ad Hoc Liaison Committee (English)*. Washington, DC: World Bank. <http://documents.worldbank.org/curated/en/942481555340123420/Economic-Monitoring-Report-to-the-Ad-Hoc-Liaison-Committee>.
- World Bank, European Union, and United Nations (2025) *Gaza and West Bank Interim Rapid Damage And Needs Assessment*. <https://thedocs.worldbank.org/en/doc/133c3304e29086819c1119fe8e85366b-0280012025/original/Gaza-RDNA-final-med.pdf>
- WFP (World Food Programme). 2023. *WFP Palestine Country Brief—August 2023*. <https://www.wfp.org/countries/palestine>.





A photograph of an elderly man with grey hair and a blue surgical mask, wearing a plaid shirt. He is pouring a liquid from a silver metal pot, and a large plume of white steam rises from the pot, partially obscuring the lower half of the image. In the background, two young boys are visible; one is looking down and the other is smiling. The setting appears to be outdoors or in a semi-enclosed space with a corrugated metal roof and a brick wall.

CHAPTER FOUR



CLIMATE IMPACTS

Climate change will accentuate the gap between supply and demand of resources and have compounding and cascading effects on social and economic development. There is considerable uncertainty regarding the future impacts of climate change, and these will manifest through various pathways to impact on a broad range of natural, social, and economic variables. Increasing variability in the water cycle is inducing more extreme weather events, reducing the predictability of water availability, decreasing water quality, increasing the damage from floods and droughts, threatening biodiversity, and impacting the human rights to safe drinking water and sanitation. Increases in temperature can also result in higher domestic consumption and per capita demand for water, the risk of waterborne diseases, and associated losses in human capital and factor productivity. Such changes will have cascading effects on the production and availability of water, energy, and food. Because the water, energy, and food sectors are inextricably intertwined, policy-related actions and investments in one sector will have compounding impacts on the other sectors and undermine the resilience of the economy.

Groundwater resources are particularly vulnerable to climate change. Shifts in patterns of precipitation, including changes in amounts, frequency, and intensity, can increase surface runoff, reducing the groundwater recharge. Similarly, changes in temperature can alter vegetation patterns, land use practices and influence evapotranspiration, increasing consumption from agriculture and reducing the amount of water that percolates into the ground and recharges aquifers. Meanwhile, climate-driven sea-level rise can accelerate saltwater intrusion into coastal aquifers.

The combined impacts of water scarcity shocks due to climate change were evaluated along three pathways: (1) an increase in municipal demand due to changes in temperature of 1 percent, 3 percent, and 5 percent; (2) an increase in agricultural water demand of 5 percent, 10 percent, and 15 percent; and (3) a decrease in groundwater, surface water, and rainwater harvesting of 5 percent, 10 percent, and 15 percent. These pathways reflect estimates of the impacts of scarcity based on the Continued Fragility, Increased Resilience, and Toward Sustainability scenarios. The impacts of the gap between supply and demand in each of these scenarios was examined for the baseline period of 2020, and these impacts were projected for 2030, 2040, and 2050 using the demand-supply model.

Factoring in the projected changes in water supply and demand in the forecasting exercise allows for estimation of the impact of climate change on future water availability. The results indicate that climate change poses a significant threat to the Palestinian water sector, exacerbating the existing gaps between supply and demand across all examined scenarios. However, when considering the effects of limited access to water resources within the complex context of the West Bank and Gaza, the impacts of climate change appear relatively minor by comparison.

In the Continued Fragility Scenario, it is anticipated that by 2050, the impact of climate change will widen the gap between water demand and supply to 73 percent, compared with 68 percent when no climate change impacts are considered. Within the Increased Resilience Scenario, the reduction in groundwater, surface water, and rainwater harvesting will increase the municipal water gap from 22 percent to 33 percent. However, agricultural demand can still be met through an increase in wastewater reuse, resulting in a total compound gap of 22 percent (compared with 15 percent when climate change impacts are not accounted for). In the Toward Sustainability Scenario, the primary impact of climate change is observed in agricultural demand, which cannot be fulfilled by scaling up wastewater reuse. The resulting gap in the demand and supply of water for agriculture is 28 percent, contributing to a total gap between water supply and demand of 15 percent. When no effects of climate change are considered, the Toward Sustainability Scenario yields a total water surplus of 7 percent.

The projections of water availability under the different scenarios, inclusive of the anticipated effects of climate change on both demand and supply, were used to assess the impact of water constraints on the West Bank and Gaza economy. This analysis was conducted using the economic modeling tools described in box 4.1.

Box 4.1

THE ECONOMIC MODELING

The macro-fiscal assessment combines insights about the macroeconomic impacts of shocks and policies using a well-known framework. It also incorporates an innovative approach to representing the interconnectedness of climate impacts, biophysical systems, and the socio-economy. This approach aims to merge insights from mainstream macroeconomic analysis with methods that account for the effects of climate change, environmental degradation, and elements of fragility specific to the West Bank and Gaza.

The assessment of climate change impacts is informed by outcomes from sector-level (urban, energy, food, and water) studies and spatial analyses.

In line with the aforementioned framework, the empirical work encompasses three modeling exercises:

1. **Computable General Equilibrium (CGE) Model:** An integrated macro representation of the West Bank and Gaza, this model uses a general equilibrium framework (a version of MANAGE for the West Bank and Gaza).
2. **Green Economy Model (GEM):** This system thinking-based, system dynamics model is specifically designed for the West Bank and Gaza.
3. **Spatial analysis:** This analysis includes dynamic scenarios that focus on land use, runoff retention, urban temperature, and water yields. These scenarios are based on InVEST tools.



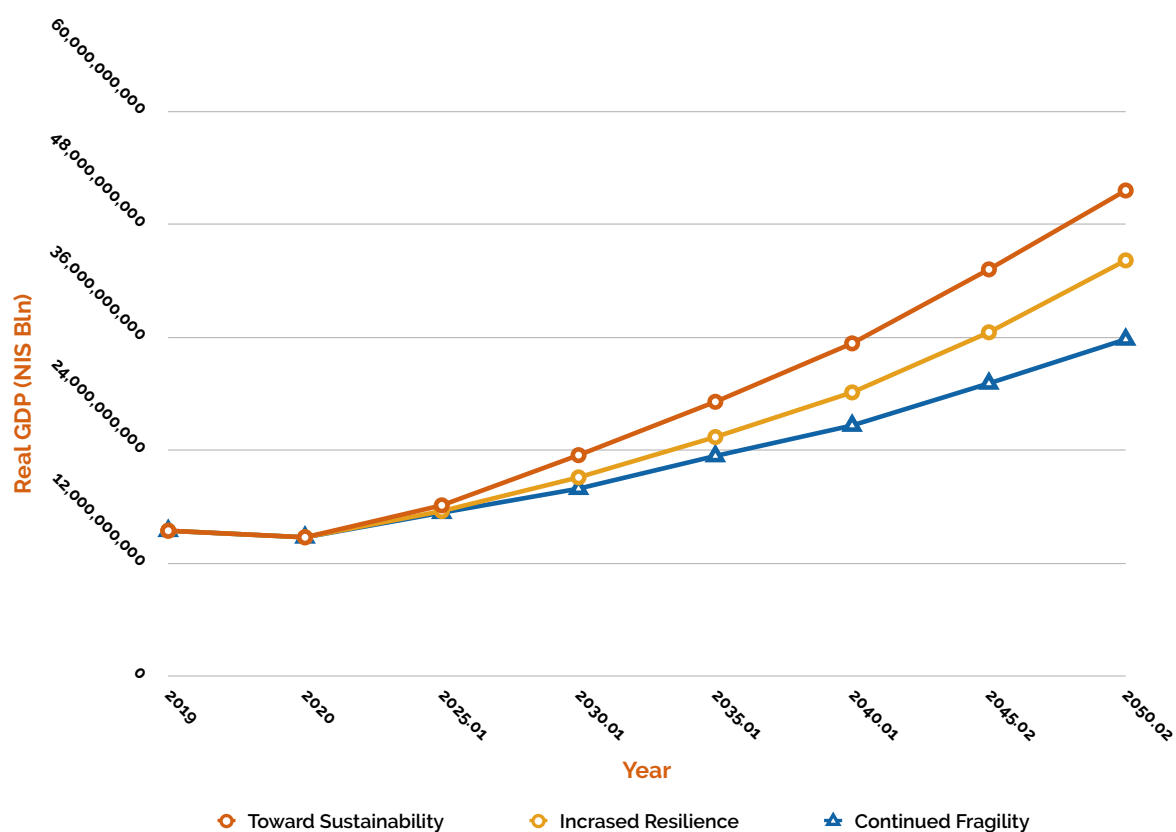
Image by hosny salah from Pixabay

The results of the economic modeling emphasize the substantial impact of water on the economic landscape in the West Bank and Gaza. Based on the assumptions in the Continued Fragility Scenario, the model demonstrates that, holding all else constant, increasing the water supply will directly contribute to a positive impact on real gross domestic product. Consequently, if the expected increase in water supply occurs as envisioned in the Increased Resilience Scenario, the West Bank and Gaza would experience an additional 2.7 percent increase in GDP by 2030, a 3.2 percent increase by 2040, and a 3.2 percent increase by 2050 compared with the baseline of the Continued Fragility Scenario.

In the Toward Sustainability Scenario, the initial increase in water availability resulting from full access to water resources, holding all else constant, will significantly boost GDP compared with the baseline of the Continued Fragility Scenario. By 2030, the Toward Sustainability Scenario is projected to increase GDP by 5.7 percent. However, as groundwater abstraction is gradually reduced to meet sustainable yield targets by 2040, the positive effect on GDP tends to shrink. In 2040, the projected GDP increase is 4.7 percent, and by 2050, it further decreases to 3.1 percent.

The impact of the additional water supply is further increased when other indirect and induced effects are factored in. When these additional effects, represented through a feedback loop in the Green Economy Model, are taken into account, they trigger a wider and more prolonged influence on GDP. Therefore, in the Increased Resilience Scenario, the compound effect of the additional water supply will lead to an increase in GDP, compared with the baseline scenario, of 3 percent in 2030, 4.8 percent in 2040, and 6.5 percent in 2050. The projected effects in the Toward Sustainability Scenario are even more significant, with increases of 8.3 percent, 10.5 percent, and 10.6 percent for 2030, 2040, and 2050, respectively, when compared with the baseline scenario. Figure 4.1 provides GDP projections in each of the studied scenarios when the compounded effect of increased water availability is considered. Figure 4.2 indicates the gap between water supply and demand in each scenario with and without considering climate change impacts.

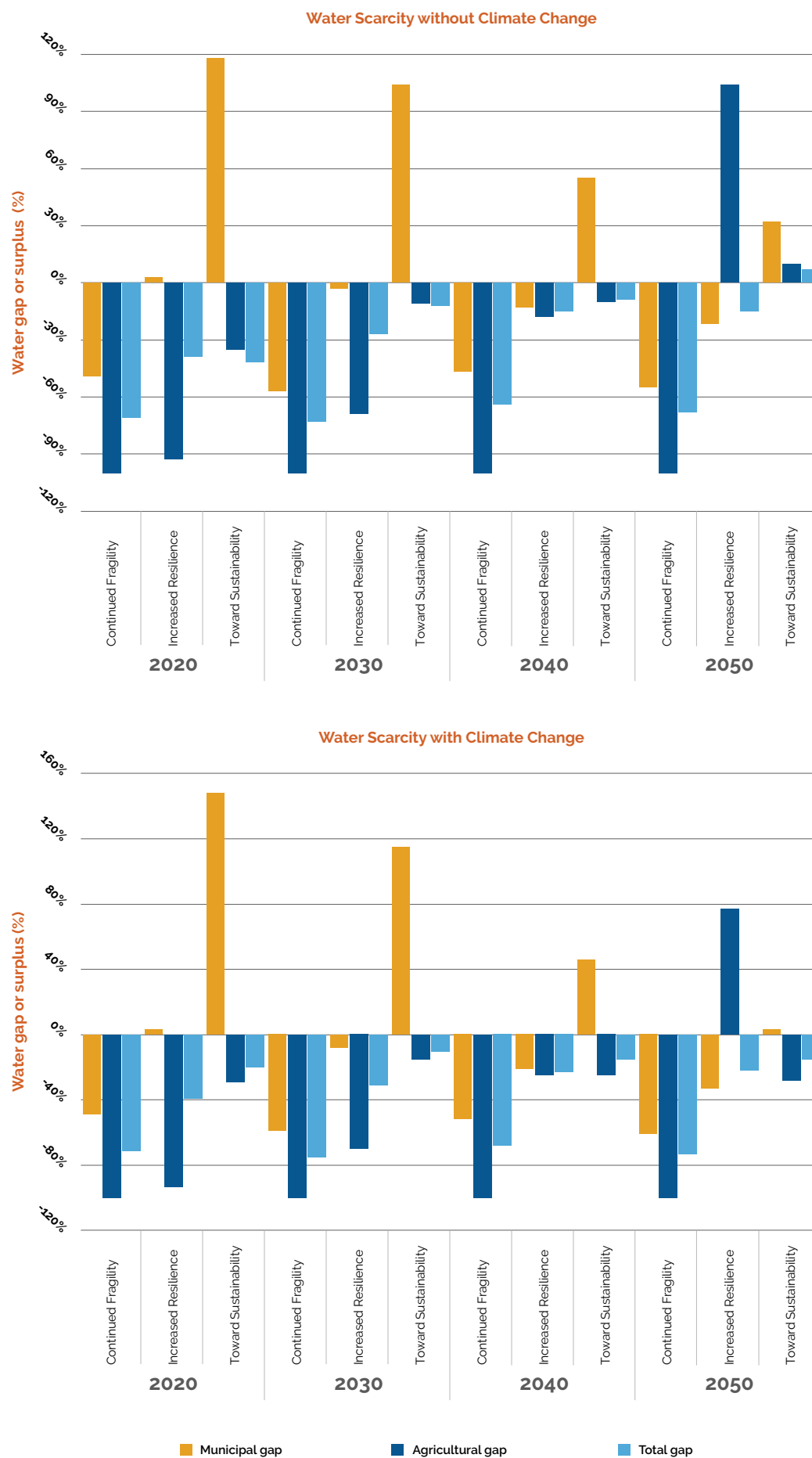
Figure 4.1 Gross Domestic Product Projections in Three Scenarios



Source: Authors' elaboration based on World Bank data.

Note: GDP = gross domestic product; NIS = New Israeli Shekel

Figure 4.2 The Gap between Water Supply and Demand, with and without Considering the Impacts of Climate Change, in Each Scenario



Source: Authors' elaboration based on World Bank data.

CHAPTER FIVE





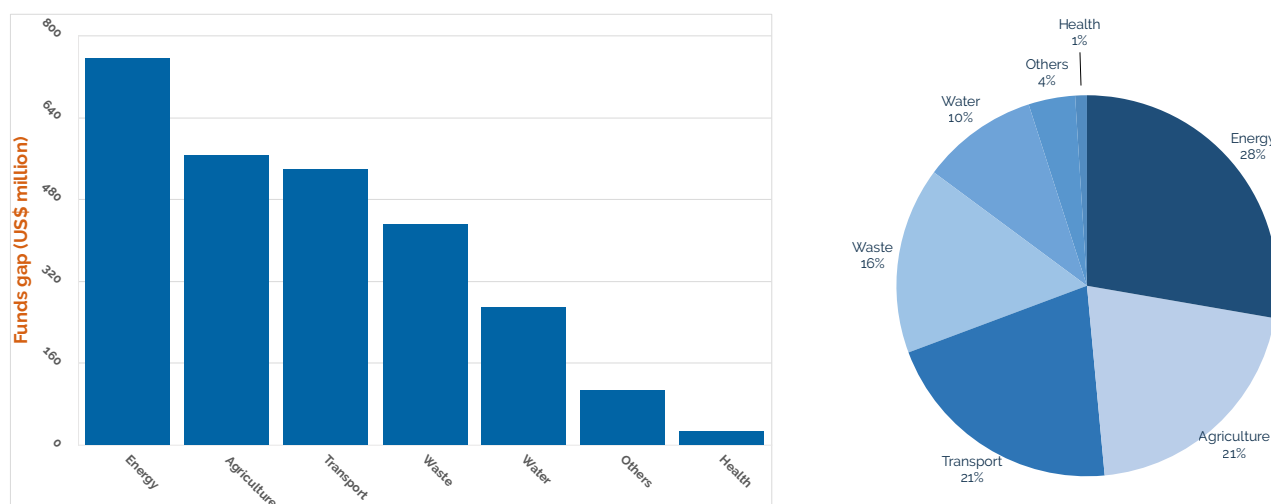
PRIORITIZING INVESTMENTS AND POLICIES AND FINANCING

INVESTING IN THE NATIONALLY DETERMINED CONTRIBUTIONS (NDC)

Investments in strengthening the water, energy, and food (WEF) nexus can build its resilience to a range of exogenous shocks in the West Bank and Gaza. While investments in infrastructure are required, these need to be complemented through a parallel program of investments in institutional reforms to strengthen sector performance, and information that can help inform strategic planning, identify opportunities across the nexus, and ensure agile and adaptive management through effective cross-sectoral monitoring and evaluation. Opportunities across the nexus need to be identified, designed, financed, and implemented through actions by the public and private sectors.

Implementing priority actions identified in the NDC over the period 2021–40 are estimated to cost US\$5.9 billion, with a funding gap of 46 percent. The updated NDC also provides an estimate of the gap in funding to implement adaptation and mitigation actions: US\$2.7 billion, with the transport, energy, and agricultural sectors exhibiting the largest needs (figure 5.1). All the Palestinian NDC actions are conditional on securing international aid. Consequently, meeting the proposed climate change targets will require innovative financing strategies, especially in the context of declining donor support to the Palestinian Authority in recent years. Given the fact that almost all climate-related development finance has been based on grants, attracting investments from the private sector becomes a top priority for the PA.

Figure 5.1 West Bank and Gaza's NDC Funding Gap (US\$2.7 Billion) by Sector



Source: West Bank and Gaza's 2021 updated NDC.

Note: NDC = Nationally Determined Contributions

Technology transfer, capacity building, and efforts to address data gaps are critical for NDC implementation. When relevant to the Palestinian context, West Bank and Gaza could take advantage of an existing well-established market for solar and thermal technology, a developing market for photovoltaic, and technologies like energy-efficient lighting. Greater efforts to expand the understanding of green initiatives beyond solar energy among the local population should be encouraged. Other climate-smart technologies include precision agriculture, water harvesting, water resources monitoring technologies, modern waste collection, recycling, and reusing waste. At the same time, addressing data gaps and linking climate-specific data and information with policy design are key capacity-building needs for West Bank and Gaza.

INVESTING IN THE WEF NEXUS

A new generation of infrastructure is needed to improve synergies across the nexus and increase resilience through circular economy approaches. The financial cost of meeting priority investments in the WEF nexus are significant, at nearly US\$2 billion over the period to 2050. This preliminary estimate is based on model assumptions of projected supply and demand and includes a range of infrastructure investments, institutional measures, and information enhancements needed to improve synergies across the nexus. The resources requirements for such efforts are well in excess of the historical spending patterns in agriculture, energy, and water and will require concerted efforts to optimize the planning, mobilization, and allocation of a broader range of possible financing sources. Bold measures are needed to ensure reliable and sufficient revenue streams to meet capital investments requirements, and their sustained operation and maintenance.

Investments in infrastructure are needed to improve linkages across the nexus and accelerate the transition to a circular economy approach. Investing in improving the efficiency of resource use will be important to increase resilience. Increasing the storage and management of conventional surface and groundwater resources will be important to increase resilience to exogenous shocks and to improve water availability for both municipal and agriculture demands. These efforts need to be coupled with investments in nonconventional water resources, such as desalination, and the upscaling of wastewater (WW) reuse to facilitate the transition from a linear water cycle focused on production, consumption, and discharge to a circular water economy (box 5.1). Such investments will have significant implications for energy demand in and water availability for the agriculture sector. Some of this increased demand can be met by prioritizing investments in renewable energy, such as solar and wind, and exploring the potential for small-scale, local energy production linked to WW. To manage demand, investments are needed to implement efficient irrigation systems, such as drip irrigation or precision sprinklers; reduce nonrevenue water; promote precision agriculture, hydroponics, aquaponics, and vertical farming methods that can optimize water and energy use in agriculture while maximizing yields; and upgrade pumping systems and distribution networks to improve energy efficiency in water supply for municipal and agricultural uses.

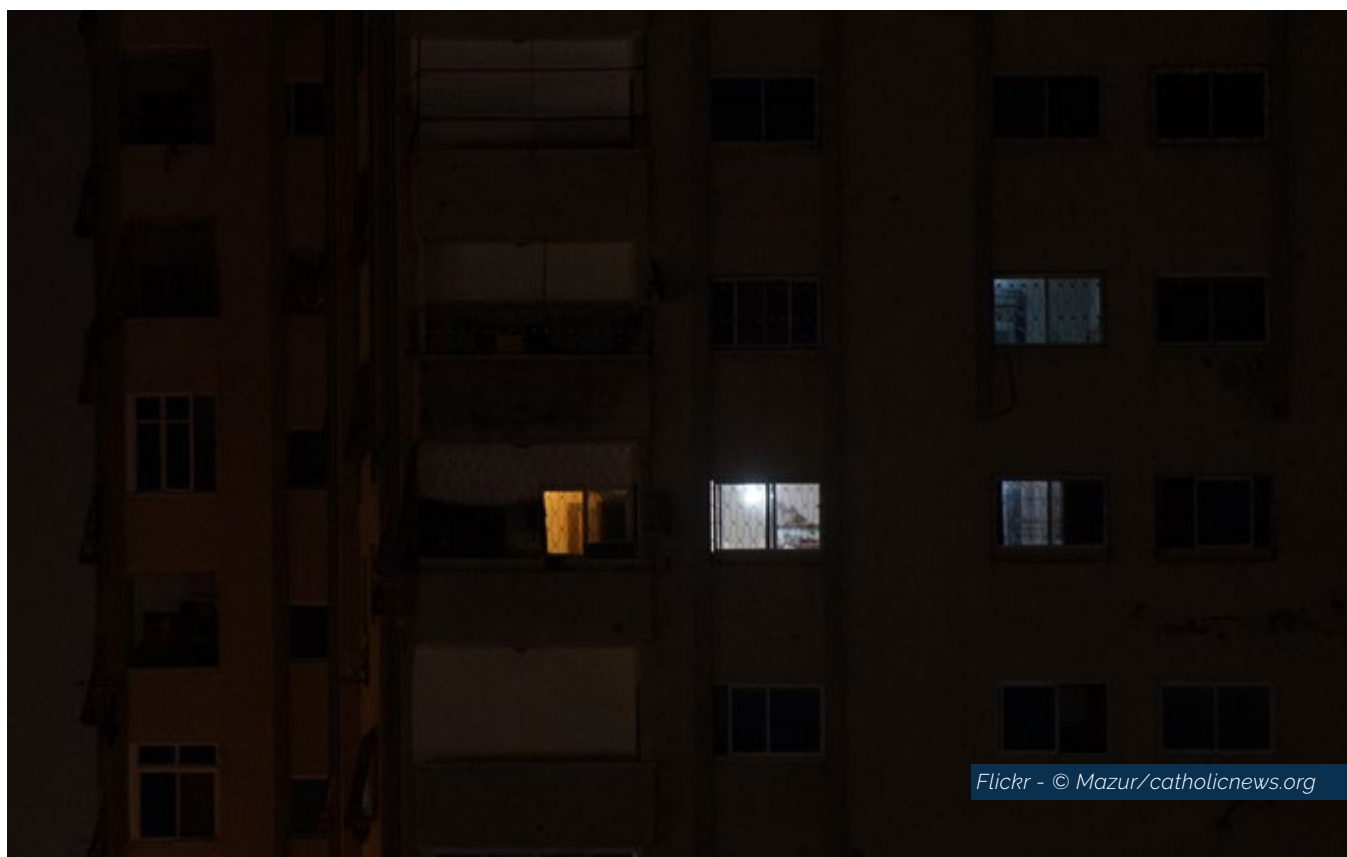




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These investments need to consider whole-of-life costs associated with operation, maintenance, and eventual replacement or refurbishment. This approach helps identify the most cost-effective options, considering factors such as energy consumption, material durability, maintenance requirements, and environmental impacts. By accounting for life-cycle costs, including both direct and indirect expenses, decision-makers can ensure the long-term viability and resilience of infrastructure, leading to more resilient and sustainable services.

Investments in institutional reforms need to accompany those in infrastructure to improve sector performance and leverage synergies across the WEF nexus. Supportive policies and regulations need to be developed and implemented to facilitate integration and coordination of the energy, agriculture, and water sectors. This approach will encourage more strategic planning, identify and address potential risks and vulnerabilities, and promote more sustainable and climate-resilient solutions. The approach relies on stakeholder collaboration, requiring facilitated partnerships of government agencies, water and energy utilities, agricultural associations, research institutions, and local communities. These partnerships require investments in training programs that can build the technical and managerial capacity of professionals working in the water, energy, and agriculture sectors, including measures to strengthen the capacity of partners to negotiate as equals on new projects, agreements, and mechanisms such as the Joint Water Committee. There is also a need to increase public awareness campaigns to facilitate changes in behavior, from promoting water conservation to enhancing value chains and shifting cropping patterns and types.

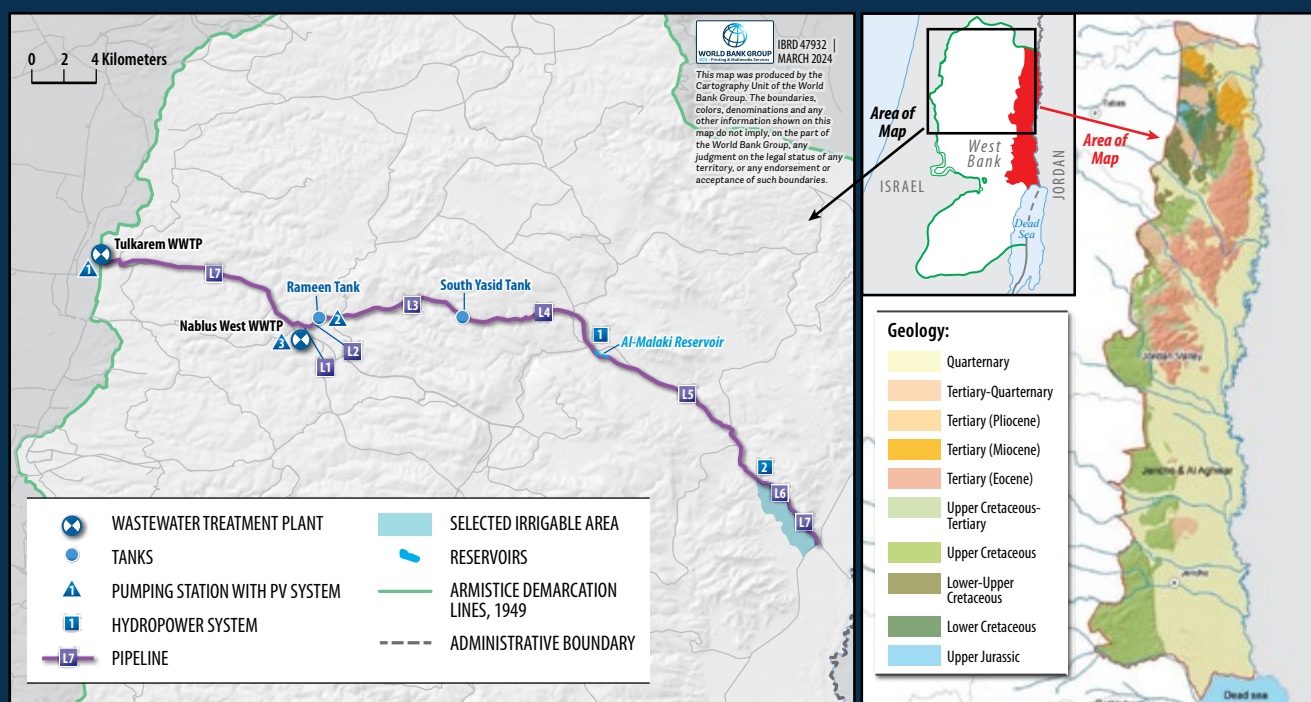
Improved information and investments in data collection are critical for realizing the opportunities afforded by the nexus approach. Data related to energy, agriculture, and water are collected and distributed by stakeholders at multiple levels. Investing in improvements in data collection, consolidation, and monitoring of water resources, energy consumption, and agricultural practices can help identify areas for improvement and enable evidence-based decision-making. Knowledge sharing platforms can help identify opportunities and facilitate the exchange of best practices, research findings, and innovative solutions to build stakeholder capacity. The value of such platforms is increasing rapidly with digital solutions promoting the use of innovative technologies, such as remote sensing, Internet of Things devices, and predictive analytics, all of which enhance planning and management at the sector level.

Box 5.1

CIRCULAR WATER ECONOMY IN THE JORDAN VALLEY

The insufficient water supply in the West Bank poses a significant challenge to achieving adequate agricultural productivity and ensuring food security. Within this context, the potential reuse of treated wastewater is a promising option for generating additional water for irrigation. Furthermore, the unique topographical features of the West Bank and Gaza offer an opportunity to maximize synergies among the food, energy, and water sectors, creating a cost-effective and energy-efficient reuse scheme to enhance water allocations for agriculture and increase resilience to the impacts of climate change.

Map B5.1.1



The Jordan Valley, situated along the Jordan River, is not only renowned for its fertility and dwindling water resources but also for being the lowest place on Earth. The shores of the Dead Sea are approximately 429 meters (1,407 feet) below sea level.

The Palestinian Water Authority has an ambitious plan to divert treated wastewater to the Jordan Valley (map B5.1.1). This would include 3 million cubic meters (MCM) of treated wastewater that the Nablus West Wastewater Treatment Plant (WWTP) produces annually—water not being reused locally. Additionally, with construction of the Tulkarem W/WTP, an additional 6 MCM of untreated wastewater, which flows into Israel, resulting in heavy economic sanctions, could be diverted.

The wastewater would be transported a 50-kilometer distance in the West Bank. Once it is pumped to the highest point at the South Yasid Reservoir, at an elevation of 512 meters above sea level, gravity would facilitate its journey to the Jordan Valley. The estimated annual energy requirement of 25.59 gigawatt hours will be met by three photovoltaic systems, supported by two small hydro power plants integrated into the main water distribution lines near the Jordan Valley irrigation system and a 4.7 MCM reservoir in Al-Malaki. The reservoir will enable complete reuse of treated wastewater.

The reuse scheme would enable the irrigation of 7,466 dunums of land with recycled wastewater at a cost below NIS 1 per cubic meter. The project's estimated total investment requirement amounts to US\$112 million. But date palm cultivation, which dominates the agricultural sector in the area, is significantly profitable, making the reuse of wastewater in the Jordan Valley particularly lucrative.

Unlocking finance to realize the opportunities provided by the WEF nexus and to increase resilience to exogenous shocks will require innovative policy levers (table 5.1). The PA has traditionally played a key role in providing economic and social infrastructure, by serving as financier with the support of various development partners and by establishing enabling policies and regulations. However, such public investments will not be sufficient to meet future challenges. The estimated financial requirements are well beyond historical trends for the water, energy, and food sectors, requiring new approaches to identifying and mobilizing different sources of funding and accessing different financing options, such as innovative climate finance mechanisms. The range of funding and financing options will increase as technologies advance; the PA undertakes policy, institutional, and sectoral reforms; and local capacity increases. These options will influence the revenue streams that can fund investments in infrastructure, institutions, and information related to the nexus. In addition, the options will enable new forms of financing and new partnerships with development partners, the private sector, and communities. Private sector partner and community co-investment, in particular, could unlock additional project value and revenue streams, increase the pool of potentially available funding options, and improve project efficiency.



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Table 5.1 Proposed Policy Levers to Improve Resilience Along the Water-Energy-Food Nexus.

PROPOSED POLICY LEVERS
PILLAR: INSTITUTIONAL STRENGTHENING AND POLICY DEVELOPMENT Institutionalize the WEF nexus. Implement reforms to improve institutional alignment in the water-energy-food nexus, to realize efficiency gains, and to increase resilience. Develop an enabling environment and regulatory oversight for improved water service provision. Take a systematic approach to clustering of service providers, improving their operational and managerial performance and incorporating climate data in planning and decision-making in WSS systems and the WSS sector. Improve data collection, monitoring, and integration. Use data to facilitate robust and resilient decision-making in the face of future uncertainty, especially within the WEF nexus. Improve groundwater management. Ensure sustainable withdrawals and manage risks associated with increased abstraction due to the introduction of new, affordable technologies (such as solar pumps for farmers). Increase capacity for transboundary cooperation. Establish water treaties and other formal agreements, technical committees, and river basin organizations to enhance resilience to variable hydrological conditions.
PILLAR: WATER DEVELOPMENT AND CONSERVATION Reduce nonrevenue water. Make comprehensive investments in reducing losses through district metered areas, metering and monitoring, leak detection and repair, and efficiency improvements to realize significant savings. Develop and rehabilitate wells. Construct and upgrade storm water systems. Increase storage capacity. Create opportunities to increase rainwater harvesting, develop agricultural ponds, and establish large-scale storage options. Increase wastewater reuse. Increase availability of water for irrigation through investments in upgrading existing and developing new wastewater treatment plants with tertiary treatment capacity. Increase desalination capacity. Power desalination of seawater, a climate-independent source of water, with renewable energy to avoid increasing fossil fuel consumption and greenhouse gas emissions. Scale up sustainable rainwater harvesting. Sustainably increase water supply within a holistic planning framework that accounts for impacts on the water balance at the watershed level.

PROPOSED POLICY LEVERS

PILLAR: ENERGY EFFICIENCY AND RENEWABLE ENERGY

Invest in water and wastewater treatment technologies.

Implement a water pressure management system. Regulate pressure in the network to ensure minimal water loss and improve energy efficiency.

Install water pressure reduction stations. Install these stations in areas with high pressure to reduce the water pressure, thereby minimizing leakage and improving energy efficiency.

Substitute treated wastewater for water when safe to do so.

Invest in agri-photovoltaics.

Invest in solar pumps for irrigation.

PILLAR: SUSTAINABLE AND CLIMATE-SMART AGRICULTURE

Shift to drought-tolerant crops. Promote cultivation of drought-tolerant and heat-resistant crops, such as millets, sorghum, or certain legumes, to adapt to reduced water availability and higher temperatures.

Adopt early-maturing varieties. Promote adoption of early-maturing crop varieties to ensure that crops reach maturity before the onset of water stress or high temperatures.

Increase the focus on high-value crops. Promote cultivation of high-value crops, such as fruits, vegetables, or cash crops, to maximize revenue per unit of water used. This shift may lead to increased investments in water-saving technologies such as drip irrigation and precision agriculture.

Diversify crops. Promote growing of a wider range of crops or adopting intercropping, whereby two or more crops are grown together, to increase resilience to changing weather conditions and to minimize the impact of crop failures.

Change planting and harvesting dates. Promote alignment of planting and harvesting schedules with changing rainfall patterns and temperature conditions.

Promote sustainable rangeland management and grazing management interventions. Increase the resilience of the livestock sector by sustainably increasing its carrying capacity.

PILLAR: EDUCATION AND AWARENESS

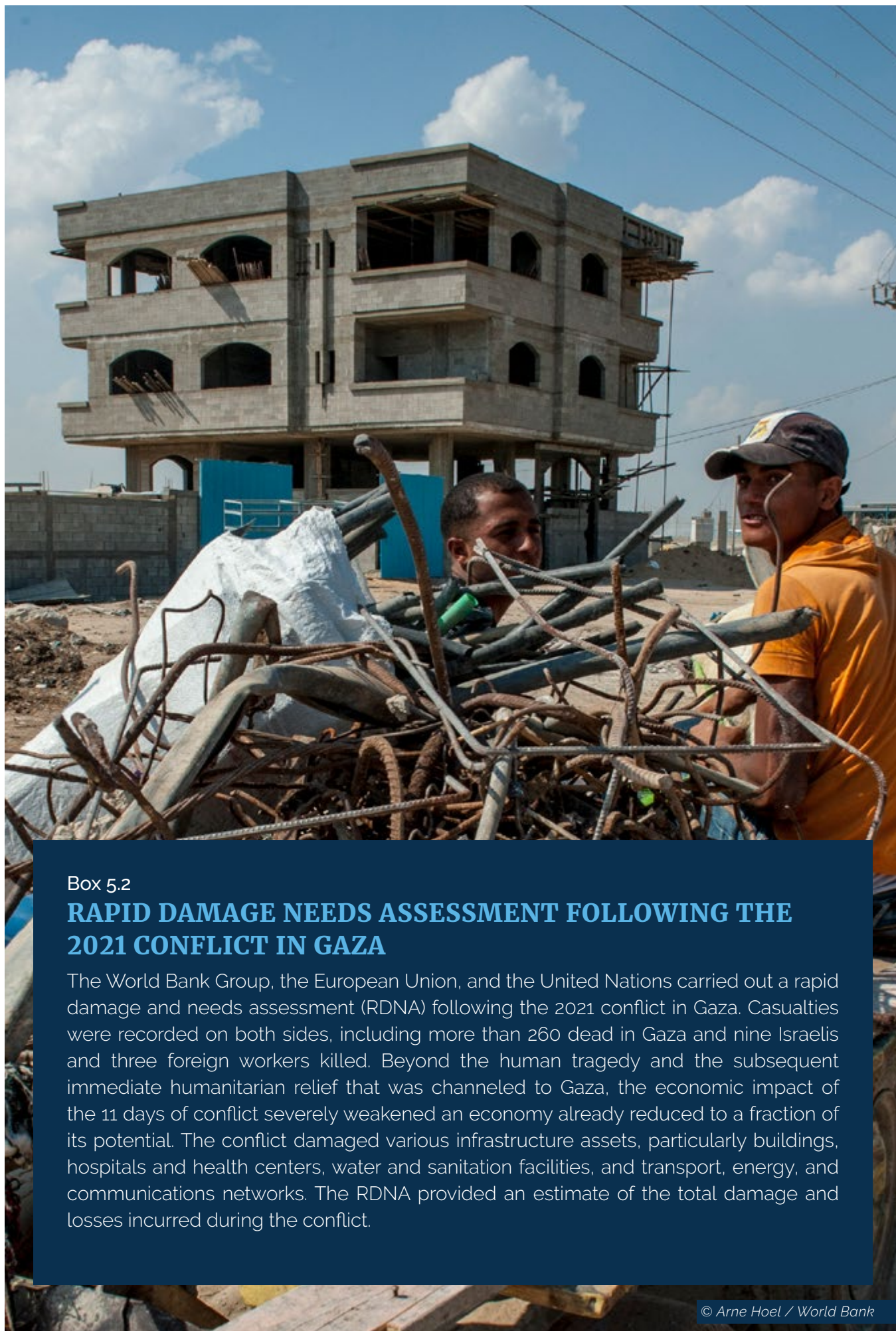
Promote demand-side interventions. Increase conservation of water, payment for public services, tariff revision, and acceptability.

Source: Author's elaboration.

Note: WEF = water, energy, and food; WSS = water supply and sanitation



There are significant challenges to realizing the opportunities afforded by the water-energy-food nexus. Political instability imposes a number of constraints that makes it difficult to plan and implement infrastructure projects and to attract investment and technical expertise to the West Bank and Gaza. Restrictions on the movement of people and goods makes it difficult to import the materials (such as cement, pipes, and chemicals) needed for the development, operation, and maintenance of infrastructure related to the nexus, particularly in Gaza following the near-blockade imposed by Israel and Egypt since 2007. Additional restrictions on the supply of electricity and fuel that can be imported to power electricity generators impose further constraints on operations, accentuating the need for maintenance and rehabilitation. Settlements in the West Bank often encroach on land and water resources, making it difficult to plan and implement water, energy, and agricultural investments, resulting in increasingly complex trade-offs and the potential for zero-sum outcomes. Investments also remain vulnerable to violent conflict, with a number of confrontations through the years having resulted in destruction of infrastructure related to the nexus. (see box 5.2).

**Box 5.2****RAPID DAMAGE NEEDS ASSESSMENT FOLLOWING THE 2021 CONFLICT IN GAZA**

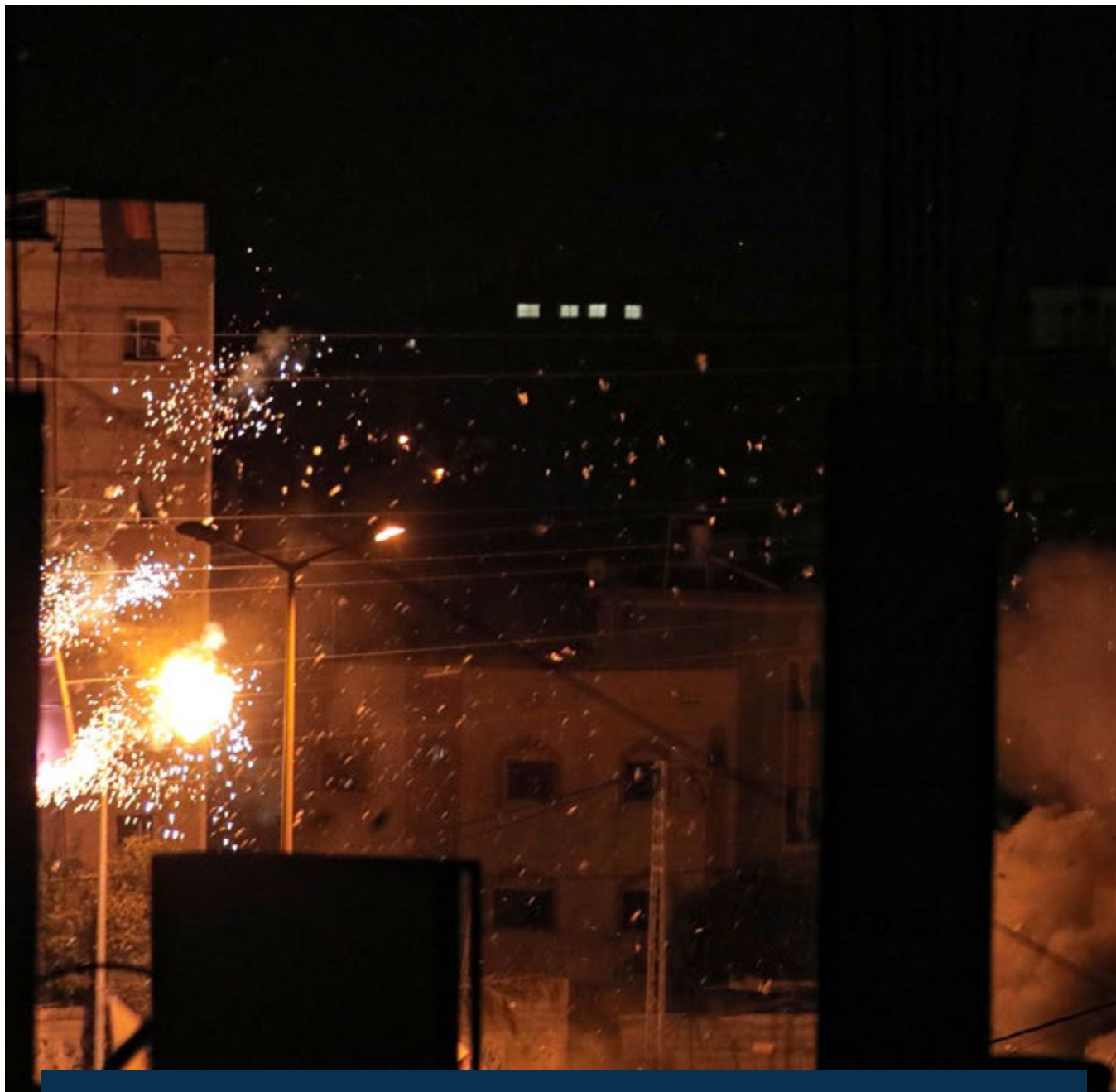
The World Bank Group, the European Union, and the United Nations carried out a rapid damage and needs assessment (RDNA) following the 2021 conflict in Gaza. Casualties were recorded on both sides, including more than 260 dead in Gaza and nine Israelis and three foreign workers killed. Beyond the human tragedy and the subsequent immediate humanitarian relief that was channeled to Gaza, the economic impact of the 11 days of conflict severely weakened an economy already reduced to a fraction of its potential. The conflict damaged various infrastructure assets, particularly buildings, hospitals and health centers, water and sanitation facilities, and transport, energy, and communications networks. The RDNA provided an estimate of the total damage and losses incurred during the conflict.

WATER SUPPLY AND SANITATION (WSS) DAMAGES

The conflict caused damage to WSS infrastructure, including water pipelines, wells, reservoirs, and wastewater systems. The estimated cost of this damage was between US\$10 million and US\$15 million. Immediate and short-term needs in the WSS sector included infrastructure reconstruction, service delivery restoration, and capacity building. The estimated cost for these needs was between US\$15 million and US\$25 million.



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ENERGY DAMAGES

The conflict resulted in extensive damage to the distribution network and power infrastructure. Most power equipment cannot be repaired and needed replacement. The estimated damage to the power infrastructure was between US\$10 million and US\$15 million.

Electricity supply was significantly reduced, with widespread outages. The losses in the electricity sector due to reduced sales and consumers' inability to pay were estimated to be US\$5 million to US\$10 million.

Infrastructure reconstruction in the electricity sector focused on reconnecting power lines and rehabilitating distribution networks. The estimated cost for these needs was US\$20 million to US\$30 million.



AGRICULTURE DAMAGES

The conflict caused significant physical damage to farms, particularly in North Gaza, Rafah, and Khan Younis provinces. The agri-food and fisheries sectors were directly and indirectly affected, including damage to agricultural land, livestock, storage facilities, boats, and fishing gear.

The estimated damage to the agriculture sector was between US\$40 million and US\$45 million, with losses of US\$10 million to US\$15 million.

Total needs in the agriculture sector were estimated to be between US\$25 million and US\$35 million. This ranges includes infrastructure reconstruction and service delivery restoration.

In summary, the 2021 conflict in Gaza resulted in extensive damage to WSS infrastructure, energy distribution networks, and the agriculture sector. The estimated needs for reconstruction and restoration in these sectors ranged from US\$15 million to US\$25 million for water and sanitation, US\$20 million to US\$30 million for energy, and US\$25 million to US\$35 million for agriculture.

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REFERENCE

- UNDP (United Nations Development Programme). 2021. "Towards a Green Economy: UNDP and the Government of Belgium Sign New Agreement to Improve Solid Waste Management in Gaza." December 9.
- World Bank, European Union, and United Nations, Gaza Rapid Damage and Needs Assessment, June 2021. © World Bank, Washington, DC.

<https://openknowledge.worldbank.org/handle/10986/35968>



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CHAPTER SIX



THE ROAD AHEAD

The water-energy-food (WEF) nexus in the West Bank and Gaza is characterized by high vulnerability to a range of exogenous factors. In addition to the natural geo-physical constraints, these vulnerabilities are accentuated by the restrictions on access and movement in the West Bank and near-blockade of Gaza, the ensuing political instability and economic dependency on Israel, coupled with restrictions on movement and access. A scenario that would impose restrictions on access to land and water resources in accordance with the interim agreements made under the Oslo II Accord would increase fragility and impose high costs on economic prospects, human capital, and agricultural and municipal development. Limited access to land and water resources imposes a number of constraints to leveraging nexus synergies, while lack of control over these resources impedes investments that could increase resilience. Climate change will only accentuate these vulnerabilities and further erode social and economic opportunities in the West Bank and Gaza. Building resilience involves advancing equitable access to water resources, enhancing agricultural practices, promoting renewable energy projects, and empowering Palestinian institutions to manage and govern their resources effectively. International support, cooperation, and dialogue are crucial in overcoming the above noted challenges and in achieving a more sustainable and equitable WEF nexus in the West Bank and Gaza.

Impacts on the WEF nexus associated with exogenous factors can be managed but not eliminated. Even under the most optimistic scenario, which relies on enhanced cooperation, water scarcity will impose constraints on municipal development and affect the quality of life, while agricultural production will require significant investments to bridge the gap between potential demand and potential supply through mobilization of treated wastewater for reuse. Perpetuating the status quo will impose increasingly significant constraints on municipal and agricultural development, human well-being, and economic prospects, making it an unsustainable solution. Climate change will only compound costs and increase cascading impacts across the economy. The question is not what can be done to mitigate these impacts, but rather what can be done to reduce their magnitude.

A series of measures need to be implemented to increase the resilience of the WEF nexus and to minimize the negative impacts of exogenous factors. Investments in nonconventional water resources, such as desalination, and the transition from a linear water cycle focused on production, consumption, and discharge to a circular water economy that places greater emphasis on reusing treated wastewater, can help increase resilience to climate uncertainties. These investments need to be coupled with improvements in irrigation and energy efficiency, increases in storage capacity, and reductions in nonrevenue water. These measures must be complemented by institutional and regulatory reforms to improve sector performance and facilitate the integration and coordination of the energy, agriculture, and water sectors, while increasing public awareness, improving financial sustainability, using strategic planning to identify investment opportunities in sustainable and climate-resilient infrastructure, and enhancing cooperation at local, national, and international levels.

Increasing resilience to exogenous factors requires bold action by all stakeholders. Although technical capacity to implement these investments exists, their realization depends on a conducive enabling environment—that is, on a comprehensive political solution that has, thus far, been elusive. In the absence of such a solution, there is an urgency to provide pragmatic approaches that can promote resilience and ensure a sustainable transition toward a peaceful resolution. Interim agreements are long outdated and no longer viable. Confidence-building measures are needed to create an atmosphere that promotes trust and cooperation, specifically in addressing issues related to the WEF nexus, and to foster an environment conducive to productive negotiations that can facilitate agreement on more equitable and sustainable solutions to water, energy, and agriculture. These measures require commitments from the Palestinian Authority (PA) and improved regional cooperation, such as with Israel on issues of access, and with neighboring countries, such as Jordan, on issues related to energy

imports, among other matters. The international development community has an important role in supporting these measures.

There is a need to empower greater coordination to harness the potential of the WEF nexus in the West Bank and Gaza. Limited control undermines the PA's ability to implement effective governance and development policies, undermining the effectiveness of the WEF nexus. It is crucial to establish a clear framework to move from a sectoral to a more holistic, comprehensive and interconnected nexus approach. This transition should be supported by development of a framework for improving policy coherence across the nexus, a framework overseen by a cross-sectoral coordination body responsible for ensuring effective implementation. Additionally, it is imperative to identify financial resources sufficient to cover both capital and operating expenditures in the different sectors, as well as to optimize the programming and alignment of these resources in support of the nexus. Such efforts need to be complemented by institutional reforms that can improve investment planning and implementation as well as enhance the capacity to engage in negotiations.



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There is an increasingly urgent need to improve cooperation in order to ensure equity and empower effective collaborative mechanisms that can facilitate robust, sustainable outcomes. The interim agreement put in place as part of the Oslo Accords is no longer fit for purpose. It is therefore necessary to negotiate a more realistic and equitable agreement that is suitable for future circumstances. In addition, strengthening the PA and PWA to negotiate more equitable and efficient coordination mechanisms and restructuring the joint governance system established under the Oslo Accords could address historical asymmetries and facilitate the rational planning and development of water resources infrastructure. In the interim, the functioning of the Joint Water Committee (JWC) could be enhanced and an independent, third-party arbitrator may help to accelerate decision-making, improve efficiency, and promote equity. Moreover, regional agreements with other neighboring countries are needed to facilitate more cost-effective and diversified sources of energy to meet growing energy demand.

Ensuring resilience requires international actors, regional powers, and development partners to play a more forward-leaning role. The water, energy, and agricultural sectors have received considerable support from a range of development partners over the years. But this support is often subject to the political context, creating considerable uncertainty. A long-term commitment to strategic engagement, rather than emergency response, is needed to address development challenges over the long term. Such a commitment is crucial to provide the financial resources needed to strengthen the WEF nexus and to provide support to the parties involved in negotiations. Such support is essential to bridge gaps among the different actors, to provide independent and objective expertise, and to offer incentives to increase cooperative outcomes around the nexus.

Confronting persistent problems that have thus far proven to be intractable is critical. Perpetuation of the status quo will continue to erode the resilience of the economy and the people of West Bank and Gaza, to the impacts of restrictions in access and compound the cascading effects of climate change.

The collective threat posed by climate change provides an opportunity to explore new cooperative pathways for enhancing resilience in the West Bank and Gaza. Looking at future uncertainties through a climate lens may encourage sustained commitment and open new opportunities. Integrating technical solutions with a process that acknowledges the rights and aspirations of all stakeholders could contribute to a more resilient and prosperous future for the people of the West Bank and Gaza.





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ANNEX A





Image by Ahed Izhiman

INVESTMENT NEEDS IN THE WATER-ENERGY - FOOD NEXUS

INTERVENTIONS (WITH BRIEF DESCRIPTION)	TYPE OF INVESTMENT (POLICY REFORM, INVESTMENT, OR CAPACITY BUILDING)	
2020–30		
<i>Nonrevenue water</i>	Investment	
<i>Rainwater harvesting</i>	Investment	
<i>Agricultural ponds</i>	Investment	
<i>Large dams</i>	Studies	
<i>Desalination</i>	Investment	
<i>Wastewater reuse—upgrading treatment plants</i>	Investment	
<i>Wastewater reuse—new treatment plants</i>	Investment	
<i>Improved groundwater management practices</i>	Policy reform	
<i>Rehabilitation of existing groundwater wells</i>	Investment	
<i>Development of new groundwater wells</i>	Investment	
<i>Construction of storm water systems</i>	Investment	
<i>Upgrading of storm water systems</i>	Investment	
<i>Updated water and wastewater policy and strategy</i>	Study	

	GEOGRAPHICAL SCOPE	COST (USD)	ENTITY RESPONSIBLE	POTENTIAL BENEFITS (MCM PER YEAR)
	West Bank: 15 percent reduction	75,000,000	PWA	83
	Gaza: 15 percent reduction	150,000,000	PWA/CMWU	20
	West Bank	6,300,000	PWA	1.5
	West Bank	1,500,000	PWA	19
	West Bank	45,021	PWA	N/A
	Gaza	25,000,000	PWA	67
	West Bank: Al-Bireh, Alauja	40,000,000	PWA	8
	Gaza: North Gaza	15,000,000	PWA	6
	West Bank: Northeast Ramallah, Tulkarm	85,000,000	PWA	38
	Gaza	58,000,000	PWA	26
	West Bank and Gaza	1,200,000	PWA	
	West Bank	8,000,000	PWA	2.6
	These quantities will be made available by increasing the accessibility to groundwater and the Jordan River	6,000,000	PWA	0
	West Bank: Ramallah, Nablus	36,000,000	PWA	36
	Gaza: Gaza City			
	West Bank: Nablus, Ramallah	80,000,000	PWA	8
	West Bank and Gaza	300,000	PWA	N/A

INTERVENTIONS (WITH BRIEF DESCRIPTION)	TYPE OF INVESTMENT (POLICY REFORM, INVESTMENT, OR CAPACITY BUILDING)	
<i>Transboundary capacity building and negotiations</i>	Study/ capacity building	
<i>Institutional reform</i>	Policy reform	
<i>Demand-side interventions: community behavior change activities related to conservation of water, payment for public services, tariff revision, and acceptability</i>	Capacity building	
2031–40		
<i>Rainwater harvesting</i>	Investment	
<i>Storage</i>	Studies	
<i>Storage</i>	Investments	
<i>Desalination Phase 2</i>	Investment	
<i>Wastewater reuse—upgrading treatment plants</i>	Investment	
<i>Wastewater reuse—new treatment plants</i>	Investment	
<i>Improved groundwater management practices</i>	Policy reform	
<i>Rehabilitation of existing groundwater wells</i>	Investment	
<i>Development of new groundwater wells</i>	Investment	
<i>Construction of storm water systems</i>	Investment	
<i>Upgrading of storm water systems</i>	Investment	
<i>Transboundary capacity building and negotiations</i>	Study/ capacity building	

	GEOGRAPHICAL SCOPE	COST (USD)	ENTITY RESPONSIBLE	POTENTIAL BENEFITS (MCM PER YEAR)
	West Bank and Gaza	300,000	PWA Ministry of Foreign Affairs, WSRC	N/A
	West Bank and Gaza	18,000,000	PWA, NWC, WSRC, SPs—in brief, the PA	N/A
	West Bank and Gaza	2,000,000	PWA	
	West Bank and Gaza	50,000,000	PWA	18
	West Bank and Gaza	5,000,000	PWA/Ministry of Agriculture	N/A
	West Bank		PWA	
	West Bank and Gaza	305,000,000	PWA	90
	West Bank: Nablus	40,000,000	PWA	11
	Gaza: South Gaza			
	West Bank: Jenin, Khalkilia	178,947,368.42	PWA	80
	Gaza	44,736,842.11		20
	West Bank and Gaza	10,000,000	PWA	3.5
	West Bank and Gaza	40,000,000	PWA	10
	West Bank and Gaza	16,500,000	PWA	7
	West Bank and Gaza	32,000,000	PWA	30
	West Bank: Hebron	6,000,000	PWA	10
	West Bank and Gaza	6,000,000	PA	N/A

INTERVENTIONS (WITH BRIEF DESCRIPTION)	TYPE OF INVESTMENT (POLICY REFORM, INVESTMENT, OR CAPACITY BUILDING)	
<i>Institutional reform</i>	Study/ capacity building	
2041–50		
<i>Rainwater harvesting</i>	Investment	
<i>Large dams</i>	Studies	
<i>Large dams</i>	Investments	
<i>Wastewater reuse—upgrading treatment plants</i>	Investment	
<i>Wastewater reuse—new treatment plants</i>	Investment	
<i>Improved groundwater management practices</i>	Study/ capacity building	
<i>Development of new groundwater wells</i>	Investment	
<i>Construction and upgrading of storm water systems</i>	Investment	
<i>Transboundary capacity building and negotiations</i>	Study, Capacity	
<i>Jordan river</i>	Policy reform	

	GEOGRAPHICAL SCOPE	COST (USD)	ENTITY RESPONSIBLE	POTENTIAL BENEFITS (MCM PER YEAR)
	West Bank and Gaza	10,000,000	PWA, NWC, WSRC, and SPs (PA)	N/A
	West Bank:	63,000,000	PWA	15
	Gaza: Al-Muqqalaq, Qana, Al-Muqatta			
	[for next generation of projects]	TBD	PWA	
	West Bank	TBD	PWA	
	5 major WWTP	50,000,000	PWA	14
	West Bank	178,947,368.42	PWA	80
	Gaza	131,973,684.21	PWA	59
	West Bank and Gaza	12,000,000	PWA	3.9
	West Bank and Gaza	41,000,000	PWA	20
	By 2050, all 16 main cities (center of governorates)	44,000,000	PWA	40
	West Bank and Gaza	6,000,000	PA	N/A
	West Bank	800,000	PA	250

Note: CMWU = Coastal Municipalities Water Utility; MCM = million cubic meters; NWC = National Water Company; PA = Palestinian Authority; PWA = Palestinian Water Authority; SPs = service providers; TBD = To Be Determined; WSRC = Water Sector Regulatory Council; WWTP = Waste Water Treatment Plant.

ANNEX B





WEST BANK AND GAZA CLIMATE CHANGE IMPACT ON WATER DEMAND MODEL

1. Estimation of the demand for Water:

The domestic water demand for the years 2020, 2030, 2040, and 2050 was calculated using population data and projections provided by the Palestinian Bureau of Statistics. The international standard of 120 liters per capita per day (lcd) was used as the benchmark for water consumption in the West Bank. However, due to the severe scarcity in the Gaza Strip, this number was reduced to 88 lcd. Additionally, the industrial demand, estimated at 7% of the domestic demand by the PWA, was factored in. To estimate the municipal demand for the entire West Bank and Gaza, the weighted average of the municipal demand in each territory was considered.

The agricultural water demand was estimated by taking into account the irrigated areas and an estimated rate of 600 cubic meters per dunum per year.

2. Estimation of the water supply:

The water supply for 2020 was estimated based on the current water production data provided by the PWA. However, projections for the years 2023, 2040, and 2050 were determined based on various factors. These factors included the investments outlined in the National Water Strategy (NWS) published in 2013, updated investments from the PWA (who is currently updating the NWS), and investments planned under the World Bank portfolio.

The feasibility of these investments and subsequent water supply was considered in relation to the specific circumstances of each scenario studied. In the "Continued Fragility" scenario, only minor increases in desalination were taken into account. In the "Increased Resilience" scenario, improved access to the region's own water resources would allow for increased use of surface water, groundwater, and rainwater harvesting.

In the "Toward Sustainability" scenario, it was assumed that there would be full access to—or alternatively, compensation for— water resources allocation in compliance with international water law. This would lead to further expansion of the water supply.

In the "Continued Fragility" and "Toward Sustainability" scenarios, it was assumed that enhanced access to groundwater resources would initially result in over-abstraction, which would gradually decrease until reaching a sustainable yield by 2040.

For the latter two scenarios, the planned investments in wastewater treatment were assumed to be accompanied by re-use schemes, allowing for an increase in the water supply for agricultural purposes only. It was estimated that by 2050, 80% of the wastewater would be collected, and 80% of the collected wastewater would be treated and available for re-use.

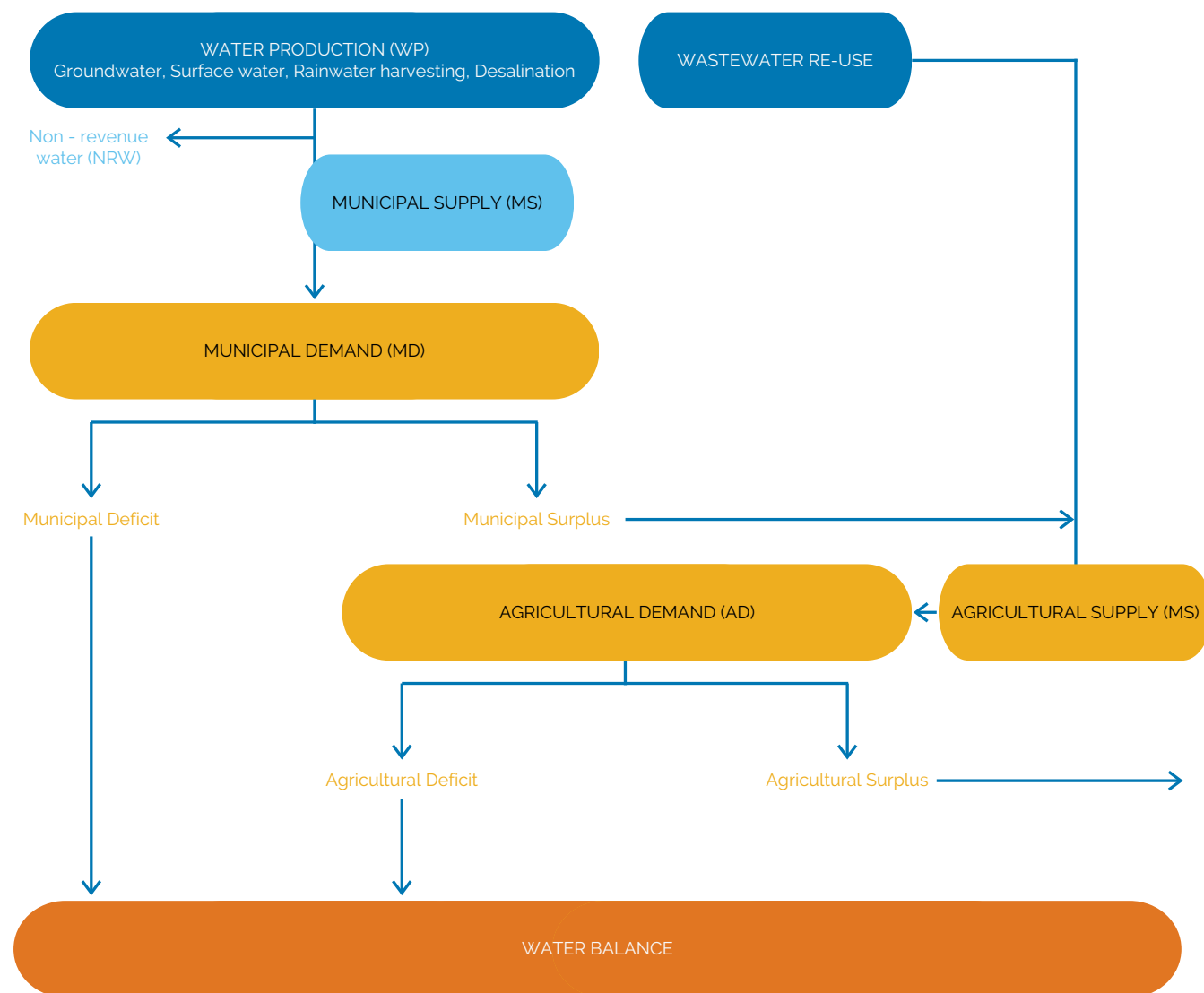
3. Non-Revenue Water

The water losses in the system were estimated to be 31% in the West Bank and 39% in Gaza, resulting in a weighted average of 33% for the entire Palestinian territories. The Non-Revenue Water (NRW) levels were adjusted to reflect gradual improvements in the system for the "Increased Resilience" scenario and more significant improvements for the "Toward Sustainability" scenario. Therefore, by 2050, the NRW levels were estimated to be 25% in the "Increased Resilience" scenario and 19% in the "Toward Sustainability" scenario.

4. Water balance

To estimate the water balances under the different scenarios, it was assumed that Palestinian operators would have the infrastructure to control water allocations effectively and would prioritize the municipal consumption over agricultural purposes. Based on these assumptions, the water balance for each scenario was estimated following the scheme outlined below.

Figure B.1. Estimation of the water balances



Municipal Supply (MS) = Water Production (WP) – Non-Revenue Water (NRW)

Municipal Surplus => Municipal Supply (MS) > Municipal Demand (MD)

Municipal Deficit => Municipal Supply (MS) < Municipal Demand (MD)

Agricultural Supply = Municipal Surplus + Wastewater re-use

Agricultural Surplus => Agricultural Supply (AS) > Agricultural Demand (AD)

Agricultural Deficit => Agricultural Supply (AS) < Agricultural Demand (AD)

In order to estimate the water balance it was assumed that all the water produced, subtracting the Non-Revenue Water (NRW) lost in the system, would be primarily allocated to fulfill the municipal demand. Any remaining water would then be allocated for agricultural purposes. Additionally, treated wastewater would be utilized in re-use schemes for agricultural needs.

As the treated wastewater is not expected to meet the standards for human consumption, any agricultural surplus that may exist cannot be used to compensate for any deficit in municipal water supply. Considering these factors, different methodologies were employed in the model to estimate the water balance. The methodologies used vary depending on the available water sources, as well as the specific municipal and agricultural demands as follows:

1. Municipal and Agricultural Deficit ($MS < MD$ and $AS < AD$). The water production does not meet the municipal demand and only the treated wastewater is available for agriculture.

Water Balance = Municipal deficit + Agricultural Deficit

2. Municipal Surplus and Agricultural Deficit ($MS > MD$ and $AS < AD$). The municipal demand is covered, but the remaining water quantities, in addition to the treated wastewater available for re-use, is not enough to cover the agricultural demand. The agricultural deficit represents the whole shortage of the system.

Water Balance = Agricultural deficit

3. Municipal deficit and Agricultural Surplus ($MS < MD$ and $AS > AD$). The water production is not enough to satisfy the municipal demand, but there is an agricultural surplus resulting from the increase in treated wastewater available for re-use. The agricultural surplus cannot be used to cover the municipal demand and the water shortage is represented by the municipal deficit.

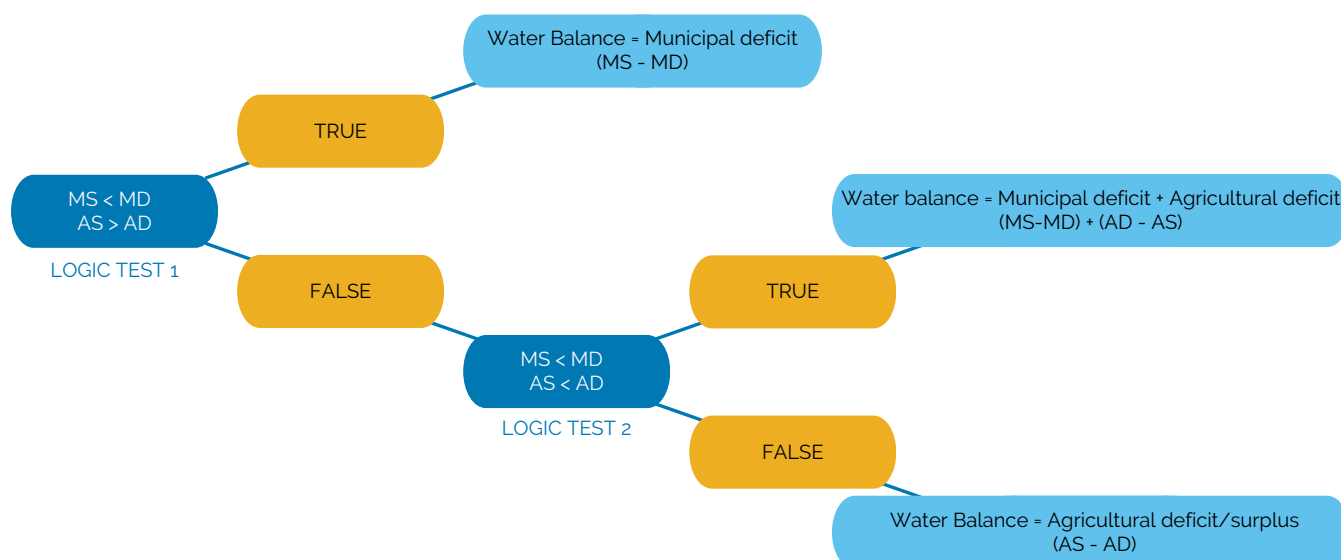
Water Balance = Municipal Deficit

4. Municipal and Agricultural Surplus ($MS > MD$ and $AS > AD$). Water production is enough to cover the municipal demand and the remaining quantities, together with the treated wastewater are enough to satisfy the Agricultural demand. There is a surplus in the system.

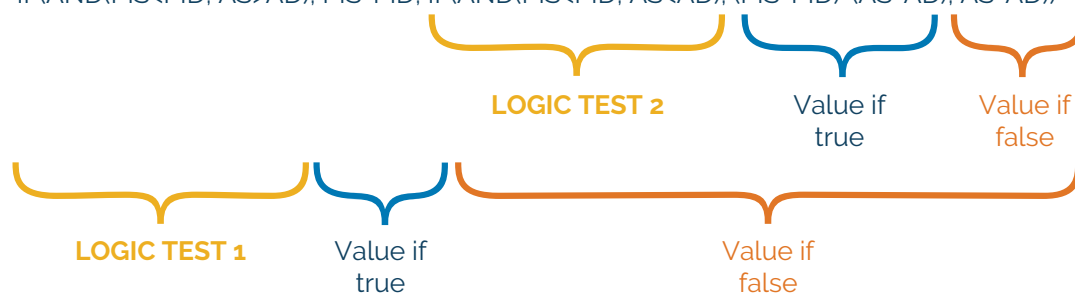
Water Balance = Agricultural Surplus

All these considerations were factored in a single formula following the decision tree on figure 2 below.

Figure B.2. Decision tree for the Water balance estimate



WATER BALANCE = IF(AND(MS<MD, AS>AD), MS-MD, IF(AND(MS<MD, AS<AD), (MS-MD)+(AS-AD), AS-AD))



In the model, the final water balance values on the model are presented as a percentage of the total demand to reflect the system's ability to cover the water requirements.

5. Climate change scenario.

To test the impact of the climate change on the water systems, the model was run under a climate change scenario where the following assumptions were considered:

- An increase in the municipal demand of 1%, 3% and 5% in 2030, 2040 and 2050, respectively.
- An increase in Agricultural demand of 5%, 10% and 15% in 2030, 2040 and 2050, respectively.
- A decrease in groundwater, surface water, and rainwater harvesting production of 5%, 10% and 15% in 2030, 2040 and 2050, respectively.



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