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Gaza: The Water-Energy-Governance Nexus

A Plan of Action for Saving What Has Been Achieved

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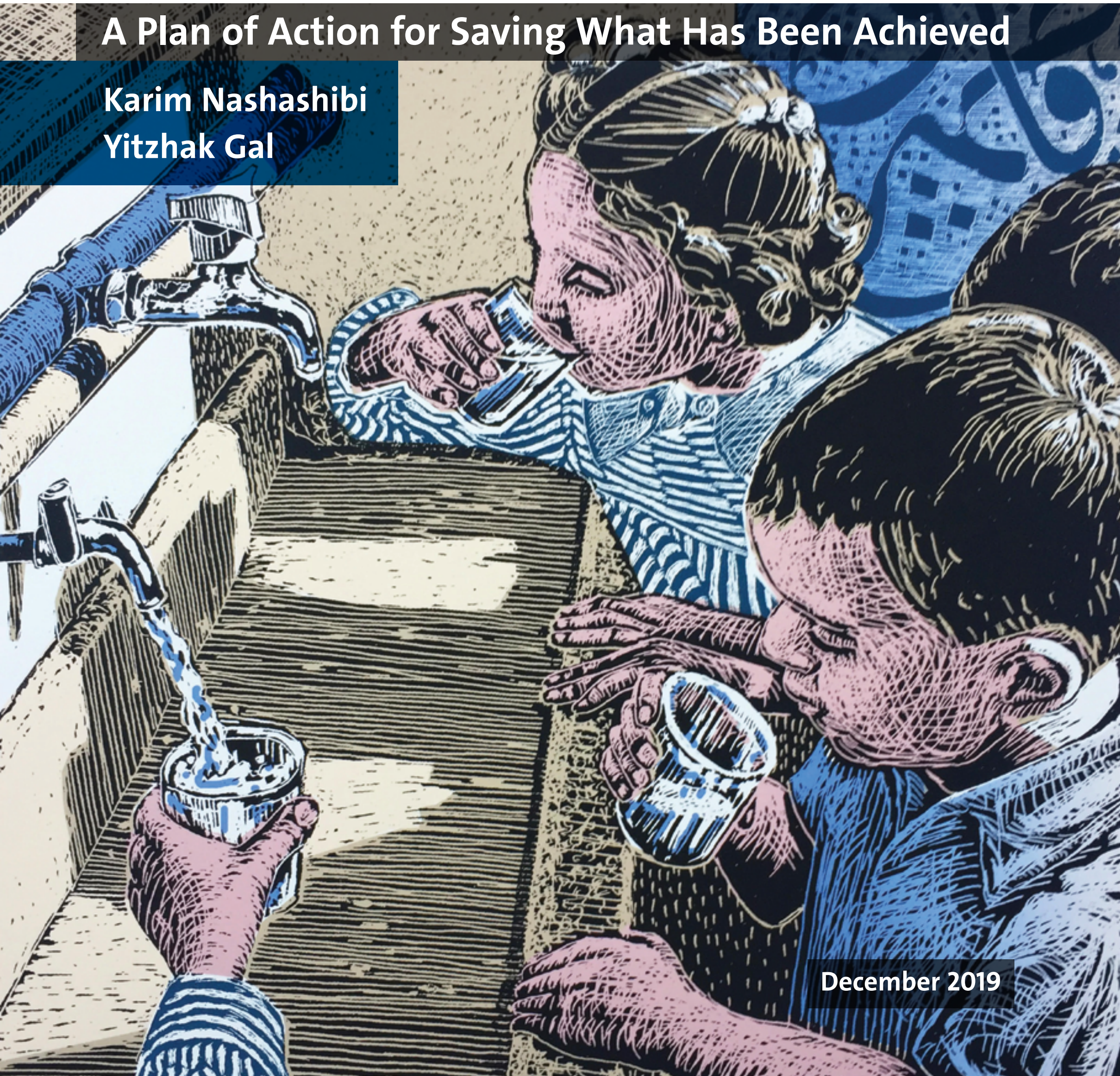

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Preface

The analysis of Gaza's water sector in this study complements our previous study on the electricity sector.[1] The fundamental problems of both sectors are intertwined, and rooted in Gaza's governance problems as well as Israel's continuous siege of the Strip. There is a need for a major reform of water and electricity public institutions in Gaza; while expediting work on raising electricity output. However, these reforms will not be implemented unless Gaza's governance takes the lead in raising bill collections, reducing leaks and diversions of both electricity and water, raising tariffs and establishing a binding legal framework. Correspondingly, as long as Gaza's economy remains depressed due to Israel's restrictions on trade, movement of people and access to its resources, implementing such institutional reforms becomes very difficult. The constant threat of war and political instability further discourages private investment and external aid.

Given the political and economic context of Gaza, only a holistic and comprehensive action plan driven by the donor community, in cooperation with Israel, the Palestinian Authority and local infrastructure institutions in Ramallah and Gaza, can address the interrelated problems of water, energy and governance. To energize the electricity and water sectors and lead them towards financial sustainability, the donor community is urged to take a proactive position and lead such a holistic and coordinated action plan.

1 Karim Nashashibi and Yitzhak Gal, Gaza Electricity Reform & Restoration: Fast Track Approach to Economic Revival (KAS and Abu Tor, January 2019)

Acknowledgements

Our two principal collaborators at Konrad-Adenauer-Stiftung (KAS), Marc Frings and Fee Brinkman have fostered a creative research environment, with free-flowing ideas and discussions. They mobilized several experts in the field as well as major stakeholders in the donor community. Their brain storming meeting in the Ramallah office was particularly successful.

Our partner in Gaza, Omar Shaaban, founder of Palthink, has been very helpful in arranging Karim Nashashibi's two visits to Gaza in April and June 2019, without which this study would not have been possible. His wide range of contacts in Gaza and his boundless energy enabled us to anchor our study in the daily reality of the operation of water, wastewater and electricity infrastructure in Gaza.

Mahmoud Ismail from the Palestinian Water Authority (PWA) in Gaza has been extremely helpful in taking us through Seawater Desalination plants in Gaza and introducing us to brackish water desalination. His deep knowledge of the seawater desalination processes, its relationship with energy supply, and of the institutional environment regulating the water sector, enabled us to focus on various technical and governance weaknesses which have inhibited the development of the water sector.

We are particularly thankful to Mustafa Masood of Masood/Ali Contractors for encouraging us to visit the wastewater treatment construction sites and guiding us through the complexities of wastewater treatment plants, particularly during our visits of NGEST and East Bureij. His knowledge of the working environment in Gaza as well as his insights into the regulatory and decision-making framework was quite revealing.

Monther Shoblak the Director of CMWU and his deputy Eng. Maher El Najjar have been very persuasive in highlighting the challenges –both financial and regulatory—which CMWU faces. As the sole operator of water and wastewater facilities, CMWU deserve strong support. Dr. Ribhi el Sheikh of PWA has been very vocal for the need of a stronger regulatory and legal framework for these facilities. We hope that his vision can materialize over the coming few years.

We thank Engineer Sameer M'teir for his guidance through GEDCO and the way he deals with electricity shortages. We also thank Engineer Maliha who runs the Gaza Electricity Generating Company (GPP) under very difficult circumstances. We highly appreciate Hatem Moghany at PADICO Industrial Zone and Abdel Salam Yaseen who created a state of the arts brackish water desalination plant. Khader-el Sourany, NGEST manager along with the managers of the East Bureij WWTP, both in their twenties, project a strong future for Gaza. They are at the front line at the Gaza/ Israeli border, yet their work has been undeterred.

Discussions with several members of the Palestinian Authority and donor community in Ramallah and Jerusalem: Dr. Shaddad Attili, former head of the Palestinian Water Authority, and Ashraf Khatib of the PLO Negotiations Affairs Department have been particularly fruitful. These discussions with Dr. Shaddad Attili were very much in harmony with our own analysis. They provided a concrete action plan on how to move forward.

The Office of the Quartet was helpful, as it thoroughly covers both water and electricity issues. Our special thanks to Ariel Ezrahi, Director of Energy at OQ, who has reviewed our draft with his colleagues and provided insightful comments. Adnan Azazmeh of OQ put his finger on two key development problems in Gaza: infrastructure and operation and maintenance. Pamela Minnigh, Director of the Gaza UNICEF SLTV project and her deputy, Zaidan Abu Zuhry have been candid and forthcoming in discussing the challenges facing the Khan Younes STLV and its expansion during dire energy shortages. We also thank Adnan Ghoshe of the World Bank. The Bank's WWTP in Gaza, NGEST, has been a model of technological persistence, over eight years of struggle with the Israeli authorities, to allow their equipment into Gaza and to obtain a dedicated electricity line. We have had many discussions with Jonas Blume, Director of KFW in Ramallah. His vast knowledge of wastewater treatment technology and seawater desalination infrastructure has enriched our analysis and policy recommendations. We also thank Nadim Mulhem, the leader of GIZ's projects in Gaza. Finally, we thank Loubna Qutami, Jos Sances and the Middle East Children Alliance for giving us the permission to use their Maia project poster as a cover page.

Anna Hammargren, Norway's Ambassador to Palestine, and Thomas Berdal of her staff discussed with us the various constraints facing the Gaza economy. To ease the electricity constraint, they invested in rebuilding the fuel storage tank at the GPP. Such an action would enable the station to operate a fourth turbine and add 25-30 MW to the electricity supply. This would be a major achievement in improving the daily lives of Gazans

Finally, we must give credit to UNSCO and the Qatar oil facility for their leaders' persistent pursuit of diesel fuel provision to operate GPP's third turbine. The resulting increase in electricity output from 5-6 hours per day to 12-15 hours per

day made a dramatic difference in people's daily lives as well as in infrastructure performance. Jonathan Lincoln at UN SCO, in coordination with other dedicated members of the donor community, kept us on track on both the electricity and water projects in Gaza.

Staff at KAS office in Ramallah, represented in Bishara Sahhar, Administration and Finance Manager, Abeer Zaghari, Hana Hijazeen and Majd Assali, has been very helpful. Majd Assali has excelled in her graphic presentations.

Abu Tor Economic Research Collaborative is a Jerusalem-based think tank that brings together Palestinian, Israeli, and international economists to respond to current challenges with practical solutions. The Collaborative focuses on the Palestinian political economy, its relations with Israel and its economic links to other countries in the region. Sound economic analysis aims at improving living conditions in the Palestinian Territory and enhancing Palestinian capabilities. Such empowerment paves the way for advocating policy changes among various stakeholders and moving toward resolution of troublesome issues.

(KAS) is a German political foundation, associated with the Christian Democratic Union (CDU) of Germany. The foundation is represented in over 90 countries and regional offices worldwide. In the Palestinian Territories, KAS supports local and regional initiatives since 1996 local. These initiatives are directed towards the two-state solution. The country office is currently working in the fields of policy analysis, rule of law, energy security, strategic thinking, civil engagement and dialogue programs.

The Authors

Karim Nashashibi

Karim Nashashibi obtained his Ph.D. in economics from the University of California, Berkeley.

He served as the International Monetary Fund (IMF) Country Director for the West Bank and Gaza from 2001 to 2006. Subsequently, he joined Prime Minister, Salam Fayyad, as his Advisor for Economic and Financial Affairs from 2007 to 2014. During this tenure, he established a macro/fiscal unit in the Ministry of Finance, supporting the Budget process and enhancing the transparency of Palestinian budgetary accounts. He also served as Chair of the Joint Economic Committee working with his counterpart, Yarom Ariav, Budget director, on the Israeli side to address economic and fiscal issues arising from trade and fiscal relations between Israel and Palestine.

Since 2015, he has been working independently for various international institutions on economic and financial issues affecting the WBG and Israel. He published a number of papers. With Yitzhak Gal and Bader Rockas co-authors, Palestinian-Israeli Economic and Trade Relations, International Council of Swedish Industries (NIR) in April, 2015;Palestinian Public Finance under Crisis Management: Restoring Fiscal Sustainability, UNDP, in May, 2015; With Arie Arnon and Saeb Bamya as editors from The Aix Group, he also had some publications: Palestinian Economy under Restrictions: Where Do We Go from Here?, Economics and Politics in the Israeli Palestinian Conflict in March 2015; and Improving the Gaza Economy and Utilizing the Economic Potential of the Jordan Valley in January 2017.

His latest publication – co-authored by Gal and published in January 2019 – under Abu Tor Economic Research Collaborative and its partner KAS is "Gaza: Electricity Reform and Restoration, *A Fast Track Approach to Economic Revival*".

Yitzhak Gal

Yitzhak Gal (MBA, Tel Aviv University) is a long-time researcher of Middle East economic issues. Gal is a research fellow in the Moshe Dayan Center for Middle Eastern and African Studies at Tel Aviv University and Mitvim – The Israeli Institute for Regional Foreign Policies. He has published many articles and academic research works, and he is a frequent lecturer on Middle East economic and business issues to Israeli public and professional audiences.

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Acronyms

AFD	Agence Francaise de Development
COGAT	Coordinator of Government Activities in the Territories Unit (Israeli entity)
CMWU	Coastal Municipality Water Utility CMWU
DFG	De Facto Government
G4G	Gas for Gaza project
GDP	Gross Domestic Product
GEDCO	Gaza Electricity Distribution Company
GOI	Government of Israel
GPP	Gaza Power Plant
GWh	Gigawatt Hour
IEC	Israeli Electric Corporation
IPP	Independent Power Producer
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt Hour
MoLG	Ministry of Local Governments

MW	Megawatt
MWh	Megawatt hour
NGEST	North Gaza Emergency Sewage Treatment
NIS	New Israeli Shekel (Israeli currency unit)
O&M	Operation and maintenance
PWA	Palestinian Water Authority
PCBS	Palestinian Central Bureau of Statistics
PEC	Palestinian Energy and Environmental Research Center
PENRA	Palestinian Energy and Natural Resources Authority
PPA	Power Purchase Agreement
PV	Photovoltaic
PA	Palestinian Authority
PIF	Palestine Investment Fund
RE	Renewable Energy
WWTP	Wastewater Treatment Plant
WSRC	Water Sector Regulatory Council

Executive Summary

- According to the United Nations, most municipal water in Gaza in 2019 is unfit to drink and over 100,000 m3 of sewage have been dumped daily into the sea.
- By the end of 2019, these two issues have been addressed and largely resolved. Water and wastewater infrastructure in Gaza have improved dramatically over the past few years. Thanks to investments by various donors and regional institutions, six state of the arts seawater desalination plants (Short Term Low Volume (STLV) and wastewater treatment plants (WWTP) have been coming on stream in 2018-20. Seawater desalination from three new facilities, coupled with imported water from Israel and current brackish water desalination, would provide enough potable water to cover the needs of most of the population. Similarly, the three WWTP would mostly eliminate the dumping of raw sewage into the sea.
- However, most of these large new facilities have neither electricity nor the funding they need for their operation and maintenance (O&M). Knowing that these six facilities would require an additional 13 MW of electricity and that there is a current shortage of 250 MW raises the question of why the donors failed to invest simultaneously in raising electricity supply to meet their needs. The answer to this question is complex. Bilateral donors from industrial countries are focused on specific projects which they can control, and which also help export their equipment. The Gas for Gaza project (G4G) and the high-tension electricity line (161 kv) from Israel to Gaza do not fit in this vision. Multilateral donors are reluctant to get involved with projects which rely on energy sources from Israel and which would face difficult purchase agreements over which they would have little control. Both categories of donors pinned their hopes of electricity supply expansion without any dedicated investment from their own development funds. Clearly, their hopes have been frustrated.
- Two new water desalination and wastewater treatment plants – Gaza STLV and Khan Younes WWTP – have just been completed and have entered their commissioning period in October 2019. However, neither Gaza STLV nor Khan Younes WWTP are getting adequate electricity. Their operation and maintenance contracts are also not secured (as of end November 2019). Unless sustainable solutions for both issues are found, these two new facilities, costing $ 12.5 million and $ 33.2 million respectively, may fall into disrepair and eventually shut down.

- As for O&M, about $ 30 million are needed annually in recurrent costs to operate these six facilities properly.[2] Neither the PA in Ramallah nor the Gaza Coastal Municipality Water Utility (CMWU) can mobilize these resources under current institutional and political dysfunctionalities: low rate of bill collection (30%); very high non-revenue water (40%); water tariffs (NIS 1.8/ m3), which is only one third of the opportunity cost of importing water from Israel's water company (Mekorot, NIS 3.644.3/m3). There are layers of subsidies: low tariffs subsidize all consumers of water; CMWU subsidize municipalities by surrendering to them 90% of water bill collections, which distort cost structures, incentives, and private investment. At the same time, all these facilities get a massive subsidy from the electricity distribution company (GEDCO) since they are not paying for electricity. Under the financial adversity and budgetary cutbacks faced by the PA over the last few years, the PA is not able to cover the recurrent costs of the six facilities or to increase electricity supply in Gaza by signing power and gas purchase agreements for Gaza.
- While the donor community has been traditionally reluctant to cover O&M recurrent costs, which may be needed for several years, there is a heightened awareness by the donor community that funding of O&M of these six infrastructure plants should be covered by the donors who have invested in this infrastructure for at least 2-3 years until a CMWU/PWA reform program brings them closer to financial sustainability.
- CMWU should be the sole operator of water and wastewater infrastructure. However, it only covers Rafah and 14 out of 25 municipalities and has no unified billing system. CMWU should cover all municipalities in Gaza. However, until this happens, it should draft memorandums of understanding (MoU) with municipalities outside its authority to specify terms and conditions of its management of their water and wastewater facilities.
- Both Gaza's water and electricity sectors lack any effective cost recovery, which is rooted in Gaza's fundamental governance problems. There is a need for a major reform of water and electricity public institutions in Gaza; while expediting work on raising electricity output.
- Given the political and economic context of Gaza, only a wholistic and comprehensive action plan driven by the donor community in cooperation with Israel and relevant Palestinian authorities in Ramallah and Gaza can address the interrelated problems of water, energy and governance.

2 Computed by the authors from Coastal Municipalities Water Utility (CMWU), O&M Budgetary Plan-Water & Wastewater Services 2019 – 2025, p. 6-7. Including depreciation

- This Joint Action Plan should focus on the three major infrastructure policy issues facing Gaza: ensuring sufficient and reliable electricity supply to these facilities, guaranteeing proper O&M of their equipment and undertaking institutional changes to establish an effective regulatory and legal framework to clarify the responsibilities of the three water utilities in Gaza (CMWU; PWA. RSWC) and establish a cost recovery mechanism. Unless this plan of action is instituted and activated, the three STLV plants and three WWTP may suffer gradual degradation.
- The three main stakeholders –Israel, donor community, and Palestinian water and wastewater institutions and Gaza municipalities– will have to play a major role in the economic and institutional recovery of Gaza's water and wastewater infrastructure.
- Israel should expand its trade facilitation measures, relax prohibitions, including reducing the "dual use" list, increase travel permits for businessmen and experts from and into Gaza and allow Gaza workers to work in Israel. These measures are essential for reviving the Gaza economy. That, in turn, is critical for raising utilities bill collection and enforcing payment for services – a cornerstone of economically viable water and electricity sectors.
- The donors are advised to establish an Executive Committee to realize the objectives of the Joint Action Plan, which have been elusive since 2005:
    - Ensure adequate amounts of electricity in the short run to operate the modern desalination and wastewater treatment plants at full capacity utilization by reordering electricity distribution priorities. The reconstruction of a large fuel storage tank at the Gaza Electricity Generation Company (GPP) site, financed by Norway, provides the opportunity to set socially desirable priorities for electricity distribution. By enabling GPP to operate a fourth turbine and add 30 MW to electricity supply, GEDCO can provide dedicated lines to the four remaining facilities (NGEST already has a dedicated line and East Bureij WWTP will be self-sufficient in energy); moreover, the replacement of the methane balloon at NGEST will allow the facility to produce biogas and cover 30% of its energy requirement.
    - Expedite getting natural gas from Israel and the extension of the 161kv line from IEC to Gaza by providing financial backing to long term gas and electricity purchase agreements with Noble/Delek and IEC.

- Improve governance through regulatory and cost recovery actions:
    - Give CMWU full authority as a service provider in Gaza by including all municipalities under its purview
    - Unify the billing system across all municipalities and gradually raise the tariff from NIS 1.6/m3 to NIS 3.2/m3 cost of Mekorot imported water) over three years
    - Launch a campaign to reduce nonrevenue water from 40% to 10% and raise bill collection rate from 30% to 70% over three years
    - Enforce electricity payments. All public buildings, schools, hospitals, refugee camps and institutions should pay their bills. Those who cannot afford to pay, should be provided explicit subsidies through the Ministry of Local Government (MoLG) with budgeted commitments in the PA annual budget.
- The Executive Committee would establish a financial plan to support the reform program and ensure adequate operation and maintenance of the infrastructure facilities handed over to PWA, CMWU and Municipalities. The core of this plan would be a dedicated O&M Fund, which would gradually decline as Gaza's economy recovers and basic metrics of bill collection, tariffs and reduction of water leakages improve.
- The Executive Committee would also coordinate the Israeli measures suggested above to facilitate the movement of people and trade in and out of Gaza and take a pro-active stance in implementing the institutional reforms proposed above and in our previous electricity study.[3]

3 Karim Nashashibi and Yitzhak Gal, Gaza Electricity Reform & Restoration: Fast Track Approach to Economic Revival (KAS and Abu Tor, January 2019)

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1 The economic and political context

Since 2007, Gaza has been under a severe blockade by Israel, and more recently under economic sanctions by the Palestinian Authority (PA). It has been on a downward spiral of denied economic opportunities, poor governance and deteriorating services. Its productive base has been hollowed out and its population has been subjected to three wars, with thousands of casualties and billions of dollars in lost capital stock. Piped water is unfit to drink, and until recently, electricity was only available for a few hours. Over half of the labor force is unemployed and has fallen into poverty. The humanitarian consequences of this relentless degradation for over a decade call for emergency measures just to reverse some of the deterioration.

Hamas, which took over the Strip in 2007, has been confronting Israel relentlessly over its blockade policies. This resulted in three wars in 2009, 2011, and 2014, resulting in severe destruction of infrastructure and housing. Due to the latest war in 2014 the damage was estimated at $ 3.5 billion. Thanks to a consortium of donors at a pledging conference, most of the infrastructure damage has been reconstructed by September 2019. However, over half of the housing destroyed has not been rebuilt. Moreover, the withdrawal of US development aid and budget support from the PA, Gaza and UNRWA and the fact that Hamas is only able to pay 40% of its personnel salaries (the PA pays 50% of salaries for its employees in Gaza) has reduced purchasing power and pushed Gaza further into economic depression. In addition, the PA has reduced its workforce in Gaza by 23,000 since early 2017, thereby withdrawing a large segment of purchasing power from the market[4]. The Gazan economy contracted by 12.5 % in 2017 and 7% in 2018[5]. Unemployment rose from 42% in 2016 to 48% during the first half of 2019.[6]

Since March 2018, "The Great March of Return and Breaching the Blockade" brought thousands of people every weekend on the Gaza side of the border with Israel to protest the blockade imposed by Israel. This resulted in many casualties on the Gaza border and periodic negotiations with Israel on fishing limits and access of Gaza businesspeople and workers to Israel. It is hoped that a longer-term agreement with Israel can be negotiated.

The PA and Hamas seem to have reached an impasse in their negotiations, and the

4 Some of the reduction of the wage bill was due to early retirement provisions and offset by increases in pension payments

5 World Bank estimates. World Bank, AHLC Report April 2019.

6 Source: PCBS, Labor market quarterly surveys 2018 to Q2 2019.

separation between the two territories appears to be getting more entrenched

The decline in pace of economic growth of the West Bank since 2014, and the reduction in foreign aid clearly show that the PA and the Palestinian Water Authority (PWA) in Ramallah cannot support Operation and Maintenance (O&M) expenses for desalination and waste water treatment (WWT) facilities in Gaza or any improvements in infrastructure. The PA was unable to honor its last payments to a local contractor on its O&M contract at NGEST for lack of funds. It is also unable to reach an agreement with Israel on a purchase power agreement (PPA) for a 161 kv line to the West Bank after three years of negotiations for lack of bankable guarantees. This is even worse in the case of Gaza's access to Israeli electricity (through a 161 kv line) or to natural gas (through a gas pipeline from Israel (G4G program)). The PA is already paying for 120 MW of electricity for Gaza and for 10 million m^3 of water from the Israeli water company, Mekorot, through the clearance mechanism. It also cannot afford to carry additional financial liabilities.

A temporary relief in the Gaza electricity and social sectors was provided by Qatar through financing of fuel imports from Israel to the Gaza Power Plant (GPP) as well as financing vulnerable groups-70,000 families through cash transfers and work programs- from October 2018 till the end of 2019. The fuel for the GPP costing $ 10 million per month has raised electricity availability from 4-5 hours to 12-15 hours per day. This has improved all facets of daily life for Gaza's population dramatically. This is to say, instead of spending money on generators, households have been spending it more productively, thus reviving economic activity[7]. Similarly, disbursements of salary arrears and cash transfers to the poor[8] by Qatar financing boosted purchasing power, reduced private debt and brought some stability to an explosive socio-economic situation. Informal imports from Egypt, through the Salah el Din road, have provided Gaza with cheaper imports and products which may face Israeli restrictions when imported through Kerem Shalom. It is also a source of tax revenue for Hamas.

What has crippled the Gaza economy are the restrictions imposed by Israel over the last two decades on imports, exports, movement of people in and out of Gaza to the West Bank and Israel. These restrictions started with the ban on 26,000 Gaza workers to work in southern Israel since 2000. Israel controls the border it shares with Gaza as well as the seashore. It has denied Gazans access to its natural resources: the sea, offshore gas discovered in 1995 and the possibility of establishing

7 OCHA, Monthly Humanitarian Bulletin, December 14, 2018

8 Disbursements of $ 100 per family through post offices. Till September 2019, this was done for eight consecutive months

a seaport and airport.

One of the most crippling trade restrictions applied by Israel on Gaza has been its access on production inputs which could have "dual use" for both civilian and military purposes. As reported by the World Bank, "the restrictions on transfer of dual use goods, as currently implemented, are problematic on several levels. First, the restrictions do not discriminate sufficiently between legitimate and illicit uses. Second, the procedure for administrating the dual use list is opaque and Palestinian businesses do not have the ability to appeal any administrative decisions. Third, the list includes 56 items restricted for both the West Bank and Gaza and an additional 62 items that only apply to Gaza"[9]. The definition of many of the Dual Use items, such as "*communication equipment*" is far too broad, and includes items, such as phone chargers that are mostly for civilian use. Spare parts, medical equipment and home appliances are all affected by these restrictions.

The World Bank estimates that the removal of dual use restrictions for businesses in Gaza would provide additional economic growth of 11% of GDP[10].

2 The water crisis in Gaza

There has been a dramatic decline in access to drinking water in Gaza between 2010 and 2016 according to two major surveys[11]. Piped municipal water extracted from the aquifer for domestic use- about 84 million m^3 or 52% of total extraction- tends to be salty in several areas and 97% of it does not meet WHO standards -maximum of 250 mg/l chloride concentration[12]. This makes the water unfit for drinking. Households can use it for washing, cleaning and gardening but they are forced to buy desalinated brackish water for drinking purposes from local entrepreneurs, who roam around the streets with tankers. The World Bank estimates that 97% of the population relies on brackish water desalination carried out by this informal water sector.[13]

The reason for this water crisis is that about 180 million m^3 are extracted yearly from the Coastal Aquifer -the only source of water in Gaza, which far exceeds the yearly recharge from rain of 55 million m^3. As a result, groundwater reserves are

9 World Bank "Economic Monitoring Report to the AHLC" April 30, 2019 p4

10 World Bank, ibid, p. 4 para 8

11 LGPA, Local Government Performance Assessment, 2016; and MICS, Multiple indicator Cluster Survey 2015

12 Most of the water has chloride concentration of 500-1500 mg/l

13 World Bank: Towards Water Security for Palestinians, ibid.

being depleted. There is also sea water intrusion which causes increased salinity. In addition, there is some seepage of sewage water into the groundwater table as well. Shortage of water has resulted in a proliferation of private wells, estimated at 5,000 wells, into the aquifer. Neither the Coastal Municipalities Water Utility (CMWU) nor the PWA in Gaza are able to regulate this digging of wells.

a. Water for domestic uses

Gaza has relatively good water infrastructure. Municipalities extract ground water from the Aquifer through 260 groundwater wells which had to be dug deeper every year because of receding water table (up to 40-50 meters). Almost every household, 94% is connected to the municipal water distribution network. While municipal water from the tap costs NIS 1.6-2.0 per m^2, desalinated brackish water in bulk for truck delivery costs NIS 4 per m^3. However, consumers who want the water delivered to their house or apartment buildings pay NIS 20-30 per m^3, depending on volume and ease of access. This price differential is taxing the poor segments of society who are often forced to drink sub-standard water, potentially causing health problems.

There are about 150 operators, private and public, who desalinate brackish water through Reverse Osmosis (RO) using groundwater wells. selling about 4 million m^3/year to households[14]. Their pumps are hooked up to the electricity grid and backed up with diesel generators. Only 31% of the operators are licensed, and only 8% of operators renew their licenses yearly. While the PWA in Gaza drafted regulations for brackish water desalination, specifying minimum health standards, these regulations were not enacted due to governance paralysis in Gaza. Most of this water is chlorinated, at various concentrations, and they lack essential minerals, such as magnesium and calcium. A recent survey found that 47% of the samples had some degrees of contamination at source[15], rising to 68% after distribution and storage. This water is distributed through a fleet of small trucks pumping water to storage tanks on the roofs of apartment buildings and selling it to households.[16]

It should be emphasized, however, that unlike seawater desalination, brackish water desalination draws water from wells which further deplete the aquifer. However,

14 According to the Ministry of Health 90% of household use desalinated brackish water for drinking

15 Infected by Total Coliform (TC). The survey included 156 operators in 2015, of which 48 were licensed. Drinking Water Qualitative Survey, GIZ and PWA, September 2015; Survey of public and private brackish water desalination plants September 2015.

16 Several small-scale projects for rehabilitation of wells have taken place, including OXFAM's (UK) project for rehabilitation of 46 brackish desalination plants, (16 public and 30 private) serving 58,000 people living in Gaza.

it did provide a critical source of potable water during emergencies for instance during the 2014 war, when the municipal water network was damaged[17]. Brackish water desalination should be viewed as a temporary solution until there is enough seawater desalination to meet Gaza's demand. This would help recharge the aquifer to a self-sustaining source of clean water. Moreover, most of the brine from desalination operations is discharged into the sewage system, raising salinity of the wastewater and making it more difficult for reuse.

Another source of potable water, which substantially exceeds supply of desalinated brackish water, comes from water imports from Mekorot, Israel. Gaza used to import about 5 million m^3 of water from Israel since 1994 but since 2015 it has been importing 10 million m^3 with improved connection lines to the Gaza border[18]. This fresh water is blended with low salinity local water (Al Muntar mixing facility, being constructed with EU support, effectively providing Gaza with 20 million m^3 of potable water per year which meets the WHO quality standards). In March 2016, Israel pledged to supply Gaza with an additional 5 million m^3, once the connection points and supply lines are established.[19]

Gaza could import all its domestic water needs from Israel. Israel has the capacity to supply 100 million m^3/year of water to Gaza, if the PA could ensure payment for the water delivery. Aside from raising its dependency on Israel further, importing more water from Israel may be more efficient than launching major desalination projects. Nevertheless, for geopolitical and "water security" considerations, it would be rational for Gaza to develop its own sources of seawater desalination, combined with higher water imports from Israel.

b. Water for agriculture – increased salinity and reduced accessibility

Almost one half - around 85 - 90 million m3 -of the 190 million m^3 extracted annually from the Coastal Aquifer were used in agriculture.[20] The availability of water for irrigation is on a declining trajectory due to groundwater depletion and increased water salinity. Irrigation water supply has been further diminished in the wake of successive wars with Israel which damaged wells and irrigation infrastructure as well as "dual use" and other prohibitions on imports of agricultural

17 Only 50% of municipal water supply in Gaza was operating

18 PWA, Gaza Water Security Mapping Project, June 2019, pp 16-17

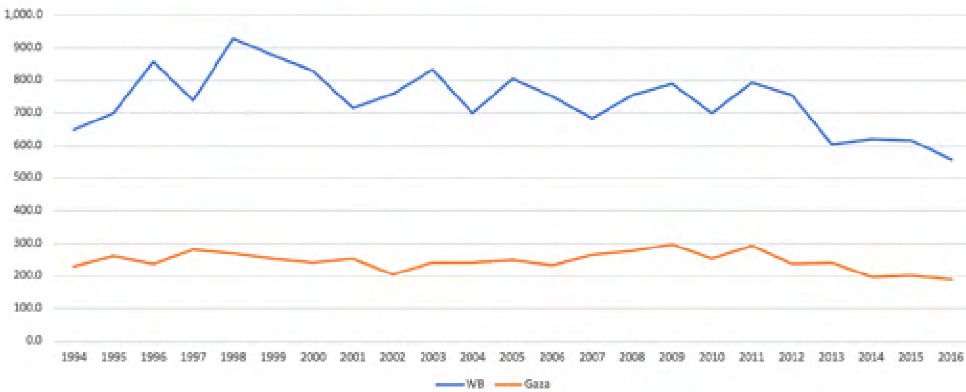
19 PWA semiannual report June 2019 p14

20 World Bank, "Toward Water Security for Palestinians" (2018), p. 16 (85 million m3 in 2014); PWA, National Water and Wastewater Strategy for Palestine (2013), P. 67 (86 million m3 in 2012); PWA and Austrian development Agency, Infographic: Water Crisis in Gaza (2015) (93 million m3)

equipment and inputs.[21]

Agricultural output has declined in both Palestinian regions, but the decline is more pronounced in Gaza. Since 2009, the value of agricultural output in Gaza, at constant prices, has declined by 37%, from $ 296 million to $ 188 million in 2016. The 2014 war caused the destruction of 30% of agricultural land (29,000 dunums, of which 2,798 dunums of greenhouses). In addition, 358 irrigation wells have been destroyed, as well as piping and irrigation systems[22]. Most of the infrastructure damaged during the 2014 war has been reconstructed by end 2018, providing the opportunity for resumption of exports of fruit and vegetables.

Chart 1. Agricultural output in the West Bank and Gaza 1994-2016 at constant prices in US dollars millions (2015 base year)



Since 2016, Israel relaxed its restrictions on agricultural exports to the West Bank, Israel and abroad. This resulted in a substantial increase in agricultural output since 2017. This increase is not captured in chart 1. From January to September 2019, exports of agricultural products from Gaza increased by 97% over exports during the same period in 2018. These exports also marked a similar increase over 2017. During October 2018 to September 2019, 254 truckloads per month of fruits and vegetables left Gaza mostly for the West Bank, and to a lesser extent for Israel. This marks substantial progress since the 2014 war, coming close to the pre-2007 agricultural export magnitude[23].

A visit to a high-end farm with greenhouses in Deir el Balah revealed a typical

21 The 2014 war caused the destruction of 30% of agricultural land (29,000 donums, of which 2,798 donums of greenhouses). In addition, 358 irrigation wells have been destroyed, as well as piping and irrigation systems (World Bank "Needs Assessment" for reconstruction).

22 World Bank "Needs Assessment" for reconstruction

23 Around 300 truckloads per month of agricultural exports in 2005–2006 (see detailed analysis in Annex A (d)).

pattern of water use for irrigation in 2019: groundwater pumped from its artesian well with a high level of salinity (1,700 p/m)[24] is mixed in a blending basin with several parts of water trucked from local brackish water desalination plant at NIS 15/m3 to reach a level of 500 p/m of salinity. This is tolerable for irrigation purposes. Tomatoes and eggplants are exported to Israel while a large variety of vegetables are exported to the West Bank which accounts for 85% of Gaza vegetable exports[25]. However, this process is expensive. Trucking desalinated water to farms to irrigate vegetables undermines their competitiveness. Providing municipal water with low salinity would substantially increase production and exports.

Supply of good quality irrigation water became a critical input for agriculture, particularly for greenhouses. This raises the question of how to improve irrigation infrastructure and how to increase the supply of water with low salinity to agriculture. Only a fraction of treated waste water is reused for irrigation. Given the large expansion in wastewater treatment plants, a large potential for increase in irrigation water would be possible. While water reuse from wastewater treatment plants cannot be used to irrigate vegetables or cereal fields, it could be used to irrigate olive groves, other fruit trees and fodder.[26]

c. Seawater desalination in Gaza

Aside from imports from Israel, seawater desalination may be the most efficient path for water supply in Gaza, but it is heavily dependent on energy availability. There are presently three small desalination plants in Gaza (Short Term Low Volume - STLV) with total installed capacity of 8.1 million m^3 per year. In addition, the construction of a large-scale desalination plant and associated works in southern Gaza was launched in 2018 with the objective of producing 55 million m^3 per year.

The Palestinian Water Authority (PWA) plans to expand STLV plants to a combined capacity of 13 million m^3 per year, which is about three times the capacity of the brackish water desalination used for drinking. So far, however, total installed capacity is more limited; it is 8.1 million m^3 per year while actual desalination is only 9 % of installed capacity[27]. In 2017, the Khan Younes (UNICEF/EU) and Deir el Balah

24 WHO standards are 250 p/m for potable water

25 Gaza food exporters noted three major limitations on their exports. 1. Trucks are only allowed at Kerem Shalom from 6am, thereby losing a day. 2. Israel only allows tomatoes and eggplants imports from Gaza. 3. Gaza cannot import fertilizers under the “Dual Use” rules. However, as of July 6, 2019 Fertilizer imports are allowed as a result of the facilitation agreements between Hamas and GoI

26 Treated wastewater is not allowed for irrigation where it directly touches a product used for human consumption (such as vegetables of field crops for human use).

27 PWA RPI semiannual report, June 2018, pp17-18

(Austria/USAID) plants jointly produced 2,253 m^3 per day on average, while in 2018 they produced 2,512 m^3 per day[28]. This is only 0.92 million m^3/year.

- Gaza STLV project has just been completed and has entered the commissioning phase. It has a production capacity of 10,000 m^3/ day (3.7 million m^3 per year). Funded by the IDB ($ 12,6 million) it will serve 200,000 people in Northern Gaza.
- Middle area (Deir el Balah) STLV. This is the oldest seawater desalination plant built in 2003, with a capacity of 2,600 m^3/ day (0.95 million m^3 per year). It only produced 300 m^3/day due to power shortages and the equipment deteriorated which was attributed by the PWA to lack of operation and maintenance funding[29]. The Austrian Development Agency funded its repair and maintenance. It was expanded in 2016 with USAID financing ($ 17.3 million) to a capacity of 6,000 m^3/ day (2.2 million m^3 per year). This work has been completed in January 2019, but has not yet been commissioned due to the abrupt recall of USAID engineering staff in February 2019 by the Trump administration. The old Deir el Balah plant contiguous to the new USAID one is operating thanks to its rehabilitation, but capacity utilization is only 200 m^3/ day (4% of capacity, June 2019). This is due to power shortages. Desalinated water is sold to schools through tankers at NIS 4 per m^3 and the plant is not hooked up to the municipal water network.
- Construction of the Khan Younes STLV desalination plant started in September 2012 but was only completed in 2017. Funded by the EU (10 million euros) and implemented by UNICEF in partnership with PWA and CMWU, it has a capacity of 6,000 m^3/day (2.2 million m^3 per year) serving 75,000 people in the Rafah/ Khan Younes area. Until mid-2018, this plant operated with only 4 hours a day of electricity and capacity utilization was only 9%. Thanks to the Qatari oil facility, which raised electricity output at the GPP, the Khan Younes plant received 8 hours of electricity per day during the January-June 2019 period, raising capacity utilization to 17%. After two years of operation, this low capacity utilization was caused by both shortages of electricity and lack of O&M funding[30]. Yet, an expansion of the plant to a capacity of 7.3 million m^3 has been launched with financing from the EU of $ 20 million, but with lingering doubts about availability of electricity and O&M funding.
- All in all, with existing STLV facilities, supply of potable water can potentially reach 22.5 million m^3 per year, 10 million m^3 of which would annually come from

28 OCHA Gaza Strip: Early warning indicators April 2019

29 PWA semi-annual Report, June 2018

30 PWA: RPI Semi Annual Progress Report, June 2019, p18

Mekorot for blending with municipal good quality groundwater in blending reservoirs; 8.1 million m^3 per year from the three STLV desalination plants[31] at full capacity utilization and 4.4 million m^3 per year from desalination of brackish water. However, actual supply during mid 2019 is much lower, at 15.5 million m^3 per year due to low STLV output, producing only 0.9 million m^3 per year 9% capacity utilization for lack of electricity[32].

The Gaza Central Desalination Plant (GCDP) and associated works (AW) has been launched in Brussels in March 2018 by the PWA and the EU[33], based on a "design, build and operate" contracting. It is expected to be completed by 2024. It will provide 55 m^3 per year of drinking water and will cost about $ 680 million. At the pledging conference in Brussels, $ 565 million were secured, or 80% of the financing needs[34]. It will require 25 MW of electricity and is expected to develop its own sources of energy at the initial stages (turbines powered by diesel fuel), until it can receive natural gas feedstock and PV electricity. At that point, desalinated water could be produced at NIS 2.5 per m^3, a little above the cost of the water at the Sorek plant in Israel but less than the water imports from Mekorot (NIS 3.2 per m^3). An upgrade of the distribution network of potable water will be needed to absorb this new source of supply, including a North/South water carrier. The Design-Build-Operate contract which is being awarded by EIB will include Operation and Maintenance, thereby solving the funding of the O&M issue, which has undermined most of the facilities analyzed in this study.

Two of the six Associated Works have been already tendered (connection to Mekorot supply in Khan Younes and "Southern Main Carrier system"). A third package related to the reconfiguration of the water distribution network in Middle and Southern Gaza will be tendered in September 2019.

With the completion of this project and bringing the STLVs to full capacity operation, while raising imports from Mekorot from 10 million m3 per year to 15 million m^3 per year, there would be ample potable water in the Gaza municipal water network meeting WHO standards. The water crisis in Gaza would be solved.

31 Excluding the expansion of the UNICEF/Khan Younes plant from 2.2 million m3/year to 7.3 million m3/year which will take 2-3 years to be completed.

32 See PWA/LACS Semi-Annual Report, June 2018

33 In partnership with the PWA the European Investment Bank, the World Bank, the Islamic Development Bank and the Office of the Quartet.

34 By April 2019, a gap in funding of $ 130 million remained. The Islamic Development Bank (IDB) was a major contributor to this project and Trust Funds were established to mobilize and disburse funding. Kuwait contributed to the AW and the North South Carrier. A task force including the EU, PWA, COGAT, Office of the Quartet and the World Bank has been established to coordinate Project implementation, entry of equipment and financing.

d. State of the art Wastewater treatment infrastructure

Access to modern sewage connections in Gaza is quite high - 78%- much higher than in the West Bank, where it reaches 30%. Rural communities which are not connected to the sewage network rely on cesspits.

Over 100,000 m^3 of wastewater (WW) is being dumped into the Mediterranean daily, polluting the beaches both in Gaza and southern Israel. Donors and the PWA have recognized this problem as early as 2010 and launched three major wastewater treatment projects with biogas facilities, solar panel fields, and reuse of treated WW in agriculture. When the three projects are in operation at full capacity utilization of 119,000 m^3 per day, they would fully absorb the sewage which is currently discharged into the sea. These three plants will serve over 1.2 million residents, covering all the main urban areas of Gaza.

- The North Gaza WWTP (NGEST) took eight years to construct[35] and started operating since March 2018 for over a year at full capacity -35,600 m^3 per day. It has a dedicated electricity line from GEDCO and operates daily for 24 hours. It has a biogas facility which will produce 20% of its energy requirement as well as a solar panel field. However, the methane balloon has been damaged during the 2014 war and is still awaiting repair. NGEST will also irrigate 15,000 dunums when the irrigation network for the contiguous agricultural lands is constructed. Funding for this irrigation network, of 45 million Euros has been provided by AFD.
- Central Gaza WWTP (East Bureij) is expected to be commissioned during the first half of 2020, with a capacity of 60,000 m^3/day.[36] It will require 3 MW of electricity during the six months commissioning period, after which it may become self-sufficient in energy thanks to biogas facilities and a solar field. It would rely on the grid during night hours and can sell back electricity to the grid during daytime. This is a groundbreaking project, considering the shortage of electricity in Gaza. By contrast to the other two WWTP, it was designed to be self-sufficient in energy. However, because of high salinity, its effluents are not suitable for reuse.
- A third WWTP has been constructed in the Khan Younes area with a capacity of 26,000 m^3/day and commissioned in September 2019.[37] This plant will require 3.7 MW of electricity and its effluents could be used for agricultural production when a funding gap of $ 25 million is covered.

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35 Funded by the World Bank and AFD, costing $ 44.1 million.

36 Financed by KFW and costing Euros 39.95 million

37 Funded by the IDB at a cost of $ 25 million

In addition to these three modern facilities, Rafah has WWTP with a 20,000 m^3/day and Sheikh Ajleen has a capacity of 60,000 m^3/day - both with a simple treatment technology and low capacity utilization. This is due to lack of electricity and funding for fuel to power the generators. All these plants have provisions for expansion in line with population growth, and they will reduce the need for transboundary wastewater management, which is quite costly to the PA, in Israel.[38]

3 The Electricity Problem

Seawater desalination and wastewater treatment plants are all energy intensive. The three STLV plants would require around 6 MW to operate at full capacity while the three WWT plants would require about 9 MW to operate. The desalination plants have included PV solar systems within their design, while the WWT plants are combining biogas with solar PV panels fields. However, except for the East Bureij WWTP, this would only provide a fraction of their needs, while the bulk of their energy demand would have to come from GEDCO, the electricity distribution company network.

The demand for electricity in Gaza is estimated at 450 MW, while the supply is around 195 MW[39], leaving a gap of 255 MW. Reconstruction of the storage tank at the GPP destroyed during the 2014 war has been launched in mid-2019. Financed by Norway, construction should be completed by mid-2020, allowing the operation of a fourth turbine at GPP and adding another 25-30 MW to the current level of 75 MW. However, this would require an extension of the current Qatari fuel facility into 2020 and an increase in fuel financing from $ 10 million per month to $ 15 million per month. If the Qatari facility is extended at a higher level of financing, the addition of 25-30 MW of electricity will offer a major opportunity for GEDCO to reorder electricity distribution priorities, providing seawater desalination plants and WWTP with dedicated electricity lines (see below)[40].

The Gas for Gaza project (G4G) which would extend natural gas from Israel to the Gaza Power Generation Company (GPGC) would be a much better alternative to trucking fuel from Israel to Gaza and would only cost one third of the diesel fuel

38 Israel charges the PA for waste-water treatment it provides for wastewater coming from Gaza, through the clearance mechanism.

39 See Gaza Electricity Reform and Restoration, Karim Nashashibi and Yitzhak Gal, Abu Tor and Konrad Adenauer Stiftung, January 2019. 120 MW are imported from Israel and 75 MW produced by the Gaza Electricity Generation Company with three turbines out of four.

40 Since NGEST already has a dedicated line, only 10MW would be required to cover the other five facilities.

cost. It would raise electricity output from 75 MW (or 100 MW after storage tank construction) to 140 MW with the potential of 560 MW by 2030 with an expansion of GEGC[41].

There have also been discussions on extending a high-tension line (161kv) from Israel to Gaza, which would add another 100 MW.

These two projects would reduce the electricity shortage to 110 MW and provide the water desalination and WWT facilities with the full-time energy supply they need. However, conservative sources estimate that it would take at least three years for these two projects to be completed. Commercial arrangements, such as a power purchase agreement with IEC and a gas purchase agreement with Noble/Delek, will need to be put in place for both projects. Given the PA's dire financial situation as discussed above, the major obstacle, so far, has been its inability to provide payment guarantees for these purchase agreements.

Qatar has informally expressed willingness to finance construction of a first connection point for the 161 kv line and pay for the electricity import from IEC for the first two years[42]. This still leaves the issue of gas payment unresolved, and the timelines for both projects are still three years away. There are several PV initiatives under way in Gaza, which can be deployed specifically for water and wastewater related projects and help mitigate the electricity crisis. However, the shortage of electricity is so large that only a combination of G4G and 161 kv line would provide an effective and sustainable solution to the electricity shortage.

With a current electricity shortage of 255 MW, GEDCO is faced with the unenviable task of rationing electricity supplies among competing needs. As new facilities come on stream, the shortage of electricity will only be exacerbated.

Out of this new water desalination and WWT infrastructure, NGEST is the only facility which succeeded in getting a dedicated line from GEDCO, allowing it to operate full time[43]. The industrial zone at Karni also obtained a dedicated electricity line. However, both dedicated lines are provided at the expense of every other electricity consumer in Gaza.

- The Khan Younes (UNICEF/EU) seawater desalination plant was only getting electricity four hours per day in 2017 and 2018. It requires 1.5 MW of electricity which is partly produced by solar panels (12 % of energy requirements). However,

41 Gaza Electricity Reform and Restoration op.cit.

42 However, Sheikh Mohammad Al Emadi, head of the Qatari commission, and a driving force in helping raise electricity output in Gaza, expressed his dismay at the three-year construction period claimed by Israeli.

43 Memorandum of understanding between PWA and GEDCO, 2018.

its solar field does not kick in when electricity is disconnected[44], with the result that capacity utilization was only 9%[45]. However, during the first half of 2019, capacity utilization has increased to 17% thanks to the increase of GEDCO power supply as a result of the Qatari oil facility[46]. It should be emphasized that when an STLV does not operate continuously, it incurs severe operational problems which raise O&M costs substantially. In the case of the Khan Younes UNICEF plant, it must be restarted every day with diesel generators, and it needs backwashing the membrane. UNICEF has declined to discuss the operational costs of the plant, but they would certainly exceed NIS 10 per m^3 instead of an estimated NIS 3-4 at full capacity. It should be recalled that desalinated brackish water is sold at NIS 4 per m^3 in bulk to water transportation trucks. Despite the on-going electricity crisis, and no solution in sight, UNICEF/EU and its partners are planning an expansion of this plant to a capacity of 7.3 million m^3 per year, by adding another 5.1 million m^3 to existing capacity. Work on the expansion started in January 2019. UNICEF/EU are expecting a dedicated electricity line for this expansion project.

The situation of Deir el Balah's new desalination facility is even worse. The newly completed plant by USAID is sitting idle because it has not been hooked up to the electricity grid. It has a PV power generation facility of 235 kw to operate the equipment part of the time. However neither the plant nor this solar energy facility have been commissioned due to the abrupt recall of USAID engineering staff in February 2019. The contiguous old 2003 Deir el Balah plant is operating thanks to its rehabilitation, but capacity utilization is only 200 m^3 per day (4% of capacity, June 2019). This is due to power shortages. The plant is not hooked up to the municipal water network, and desalinated water is sold to schools through tankers at NIS 4 per m^3. This doesn't even pay for the 3-4 staff manning the plant on behalf of CMWU[47]. To operate at full capacity, 2,600 m^3 per day, it would need 1.8 MW of electricity.

The newly completed Gaza STLV has been hooked up to the electricity network during the 45-day commissioning period. It is currently using 1 MW which allows it to operate at 27% capacity. Due to lack of land in the proximity of the plant, network electricity cannot be augmented by PV solar energy.

The question arises as to what will happen with the Gaza desalination plant and the Khan Younes WWT facilities when it is completed. If electricity is not provided, as in the case of Deir el Balah, this $40 million investment by donors will remain idle,

44 The solar field is not synchronized with electricity cut off and would need electricity storage in batteries to kick-in.

45 See PWA/LACS Semi-Annual Report, June 2018

46 See PWA/ADA RPI: Semi Annual Progress Report, June 2019

47 See PWA Semi-annual progress report, PWA/LACS, June 2018, and June 2019

with possible degradation, until the electricity issue is solved.

The East Bureij WWTP has better prospects. Initially, Germany/KFW will assist CMWU in operating the East Bureig plant for a couple of years. It is assumed that adequate operation and maintenance can be provided by CMWU, with KFW assistance, beyond the two-year learning period. As mentioned earlier, this project has been designed to be self-sufficient in energy consumption with biogas and PV panels facilities. Initially, backup generators on the site will provide energy until the sludge is ready to produce biogas. While this project has the distinction of having solved both its energy requirement and O&M at least for a few years, the governance problem still needs to be addressed: will there be any cost recovery? Who will pay for wastewater treatment? What needs to be done at the institutional level to ensure that the project is economically sustainable over time?

4 Regulatory Environment and Weak Governance

The regulatory framework for the water sector for both the West Bank and Gaza has been set by the Palestinian Authority through legislation and its policy implementation agency, the Palestinian Water Authority (PWA). A 2014 Water Law was decreed to clarify responsibilities in the West Bank and in Gaza, particularly between the PWA and the Ministry of Local Governments (MoLG) and to establish autonomous agencies. A Water Sector Regulatory Council (WSRC) was also established under the Water Law as an independent legal entity. It is expected to monitor performance, license service providers and set standards for water quality. In 2017, a draft action plan was issued to establish a National Water Company to be the sole buyer of bulk water from desalination plants, Mekorot and other water producing entities. It would then sell this water to various service providers. By end-2019, the National Water Company was not yet established.

While the PWA has a presence in Gaza, the geopolitical environment proved to be difficult for regulation and development planning. There were 25 municipalities in Gaza which have been operating with great autonomy and, until 2005, several Israeli settlements. Therefore, it was decided in 2000 to establish a local water authority, the Coastal Municipalities Water Utility CMWU, a service provider (SP) and a project manager under the MoLG in Gaza with representation of all municipalities on its board. However, only 14 municipalities and Rafah joined CMWU. While CMWU is expected to support local governments to upgrade and maintain their water and wastewater systems, it has no responsibility on setting tariffs.

With the 2007 political division, when Hamas took over the Gaza Strip, the CMWU became the effective water operator in Gaza, relegating the PWA in Gaza, which received its policy directives from the PWA in Ramallah, to a secondary role. Bilateral donors, who wanted to develop projects in water desalination and wastewater treatment facilities, would go directly to CMWU to negotiate project implementation and respective roles of donors and service providers. At the same time, major projects, such as the NGEST and the Gaza Central Desalination project required the full involvement of PWA in both Ramallah and Gaza. These projects needed financial backing from several external donors and support from the Israeli authorities. Hamas, which exercises control over municipalities and the Gaza Ministry of Planning and Environmental Quality Authority, also needed to be involved in decision making and project implementation.

This duality in governance between Hamas and the PA as well as the semi autonomy of local agencies caused policy implementation problems. For instance, when the PWA in Gaza proposed a regulatory framework for the brackish water desalination operators in 2015, it faced local opposition from municipalities which blocked the reform. Similarly, the unified billing system proposed by CMWU for water delivery and sewage services was only adopted by 14 municipalities. As a result, this left out 9 municipalities, including Gaza, the largest municipality, which set up their own tariffs and bill collection mechanisms. By contrast, Rafah water and sewage services are entirely run by CMWU which pays salaries to Rafah municipal staff.

Despite difficulties in establishing a robust regulatory framework for water and wastewater, CMWU has succeeded in operating water infrastructure facilities. It controls 270 water wells, 55 water reservoirs and 63 wastewater pumping stations[48]. It oversees licensing of water wells and brackish water desalination plants, but most of the water wells remain unlicensed. Of the 154 brackish water desalination plants, 104 are unlicensed and 40% of all plants use water from unlicensed wells. Only 8% of licensed plants renew their licenses on a yearly basis[49]. Since 2007, experience with attempting to regulate private desalination plants and water wells clearly demonstrates the inability of PWA to regulate these activities.

Establishing water quality standards for desalination of brackish water, including the addition of chlorine and necessary minerals is important for both health and environmental reasons. Monitoring water quality, providing adequate amounts of

48 CMWU: Operation and Maintenance Budgetary Plan 2019-2025 February, 2019

49 PWA and GIZ: Survey of Private and Public Brackish Water Desalination Plants in Gaza Strip, September 2015, pp 6 and 7

chlorination and adding necessary minerals are three essential functions for the WSRC to undertake. Similarly, the extraction of water from the Coastal Aquifer should be regulated if there is any hope of bringing back the aquifer to a self-sustaining source of good quality water. Water wells producing low salinity water should not be allowed to feed the brackish water desalination plants. Instead, their water should be available for blending with Mekorot and STLV water for drinking purposes.

In March 2020, the World Bank was expected to hand over the NGEST plant to CMWU which would oversee its operations and maintenance. However, CMWU did not have funding for O&M and declined to take on this responsibility at NGEST. Due to the financial crisis experienced by the PA in Ramallah following the stand-off with Israel on Clearance Revenue deductions, the contractor in charge of NGEST was not paid his last installment and withdrew from its O&M task. PWA took over the plant in August 2019 despite its lack of experience in operating these highly specialized and complex facilities.

5 Operation and maintenance on the brink

CMWU oversees operation and maintenance of the water and sewage infrastructure in Gaza, which falls under its jurisdiction. The maintenance cost of NGEST is estimated at $ 4 million per year, excluding electricity costs. When the Central Gaza WWTP is completed in 2020, its maintenance costs may be around $ 5 million, including depreciation[50]. The six facilities discussed in this report would incur $ 30 million in O&M expenses annually, including payment for electricity and depreciation.

Donors have been investing heavily in Gaza infrastructure, but they are reluctant to subsidize the recurrent operation and maintenance of these facilities. These projects should be economically viable and sustainable under normal conditions and able to cover their recurrent expenses[51]. However, given that cost recovery is not possible for this infrastructure under the current institutional fault lines described below and that neither the PWA in Ramallah nor the water institutions in Gaza have the resources to finance O&M, the donors have come to the realization that they need to find a way to fund these recurrent costs for a period of time. This will continue

50 Masoud/Ali contractors

51 World Bank contractual agreements with project builders specifically exclude the possibility of covering operation and maintenance costs after projects are commissioned.

until institutional reforms take place and the economy recovers. This will happen when Israel undertakes a major relaxation of movement of trade and people in and out of Gaza.

The CMWU takes over projects from PWA once they are completed. The World Bank covered O&M recurrent costs for NGEST for two years and CMWU was expected to take control of the wastewater treatment plant once the two-year initiation period - end February 2020 - was completed. However, CMWU did not receive any financial support from donors to undertake training and to cover operation and maintenance costs. If not properly operated and maintained[52], that $ 44 million facility may deteriorate. As mentioned above, in early August 2019, the NGEST contractors appointed by the WB to provide O&M withdrew from their contract with PWA for non-payment of their fees. PWA took over the facility and hired 23 staff with the assistance of a skeleton crew which the contractors left on the ground to ease the transition. However, PWA does not have the expertise to operate WWTPs and STLVs, and it needs a fund to finance the experts it has hired. A recent joint visit, in October 2019, by donors, PWA, and CMWU, to the four WWTP in Gaza, demonstrated to the donors the urgent need for establishing a dedicated O&M fund for the WWTP and SLTVs.

Gaza STLV, which is undergoing the commissioning period (45 days), still does not have electricity from GEDCO and responsibility for O&M has not been set. Lack of electricity to operate the plant and lack of resources to ensure proper operation and maintenance may force it to limp along at very low capacity utilization, until electricity is made available and funding is provided for O&M. The newly completed Khan Younes WWTP, (phase one, at 26,600 m^3 per day) is also in the commissioning period (45 days) but it does not have electricity on a sustainable basis and it is not clear who will assume responsibility for O&M. So far, no funds for O&M have been allocated and the plant may fall into the hands of PWA (Gaza) as was the case for NGEST.

a. CMWU: partial service and insufficient cost recovery

The CMWU is a service provider, operating the water network and most of the municipal wells. It is also involved in project implementation. However, as mentioned above:

- The CMWU does not have full authority as a service provider in Gaza. It only

52 Rebhi el Sheikh, formerly Deputy Director of the PWA in Gaza has recently warned about the impending disaster at NGEST. See Palestine this Week, July 2019 p. 8

covers 14 municipalities and Rafah, out of 25 municipalities. Tariffs and billing vary from one municipality to the other, which is very inefficient. CMWU aims at bringing all municipalities into its system and at having a unified billing system across all municipalities.

- While CMWU collects water and sewage fees from the 14 municipalities, it remits all proceeds to municipal councils, minus a 10% management fee. This system is intended to support municipal finances but undermines CMWU cost recovery and distorts collection incentives. Some households are reluctant to pay for water and sewage, knowing that most of the proceeds will go to municipalities. These municipalities do not provide them with adequate services. As a result, CMWU does not have the resources to operate and maintain its own water network and municipal wells, let alone taking over new facilities such as NGEST.

More specifically, three parameters undermine cost recovery for CMWU[53]:

- The average water tariff is NIS 1.6 /m^3, about half the opportunity cost of water from Mekorot.
- The bill collection rate is 32%
- Non-revenue water, lost or stolen, is 40%

The water tariff is about half the cost of alternative sources: NIS 3.6/m^3; estimated cost by CMWU for both water and wastewater treatment; NIS 3.2/m^3 for water imported from Israel (Mekorot) and NIS 4 for desalinated water from brackish wells (bulk delivery). The cost of pumping good quality groundwater from the aquifer is about NIS 2.2/ m^3 [54].

Both CMWU and PWA maintain that they are planning to raise the tariff to at least NIS 1.9/m^3 at a first stage. They would also like to raise the bill collection rate to 75% and reduce non-revenue water to 10% through a campaign of plugging leaks and disconnecting illegal connections. However, they feel it is very difficult to raise tariffs and enforce higher collections in a depressed economy- with unemployment at 48% and poverty at 50% of the population. They argue that a revival of the economy, through trade facilitation measures taken by Israel and higher exports, would enable them to implement these reforms. The donor community views this stance as a delaying tactic and argues that this institutional reform can be carried out under existing conditions. They also stress that its implementation is essential for CMWU to regain credibility and donor support.

53 CMWU budget report op.cit. table 4

54 Office of the Quartet, Report to the AHLC, September 17-18, 2017, p18

b. Cost recovery, subsidies and financial distress

A budget analysis by CMWU covering the 2019-2025 period has estimated the annual O&M expenses for all these water and WWT facilities amount to $ 30 million. This includes depreciation.[55] When depreciation is excluded, the combined total decreases to $ 17.5 million.[56] These amounts include the cost of electricity, diesel fuel, maintenance and spare parts, staff, chemicals and other recurrent costs[57]. The study then derives the unit cost of water and sewage combined at NIS 3.5 per m^3 in 2020 rising to NIS 4.3 with depreciation.

It should be recalled that water purchased from Mekorot costs NIS 3.2 per m^3 and that the typical tariff for tap water in Gaza is NIS 1.6 per m^3. Sewage treatment tariff adds another NIS 0.9 per m^3, with a combined cost of NIS 2.5 per m^3.[58] The paper argues that it would be necessary to raise the combined water and sewage treatment tariff to NIS 4.32 per m^3 in 2020 (costs with depreciation) to balance the books. It implies that "a gradual subsidy scheme" would be necessary over a few years to bring the tariff to the breakeven point level and ensure that operation and maintenance of these facilities could be sustained.

Under present conditions, even if CMWU collected the full amount of the water and sewage produced at a tariff of NIS 2.5 per m^3, it would incur a structural deficit of NIS 1.8 per m^3 of water produced. In reality, the actual deficit is substantially larger. CMWU gets much less than the tariff charged to consumers because of a large component of non-revenue water of 40% and a low rate of bill collection of 32%. This is due to widespread de facto exemptions from payments which includes public buildings, refugee camps, mosques and schools. In effect, collection of revenue is only 19% of the value of water and sewage produced[59]. With water and wastewater costing NIS 4.3 per m^3 and collections at the current average tariff of NIS 1.9 per m^3 amounting to NIS 0.68/m^3.. When non-revenue water and the low collection rate are considered, there is a shortfall of NIS 3.62 per m^3 supplied. Cost recovery at the service-provider level is only 16% of the actual cost.

The CMWU budget study does not detail revenues collected from consumers and

55 Computed by the authors from CMWU, op. cit, 6-7.

56 Op. cit.

57 The study assumes that STLV plants are operating at full capacity, receiving 20 hours of electricity per day and consuming diesel fuel for 4 hours per day.

58 The CMWU assumes combined tariff of NIS 1.9 per m3 of supplied water (0p. cit, p. 8). That seems to be a weighted average, considering the much smaller amount of sewage that is treated, in comparison to supplied water.

59 An earlier estimate was of a shortfall of NIS 2.01/CM. See World Bank: Securing water for development in the West Bank and Gaza. 2018

municipalities for the water provided and for wastewater treatment[60]. Therefore, it does not come up with an operational current budget deficit or explains how it is financed[61]. CMWU gets two major implicit subsidies: it does not pay for Mekorot water which is paid for by the PA in Ramallah through the Clearance mechanism; and it does not pay GEDCO for network electricity used by STLVs, wastewater treatment plants and pumps used to extract water from its wells and reservoirs. On the other hand, CMWU subsidizes municipalities by giving them 90% of their collections instead of retaining these revenues to cover their costs. Layers of subsidies in Gaza have distorted costs and incentives and have undermined cost recovery and investment (see box below).

Layers of Subsidies

- Pumping underground water is subsidized by not paying license fees or electricity costs
- Consumers of water and sewage treatment are subsidized by paying very low tariffs
- CMWU is subsidized by not paying for electricity and not paying for Mekorot water
- Municipalities are subsidized by taking 90% of water bill collections and not remitting to GEDCO electricity bill collections. Their debt to GEDCO by end 2017 was NIS 667 million
- STLVs and WWTP are subsidized by not paying for GEDCO electricity

To summarize, a combination of high non-revenue water, low tariffs for water and sewage treatment, low collection rates and layers of subsidies have undermined cost recovery and financial viability of the service providers in Gaza. As a result, CMWU and other service providers finance their operations by not paying for imported bulk water, by not paying their electricity bills and by deferring O&M expenses. A clear accounting of all these cross subsidies is necessary for undertaking a serious institutional reform and moving towards full cost recovery.

Capital investment and replacement of worn out equipment financed by donors should be accounted for as well, to provide adequate funding for depreciation costs.

60 CMWU collects water and sewage fees but transfers the revenues to municipalities minus a 10% management fee.

61 Municipalities get 15% of their revenue from water payments and 35% from electricity payments

6 Enhancing Water Supply for Agriculture: Revival of Agricultural Exports

Agriculture had traditionally been a mainstay of Gazan economy and exports. It experienced steady decline over the last 3 decades, but the declining trend sharpened since 2007. In 2015 – 2018, the share of agriculture was already as low as 4 - 5 percent of GDP. Due to an Israeli ban on all exports from Gaza agricultural exports stopped almost totally between June 2007, with the Hamas takeover in Gaza, till 2015 when Israel started allowing some exports to go through (see Annex A for a survey of these trends).

In contrast to the West Bank where agriculture has traditionally been mostly rain-fed, in Gaza, agriculture is dominated by irrigated crops. As recently as the early 2010s, it was estimated that 77 per cent of cropped land in Gaza were irrigated, in comparison to only 12 per cent in the West Bank.[62] Gaza also uses drip irrigation in greenhouses for high end fruit, vegetables, and flowers which it exports to the West Bank, Israel and abroad. Gaza's agricultural sector was more advanced than agriculture in the West Bank with strong export performance[63]. Over the last decade, with worsening water shortages and deteriorating water quality, land under irrigated crops has been decreasing. In addition to continuous reduction in orange groves, mostly because of higher water salinity, there has been a reduction in vegetable areas as well.

The prospects for irrigation-water availability in coming years are even gloomier. Ground water level in the Gaza aquifer is already below sea level, and the pace of salinization of the aquifer is increasing. Underground water extraction, which is triple the annual recharge level, must be severely reduced.[64] Supply of water for domestic use (90-plus million m^3/year)[65], is expected to increase with population growth, reducing the availability of water for irrigation. On the other hand, supply of potable water will increase significantly with three STLV's (8 million m^3 per year) and higher Mekorot imports of 10 million m^3 per year. This will provide some room for increase in irrigation-water availability. Israel is gradually relaxing restrictions on agricultural exports from Gaza to the West Bank, Israel and abroad. The number of

62 OQ, IPE: Agriculture (2013), Slide 14

63 Eight Gaza farms were certified by the EU in 2005 under stringent rules of operation, to export high end vegetables and fruit to European Union countries, as well as flowers. Only two farms were certified in the West Bank for such exports.

64 RAND Corporation, The Public Health Impacts of Gaza's Water Crisis (2018), p. 11-12.

65 Ibid

export trucks carrying agricultural products increased from 1 – 2 trucks per month in 2008 - 2014 to 282 truckloads per month in January-May 2019[66]. As of 2018, at a total volume of more than 30,000 tons, agricultural exports have come close to their pre-2007 magnitude. Trends in 2019, till September, point to an annual level of exports of fruit and vegetables of $ 30 million[67].

In order to bridge the large gap between demand and supply, new sources of water for irrigation must be developed. A combination of the following solutions can generate the required quantity of new irrigation-water that would replace extraction from the aquifer and enable sustainable growth of Gazan export-driven agriculture:

- **Rehabilitation of salinized / polluted wells and use of treated brackish water for irrigation.** Several small-scale projects are already underway in Gaza.[68] These "pilot projects" can be expanded, using advanced low-energy-use well-rehabilitation and brackish water desalination technologies. Until the new large seawater desalination plants in Gaza come on stream, the development of this source may be slow. Their development will be further reduced in the longer term, when most of Gaza's domestic water needs will be supplied by cheaper desalinated water (as it is already the situation in the Arabian Gulf countries, and to a large extent in Israel as well).
- **Blending drinking-quality water with brackish water, generating irrigation-quality water.** This source is used in Israel in areas suffering from shortage in water for irrigation, especially in the south of Israel. It has been proven to be economically viable for a wide range of crops.[69] However, to achieve good productivity and high quality, cropping and irrigation need to follow specific protocols.

These two sources of water for irrigation, can be developed in parallel to gradual decrease in the use of aquifer water for irrigation. Such use should focus on vegetable crops, which can't be irrigated by the third and largest new source – treated wastewater

66 Data for 2019 covers January-May. As of 2018, at a total volume of more than 30,000 ton, agricultural exports have come close to its pre-2007 magnitude.

67 FAO: Gaza Strip Agricultural Trade; January- September 2019; http://www.lacs.ps/documentsShow.aspx?ATT_ID=43654

68 As mentioned above - the Oxfam (EU Supported) project for rehabilitation of 16 public and 30 private wells, ANERA's Beit Hanoun well rehabilitation project, and the Al Zannah and Sureij project in the Khan Younis governorate

69 Water and Irrigation (Israel, May 9, 2016) (in Hebrew) https://iwwaportal.co.il/; Israeli Center for Desert Agriculture https://www.wikiwand.com/he/מרכז ניסויים לחקלאות מדברית

Re-use of treated wastewater for irrigation

- 75 million m³/year of wastewater generated in Gaza[70] is the largest potential source of water for irrigation in Gaza. In Israel, more than three quarters of all wastewater are re-used, and treated wastewater has already become the major source of water for irrigation.
- As shown in the following section ("expanding wastewater treatment for reuse in agriculture"), over 30 m³/year of wastewater treated in the two new, large wastewater treatment plants (WWTPs) which have been completed (NGEST and Khan Younes) can be re-used for irrigation.[71] Additional quantity of 20 m³/year of irrigation water can be generated from a network of small, decentralized WWTPs suggested for smaller localities and villages.[72]
- This source of irrigation water will be used, primarily, for irrigation of olive trees, other fruit trees and fodder[73].
- According to estimates of PWA and estimates used by the Office of the Quartet (OQ) in its in-depth IPE study, irrigation-water needs per donum range between 500 and 750 m³/year.[74] In Israel, quantities of irrigation-water per donum (as optimally recommended according to agronomic instructions) are higher for certain crops, ranging between 500 – 1,200 m³/year per donum for most of the relevant crops (depending on crop, zone and other factors).[75]
- Considering Gaza's optimal mix of export-oriented high-value crops, the average irrigation water requirements for the medium term are estimated to be as follows: about 750 m³/year per donum for 60,000 donum that will continue producing for the local market; and 1,000 m³/year per donum for 60,000 donum that will be shifted to high-yield, high-value crops for export. Altogether, around 100 million m³/year (total irrigated area will grow moderately - to 120,000 donum).
- In the longer term, irrigated agricultural area may increase further, re-gaining part of the agricultural lands which were abandoned over recent decades.

70 Around 200,000 m3/day (100 liter/day per person, 2 million persons)

71 Salty wastewater treated in the Gaza City WWTP (Bureij) cannot be reused for irrigation.

72 60,000 m3/day (100 liter/day per person, 600,000 persons) – see detailed analysis in the section on reuse of wastewater.

73 In line with Palestinian regulation regarding use of treated wastewater, as well as Israeli regulation and that of other countries

74 PWA, National Water and Wastewater Strategy for Palestine (2013), P. 67; OQ, IPE: Agriculture (2013), Slide 22

75 Various Ministry of Agriculture and other professional guides (in Hebrew) http://agri.arava.co.il/ ; https://www.moag.gov.il/shaham/professionalinformation/documents/hoveret_mekadmey_hashkaya_mataim_2018.pdf

Historical evidence shows great potential for export-driven agricultural development in Gaza (Annex A). If sustainable supply of water for irrigation can be secured, irrigated agriculture can become an important growth engine, major generator of jobs and key enabler of poverty alleviation.

Comparative analyses of productivity and income between irrigated and un-irrigated plots - and as per mix of crops, cropping methods and fertilization - show huge gaps. For Palestinian agriculture, a donum cropped under irrigation generates income that is 14 to 20 times as high as an unirrigated donum, on average.[76] Shifting unirrigated cropped land to irrigation increases farmers' income by more than USD 2,000 per donum, on average. If that is done in combination with shifting from low-value crops to higher-value export-oriented vegetable and fruit crops, as suggested for Gaza, the gain in income per donum can be closer to USD 3,000.[77] Cost of irrigation water supplied from the new sources presented above, using advanced low-energy use technologies as presented in Annex B, makes that shift economically sustainable.

Assuming income gain of USD 2,000 - 2,500 per donum, total increase in the value of production from the 60,000 donum shifted to higher-value export-oriented vegetable and fruit crops is estimated at USD 120 – 150 million; a 50 – 75 percent jump in comparison to the 2016 -2017 figures (Annex A). In macro-economic terms, that would generate 3 - 4 percentage points increase in the GDP of Gaza, assuming value added of about 60% of output value and taking into account associated increase in related services etc. That would almost double the share of agriculture in the Gaza GDP.

7 Expanding Wastewater Treatment for Re-Use in Agriculture

Untreated wastewater presents both a potential large source of water for irrigation, as well as health and environmental risks.

As mentioned above, more than 100,000 m^3 of untreated or poorly treated sewage have been discharged into the sea every day from Gaza's urban centers. These centers have sanitary sewage collection infrastructure. If present trends continue, the amount of sewage dumped into Gaza's sea was expected to increase to

76 Depending on method of calculation – see Annex A.

77 Annex A; IPE: Agriculture (2013), Slide 8, 18, 29, 34.

120,000 m3/day by 2025.[78] Smaller quantities of urban sewage, partly treated in the outdated and dysfunctional old WWTPs of Gaza City and Rafah, is dumped into the groundwater table.

By the end of 2020, most of the Gaza Strip urban sewage would be piped to and treated in three new, modern large WWTPs. As detailed above, that network is almost complete and is gradually coming on stream. It is scheduled to be fully operational by the end of 2020. The two old WWTPs too are in the process of being upgraded as well, and they will supplement the three new WWTPs.

However, that network of new WWTPs, only cover urban centers. One quarter to one third of Gazans live in areas without sanitary sewage collection systems.[79] They use cesspits and open drains to dispose of their wastewater, which causes significant health and environmental problems, and high associated costs. These problems are intensified by poor maintenance and disrepair, including, inter alia, substantial likelihood of sewage overflow. Once a month, some 10 percent of these households report frequent overflow incidents, while once a year, one third reports facing occasional overflow incidents.[80]

Most of those who are not connected to the large WWTPs are residents of smaller localities and village communities, which are not connected to these WWTPs. For this segment of the population, estimated at around 600,000 persons, the study proposes a network of small local WWTPs as detailed below. This solution is, by far, more cost effective and more technically and economically feasible than pumping the wastewater out of cesspits in these villages and trucking it to the large WWTPs.

a. Decentralized solutions for smaller localities and villages

Most of the smaller localities and villages in Gaza are not connected to piped sewage collection systems. Unconnected population is estimated at around 600,000 people.[81] Most of them use cesspits for disposal of wastewater. This causes significant health and environmental problems, and high associated costs. PWA does not plan to provide these localities with piped sewage connection.

78 RAND Corporation, Shira Efron The Public Health Impacts of Gaza’s Water Crisis (2018), p. 19;

79 Emergency Water, Sanitation, and Hygiene Group, “Water and Sanitation in Palestine,” fact sheet, 2017 (cited in RAND, ibid); World Bank, THE PERFORMANCE OF PALESTINIAN LOCAL GOVERNMENTS (2017), http://documents.worldbank.org/curated/en/920051497530257564/pdf/ACS22456-REVISED-WB-LGPA-report-TO-IDU-6MB-Nov-16-2017.pdf , p. 28

80 World Bank, Toward Water Security for Palestinians (2018), p. 46

81 RAND Corporation, ibid, p. 19 ; http://documents.worldbank.org/curated/en/920051497530257564/pdf/ACS22456-REVISED-WB-LGPA-report-TO-IDU-6MB-Nov-16-2017.pdf , p. 28

This study recommends for them a network of small, decentralized WWTPs that will replace the use of cesspits and generate some 20 million m3/year of irrigation water for use in near-by agricultural lands.[82]

- These solutions are based on new natural-biological and other low-energy-use wastewater treatment technologies, which have been developed over the last two decades[83] and successfully implemented in hundreds of sites worldwide. Raw sewage is treated to secondary or tertiary irrigation quality, as required by the specific use, in compliance with the strictest international health and environmental standards.[84]

The main advantages of the proposed small local WWTPs are:

- Do not require large Capital Expenditure (Capex) on long pipeline systems for taking wastewater from the village to far-away large WWTPs.
- Fast and simple to supply and install (no need for complicated and capital-intensive infrastructures and machinery that require long delivery and installation times)
- Simple to operate and maintain
- Low use of electricity and low maintenance costs. Hence, Operation Expenditure (Opex) is, by far, lower (per m^3 of treated water), than that of large "conventional" WWTPs [85]
- These small WWTPs are installed in closed-system, smell-free and nice-looking containers; or underground. In many instances, such projects are integrated into nice green spots or eco-parks, creating another important added value for the community – as shown in Annex B.

See Annex B for a survey of these solutions and technologies

82 60,000 m3/day (100 liter/day per person, 600,000 persons)

83 See a summary of various types of these technologies in Qaisar Mahmood, Natural Treatment Systems as Sustainable Ecotechnologies for the Developing Countries (June 2013), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3708409/

84 See for example in Stanford's Codiga Resource Recovery Center, Interim Report of Testing of a Membrane Aerated Bioreactor 12/21/2018 , https://cr2c.stanford.edu/sites/g/files/sbiybj6816/f/interimreport2018121final_0.pdf See also Fluence Inc, ADVANCED ON-SITE WASTEWATER TREATMENT FOR GREENFIELD AND RETROFIT APPLICATIONS https://thatcleantechcopywriter.com/wp-content/uploads/2019/07/WHITE-PAPER-CLIENT-190719.pdf ;

85 Large, centralized WWTP enjoy economies of scale in capital equipment and O&M costs per m3 /d. However, this advantage is counterbalanced by large distribution/ collection network costs. See for example https://pdfs.semanticscholar.org/dcfa/b49323dd0aeb5474c797c3aa3b582f39c4e1.pdf p. 223. and https://fenix.tecnico.ulisboa.pt/downloadFile/281870113701934/resumo.pdf p. 1 and 10. See also comparisons in Fluence Inc, ADVANCED ON-SITE WASTEWATER TREATMENT FOR GREENFIELD AND RETROFIT APPLICATIONS, p. 9: energy consumption of 0.267 kWh/m3 – a reduction of 61 percent in comparison to industry baseline for a typical energy consumption of a small nitrifying CAS secondary treatment plant (0.685 kWh/m3 of wastewater treated).

b. Re-use of treated water for irrigation

As mentioned above, that set of decentralized small WWTPs can generate about 20 million m^3 a year of high-quality treated water for irrigation (equivalent to 25% of total irrigation water use in Gaza today).

This new source of water will be used by local farmers in irrigation of near-by agricultural lands. These lands are either uncropped today (because of lack of irrigation water) or used for rain-fed, low-value crops. It will be used, primarily, for irrigation of olive groves, other fruit trees and fodder.

Given the estimates of irrigation-water needed per donum in Gaza, the 20 million m3 a year of new irrigation water would enable an increase of 20,000 – 25,000 donum in intensively irrigated cropped area in Gaza. That is an addition of 25% - 30% to the presently irrigated agricultural lands.

c. Implementation: existing projects and a new model project

Despite their large potential, none of the existing treated-wastewater-reuse projects has become operative. That includes wastewater reuse from the NGEST facility, which plans to irrigate 15,000 dunums in the Beit Hanoun area. The construction of an irrigation network, using treated wastewater from NGEST is expected to be funded by AFD for Euros 45 million, to irrigate 5,000 dunums in a first stage. d. Another recent project, a 600 dunum one in Mawassi (Khan Younes), hasn't been operating for lack of electricity from the grid. Another scheme is planned in Rafah, where the wastewater treatment plant will be reusing 3,600 m3 /day of treated water per day, with the support of UNDP and Japan.

This study is proposing a new model for such projects, which is designed - technically, financially and operationally – to overcome the impediments detailed above.

This model project is presented in Annex B.

8 Policy Implications and Recommendations

To ensure the operation of the six STLV and WWT facilities recently constructed at full capacity utilization, three major issues need to be addressed: improvement of energy supply, establishment of well-funded and sustainable operation and maintenance systems and improvement of the regulatory and legal environment to achieve cost recovery and financial sustainability.

a. The electricity conundrum

Donors from various countries and regional institutions invested close to $ 200 million in six technologically advanced infrastructure facilities in Gaza: three small seawater desalination plants and three wastewater treatment plants. This is highly commendable and has dramatically changed the water and wastewater infrastructure footprint in Gaza with ultra-modern facilities. These facilities will provide most of the Gaza population with drinkable water through the municipal water network and virtually eliminate dumping wastewater into the sea.

However, knowing that there was a major electricity shortage in Gaza, and that there were no prospects for alleviating this crisis for at least three years, the donors did not address this issue in conjunction with their investment. Two desalination plants are almost idle, due to electricity shortages. Two other projects: Gaza desalination and Khan Younes WWTP just completed, also do not have dedicated electricity lines. Efforts have been made to generate electricity through PV solar fields, and biogas facilities, but with exception to the Bureij WWTP, these efforts are still mostly reliant on the electricity grid. Operating these energy sources in conjunction with electricity inputs from the grid has proved to be technically challenging and time consuming[86]. In the case of the UNICEF plant, the solar field has not raised capacity utilization. Yet it helped reduce consumption of electricity from the grid.[87]

It should be emphasized that electricity generated from solar panels is land intensive. Scarcity of land in Gaza is a major constraint on expanding this source of energy and has limited the construction of solar panel fields in the proximity of the new facilities.

When water desalination and wastewater treatment projects were proposed by donors, the PWA promised them that electricity would be made available by the time the projects were completed. However, a more sober assessment would have demonstrated that the electricity imbalance between supply and demand existing at the time would only widen. [88]

Has there been donor coordination when these investments were designed? Donors do have regular meetings with one another to exchange notes on the

86 It takes time for the sludge to be ready for biogas production. After the Nablus WWT plant in the West Bank was completed in 2015, it took over a year and half to operate the biogas "digestor" to produce methane gas for energy production'

87 Interview with UNICEF, Ms. Pamela Minnigh and Mr. Zaidan AbuZuhry, November 5, 2019

88 Biogas at NGEST is expected to produce 1.2 MW, or 60 % of the energy required. At the East Bureij WWTP, PV and Biogas will provide 70% Of the energy required.

various challenges they face. However, this type of low-level coordination does not address their investment plans and how to alleviate collectively the major constraints they are all facing. The obvious answer would have been: one donor invests in the electricity supply, another in getting natural gas to reach the Gaza electricity generating station, a third donor would focus on the STLVs, and a fourth donor would focus on the WWT plants. However, this is not how bilateral donors operate. They focus on specific projects which they can control, and which fit in their countries industrial development policy. Gas for Gaza and the 161kv line from Israel do not fit into this vision. Multilateral donors are reluctant to get involved with projects in Gaza which rely on energy sources from Israel and energy purchase agreements over which they would have little control. Both categories of donors pinned their hopes on electricity supply expansion without any dedicated investments in the energy sector from their own development funds.

There has recently been some progress in improving electricity supply. Thanks to the Qatar oil financing facility, a third turbine started operating in mid-2018, raising electricity output at the GPP from 45 to 75 MW. By doing so the performance of some infrastructure projects, including the UNICEF seawater desalination plant, improved. A further increase in GPP output by 25-30 MW is expected in mid-2020 upon the completion of the fuel storage tank at the GPP. This opens the door for providing dedicated electricity lines to the STLVs, which are energy intensive[89], and to the WWTP.

However, further increases in electricity will depend on progress in connecting the GPP to a natural gas pipeline from Israel (G4G) and extending high voltage electricity lines from Israel (161 KV). Both may take three years to be implemented. This time span would argue in favor of attaching solar fields, or expanding existing ones, to the facilities we have discussed. The objective of this approach is to obtain adequate energy, in conjunction with grid supply to operate at full capacity utilization.

b. Operation and maintenance

Donors have been investing heavily in Gaza's infrastructure, but they are understandably reluctant to bear the cost of the recurrent operation and maintenance of these facilities. In their view, these projects should be economically viable and sustainable under normal conditions and able to cover their recurrent

89 One should note, however, that all these short-term improvements depend on the continuation of Qatari financing of fuel for the GPP. If that is discontinued in 2020, electricity supply situation would return, almost immediately, to the pre-mod-2018 situation.

expenses[90]. However, given that cost recovery is not possible for this infrastructure under the current institutional fault lines described above and that neither the PWA in Ramallah nor CMWU in Gaza have the resources to finance O&M, the donors have come to the realization that they need to find a way to fund these recurrent costs for a period of time. This will happen when institutional reforms take place and the economy recovers as a result of Israel allowing much greater movement of trade and people in and out of Gaza.

The annual cost of O&M is not large; a few million dollars per facility not exceeding $ 30 million for the six plants, including depreciation. O&M need to be addressed across all new facilities in a systematic and deliberate way with adequate budgetary resources to ensure a lasting and smooth functioning of the equipment provided. CMWU has charted a detailed O&M budgetary plan for the next six years, with all the associated costs, by specific activity. This can serve as a basis for estimating donor support. CMWU would continue covering the O&M costs of water wells, distribution networks, wastewater collection and pumping systems. The donors would establish a dedicated O&M fund for the six facilities.

Nevertheless, these are recurrent expenses which should not be funded indefinitely. There must be a timeline of three years to allow for an institutional and regulatory reform plan. Such a plan would lead the six facilities towards cost recovery. A three-year O&M funding guarantee, in conjunction with institutional and regulatory reforms, would pave the way towards cost recovery and financial viability.

c. Regulatory framework and governance

CMWU is the sole operator of water and wastewater infrastructure in Gaza as well as recently constructed STLVs and WWTP. It should expand its operational coverage to all municipalities and establish a unified billing system for its services. Since this process may take some time, CMWU should seek to operate all water and wastewater facilities in the 10 municipalities laying outside of its operational sphere. This can be done by submitting memorandums of understanding (MoUs) to these municipalities, specifying terms and conditions for its O&M activities related to their water and wastewater infrastructure. It would also seek to improve bill collections and reduce water leakages and diversions.

Managing the Coastal Aquifer and nurturing it back to sustainability would require the PWA in Gaza and the Water Sector Regulatory Council (WSRC) to establish a

90 World Bank contractual agreements with project builders specifically exclude the possibility of covering operation and maintenance costs after projects are commissioned.

robust regulatory framework and the legal underpinnings. This would clarify the roles of the three water institutions and issue by-laws to the 2014 Water Law: The number of water wells into the Aquifer needs to be regulated, minimum health and quality standards should be issued for all brackish water desalination plants; as the quality of water in the municipal water networks improves, water and sewage tariffs should be raised towards the actual cost of delivering water to the consumer; enforcement of bill payments must be imposed, particularly on institutions, municipalities and government entities which have not been paying their bills.

d. Rescuing what has been achieved

The three major infrastructure policy issues facing Gaza are: how to ensure adequate and reliable electricity supply to these facilities?; how to guarantee proper operation and maintenance of the equipment? and what are the institutional changes which need to be undertaken to establish an effective regulatory and legal framework and clarify the responsibilities of PWA and CMWU, improve cost recovery, and raise the water and sewage bill collection rate? [91]

The three main stakeholders –Israel; donor community; and local water and wastewater institutions, PWA and CMWU, WSRC, and municipalities- will have to play a major role in the economic and institutional recovery of Gaza's water and wastewater infrastructure.

i. The role of Israel

Only when there is a revival of the Gaza economy will its institutions be able to function effectively in raising utilities bill collection and in enforcing payment for services. Israel plays the major and determining role in reviving the Gaza economy. Towards that end it should expand its trade facilitation measures:

- Facilitating exports to Israel, the West Bank and abroad, – including industrial exports directly from the industrial zone at Karni and/or through Erez. Outsourcing of manufacturing to Israel through Karni/Erez is essential to revive the Gaza economy. In 2005, there were 120 trucks going to Israel daily. Now, in 2019, exports are down to 9 trucks per day.

91 These institutional changes and measures for improving cost recovery should relate to all aspects of O&M costs of CMWA, including water wells & their distribution networks and the wastewater collection & pumping system. According to the CMWU budget for 2020, these aspects add close to $ 30 million to annual O&M costs (CMWU, op. cit. p. 7).

- Allowing a broader mix of vegetable exports to the Israeli market. Allowing vegetable trucks to cross Kerem Shalom (which is open till 10 pm) during the same day that the produce is picked instead of waiting for the next day at 6 am.
- Spraying of chemical herbicides on the border area has adversely affected over 150 hectares of agricultural land. Ideally, this spraying should stop or, at the very least should be limited to a smaller area, using fewer toxic chemicals.
- Allowing permits for Gaza businessmen to travel to Israel, the West Bank and abroad, for training, contracts and conferences. Allowing businessmen, experts and academics to travel to Gaza.
- Allowing 20,000 Gaza workers to work in Israeli towns adjoining Gaza. This is a critical injection of income into the Gaza economy. This process has been recently initiated with 5,000 permits daily for workers going mostly into agricultural work in southern Israel
- Codifying the 15-mile fishing limit with some degree of permanency. This cannot be switched on and off depending on political developments
- Reducing the "dual use" list of imports to a minimum and allowing imports of inputs to exportable products to come into Gaza. Some of the equipment needed for the six facilities has been delayed under dual use restrictions. A case in point is the repair of the methane balloon at NGEST which has not been completed due to delays in importing the necessary material.
- Starting work, within Israel, on the natural gas connection line to Gaza (Gas for Gaza project) and on the high tension (161kv) line from Israel to Gaza. The PA is not in a financial position to make a financial commitment for these projects, but donors should be able to provide financial guarantees. Qatar has expressed an interest in financing the building of the 161kv line as well as covering recurrent costs for the imported electricity for a period of two years.

ii. The role of the Gaza PWA and the Regulatory Council (WSRC)

- PWA should issue by-laws to the 2014 Water Law and clarify its responsibilities and functions and specify the role of the WSRC and CMWU, under the Water 2014 Law. A legal framework for the water sector needs to be put in place. While the WSRC has been established, it has not been empowered.
- PWA should regulate private and public sector brackish water desalination

plants. It should impose minimum standards on chloride, nitrates and TDS[92]. It should also mandate re-mineralization of the desalinated water and Ph-adjustment.

- PWA should state, as an objective, that the Coastal Aquifer needs to be recharged and replenished to a sustainable level. In this respect, it should license all existing wells and monitor new wells with a view of reducing abstraction from the aquifer, in conjunction with the increase in Mekorot water imports from Israel and seawater desalination output.
- When there is enough potable water from Mekorot and seawater desalination plants to serve major municipalities, sources of saline water (over CL 500 mg/l) going into the network should be shut down. Gaza would then have a normal potable water system. Consumers who had disengaged from public providers of water would be engaged again and more willing to pay their water bills.

iii. The role of CMWU

CMWU has the technical expertise and qualified staff to run day to day operations of wells, water distribution networks, sea water desalination and WWTP. It should oversee all water and wastewater infrastructure, but it also needs a major institutional transformation:

- All municipalities should join CMWU and put it in charge of its water and wastewater treatment facilities. However, until this reform is implemented, all STLVs and wastewater treatment facilities should be under CMWU management.
- CMWU should draft memorandums of understanding with municipalities outside its authority, receiving new desalinated water and benefitting from wastewater treatment, to specify terms and conditions of its management of these facilities.
- CMWU needs to have a unified billing system for all municipalities.
- Together with the supply of potable water through the network, the water tariff and sewage fees need to be adjusted under a three-year plan of attaining full cost recovery.
- A campaign needs to be launched to reduce non-revenue water by plugging leakages and cutting off illegal diversions.

92 The WHO standard for chloride (CL) is 250 mg/liter and for Total Dissolvable Salts (TDS) is 500 mg/liter. Palestinian standards are more tolerant: CL 500mg/l and TDS at 1000

- Similarly, a campaign needs to be launched to increase the rate of water and sewage bill collection, which had reached 70% in 2005 but went down to 32% in 2019. CMWU should aim at reaching 80% over three years.
- All water revenues should go to CMWU, not to the municipalities. The Ministry of Local Governments should mobilize financial resources from donors to make up for this loss.
- Electricity and to a small extent, diesel costs in seawater desalination plants are 73% of total operation costs[93]. In WWT plants, electricity and diesel fuel amount to 23% of total costs. However, CMWU does not pay its electricity bills. It should be paying these bills to GEDCO once the structural reforms mentioned above are implemented.
- Operation and maintenance costs of the facilities ceded to CMWU by donors should be funded by donors for a three-year period during which the institutional reforms mentioned above are undertaken to ensure cost recovery. The donors should have a binding agreement on the implementation of the reforms and their monitoring with CMWU.

iv. The role of Donors

Donors who have made a major contribution to the development of Gaza's electricity, water and wastewater infrastructure[94] should establish an Executive Committee to realize the following three objectives, which have been elusive since 2005:

- Ensure adequate amounts of electricity to operate desalination and wastewater treatment plants at higher capacity utilization. The completion of the storage tank currently being rebuilt with Norwegian support should allow the generation of another 25-30 MW of electricity, bringing total electricity generated at the GPP to 110 MW. This, together with electricity imports from IEC (120 MW) would cover 51% of demand. This committee should review with GEDCO how available electricity is being allocated and set clear priorities to ensure that the six STLVs and WWTP receive enough electricity to ensure their full capacity utilization.
- Moving forward, Gaza should be getting natural gas from Israel to the Gaza

93 Assuming full capacity utilization of the plant, with 20 hours of electricity and 4 hours generated electricity through diesel fuel generators. Electricity is billed at NIS 0.62/kw. See CMWU O&M budgetary plan table 4

94 A partial list: ADA; AFD; Islamic Development Fund; KFW, Kuwait Development Fund; OQ , Qatar Development Fund, UNICEF, UNSCO, USAID, World Bank

Power Plant and the extension of a high-tension line (161kv) from IEC to Gaza. This new infrastructure would require long term purchase agreements with Noble/Delek and IEC. Since the PA is not in a bankable position to have such agreements, the donors should consider payment guarantees to facilitate these commercial transactions

- Establish a financial plan to ensure adequate operation and maintenance of the infrastructure facilities handed over to PWA, CMWU and municipalities after their commissioning and end of their trial period. Full transparency in terms of the actual O&M costs incurred by the six facilities is necessary to reveal implicit subsidies and donor financial support. Only then can there be a full assessment of the actual costs and of the need for financial support. This financial support under a dedicated O&M FUND would gradually decline as Gaza's economy recovers, and basic metrics of bill collection, tariffs and reduction of water leakages improve.

All these measures are urgent and should be accompanied by institutional reforms in the electricity and water sectors as outlined earlier to be implemented by GEDCO, PWA, RSWC, and CMWU[95]. The Donor Committee would coordinate with Israel and take a pro-active stance in implementing the institutional reforms proposed above and in our previous electricity study[96]

Unless this plan of action is instituted and activated, the three STLV plants and three WWT plants may continue to linger under low capacity utilization, gradual equipment degradation and possible shutdowns

95 For reforms in the electricity sector see Nashashibi and Gal, Gaza Electricity Reform and Restoration (KAS and Abu Tor, January 2019)

96 Op.cit., Electricity Reform and Restoration.

Annex A: Irrigated Agriculture in the Gaza Strip

a. Cultivated land, availability of water for irrigation and cropping patterns

About half of Gaza's area was cultivated in the 1980s - 1990s: 180 - 190 square kilometers. Cultivated area has decreased, significantly, over the 2000s and the 2010s. The latest available agricultural survey of 2011 showed a sharp decline to 105 square kilometers in cultivated area.[97] That decline reflects the combined effect of water shortage, increased groundwater salinity and contamination by untreated wastewater, and inability to access agricultural land. That included broadening of the buffer zone with Israel, which took away 15% of the most fertile agricultural land, uprooting of productive trees and land levelling. Following the start of the second intifada, more than 1 million trees were estimated to be uprooted in Gaza. In all, It was estimated that, by 2009, 46 per cent of Gaza's arable land was inaccessible or out of production.[98]

In contrast to the West Bank where agriculture has traditionally been mostly rain-fed, in Gaza, agriculture was dominated by irrigated crops. As recently as the early 2010s, it was estimated that 77 per cent of cropped land in Gaza were irrigated (in comparison to only 12 per cent in the West Bank).[99] Vegetables and fruit trees were almost fully irrigated, while field crops were mainly rain-fed.

That is changing in the 2010s. In the first half of this decade, almost one half of the 170 - 190 MCM extracted annually from the Coastal Aquifer were used in agriculture (around 85 - 90 MCM).[100] This is a decline from the 100 MCM utilized in 2005; and the declining trajectory continues due to several reasons: increased water salinity; need to dig deeper wells due to groundwater depletion; cost of energy- diesel fuel and electricity - needed for extraction; successive wars with Israel which damaged wells and irrigation infrastructure; and preventing the import of some fertilizers under the "dual use" prohibitions.
As water shortage becomes more severe and water quality is rapidly deteriorating, the size of land under irrigated crops is decreasing. In addition to continuous

97 UNCTAD, The Besieged Palestinian Agricultural Sector (2015), p. 8; OQ, IPE: Agriculture (2013), Slide 17

98 UNCTAD estimate, based on PCBS' 2010/2011 Agricultural Survey. UNCTAD, The Besieged Palestinian Agricultural Sector (2015), p. 13-14, 20. In 2013, cultivated land was estimated at 47 per cent of arable land (OQ, IPE: Agriculture (2013), Slide 14).

99 OQ, IPE: Agriculture (2013), Slide 14

100 World Bank, Toward Water Security for Palestinians (2018), p. 16 (85 MCM in 2014); PWA, National Water and Wastewater Strategy for Palestine (2013), P. 67 (86 MCM in 2012); PWA and Austrian development Agency, Infographic: Water Crisis in Gaza (2015) (93 MCM)

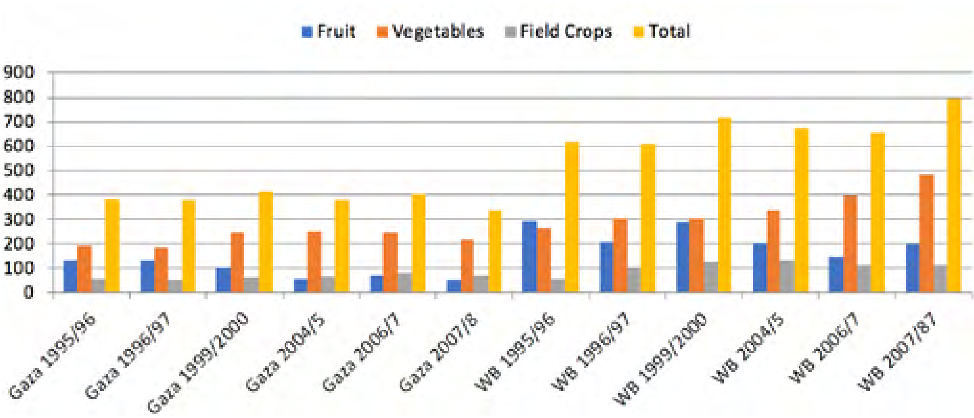
reduction in orange groves areas and other fruit trees that need more water and are more sensitive to water salinity, farmers report start of reduction in vegetable areas as well. Olive trees that can be rain-fed and date palms, which are more tolerant of salinity, have been gradually substituting citrus and other fruit trees.

b. Agricultural production and value of production

As shown in Chart 1, the total volume of agricultural production in Gaza showed no growth over the 1990s and the 2000s, ranging around 350 - 400 thousand tons a year. Vegetable production increased from below 200 thousand tons a year in the 1990s to about 250 thousand tons a year in the 2000s, while fruit production halved, from 100 - 150 thousand tons a year to 50 - 75 thousand tons. Field crops increased slightly, from about 60 thousand tons a year in the 1990s to 70 - 80 thousand tons a year in the 2000s.[101] Informal estimates for the 2018/2019 agricultural year indicate similar magnitude of vegetable production. Given the fast growth of population in Gaza, the resulting effect is continuous sharp decrease in local vegetable production per capita, and reduced surplus for export. Reports indicate even incidents of shortage of certain vegetables in the local market in the first months of 2019.

Agricultural surveys show similar trends for most animal products. Given that the demand for these basic food products is relatively rigid, these trends have significantly increased Gaza's dependence on imports for their supply.

Chart 1: Volume of Agricultural Production in Gaza by Main Crop Groups, in Comparison to the West Bank (thousand tons, selected agricultural years)

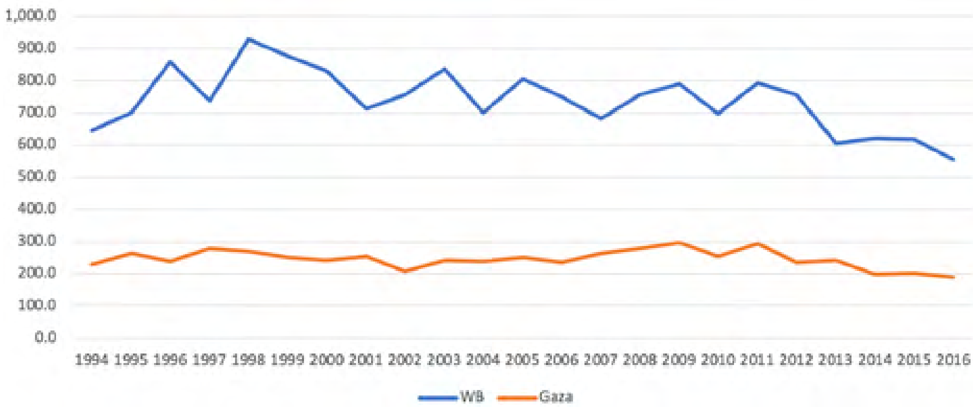


Source: PCBS, Agricultural Surveys

101 PCBS, Agricultural Surveys. No new agricultural surveys have been published since 2011.

All these factors have contributed to a sharp decline in total value of agricultural production, especially in the 2010s. The chart below shows the growth of agricultural output at constant prices since 1995 in both the West Bank and Gaza.

Chart 2. Agricultural output in the West Bank and Gaza 1994-2016 at constant prices in US dollars millions (2015 base year)

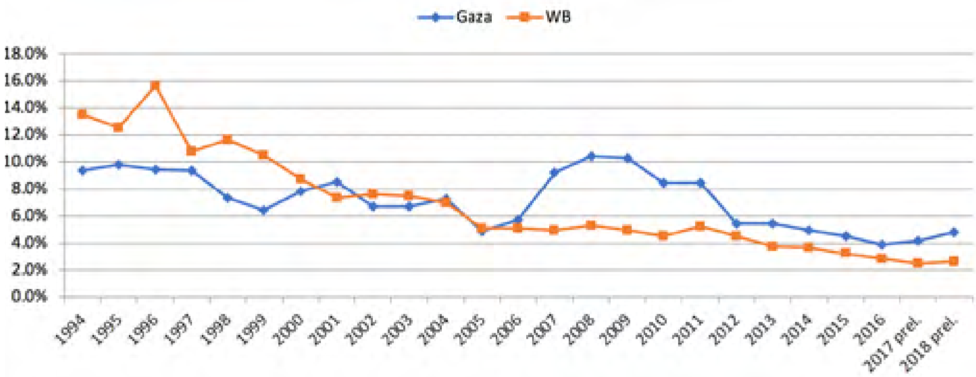


c. Contribution to GDP

Agriculture had traditionally been a mainstay of the Palestinian economy at large, and the Gazan economy in particular. Between 1948 and 1967, agriculture contributed more than one-third of Gaza's GDP.[102] During the two decades of Israeli direct rule, the share of agriculture decreased, reflecting two main trends: changes in the structure of the Palestinian economy and massive move of employment from traditional farming to work inside Israel. At the end of Israeli direct rule, in 1994, the contribution of agriculture to Gazan GDP was below 10 percent (14 percent in the West Bank). This trend continued and deepened overtime, as it has in Israel. In 2015 - 2018 it was already as low as 4 - 5 percent (around 3 percent in the West Bank).

102 Paltrade, THE AGRICULTURAL SECTOR IN GAZA STRIP: Fact Shet (2017), p. 1 (citing Sara Roy, The Gaza Strip: A Case of Economic De-Development, Journal of Palestine Studies, Vol. 17, No. 1. (Autumn, 1987), pp. 56-88)

Chart 4: Share of Agriculture in the GDP of Gaza, in Comparison to the West Bank 2004 - 2017 (percent, constant 2015 prices)

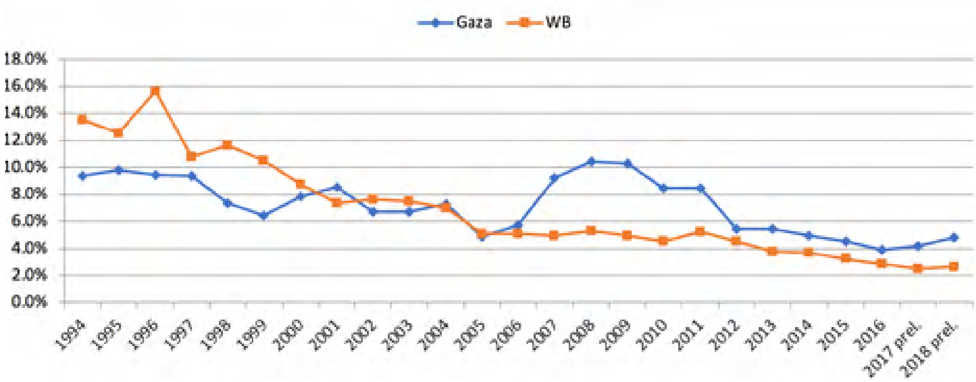


Source: computed from PCBS, National Accounts Statistics

Although the decline in the contribution of agriculture to GDP was continuous, there is a significant difference between the two eras. The 1970s and the 1980s were characterized by fast growth of agriculture, but at a lower rate than the GDP. Agricultural GDP (added value) in Gaza grew 5 percent a year in real terms (on average) during 1968 - 1973, against annual growth of 6.5 percent of total GDP (the figures for the West Bank were 6.5 percent and 7.5 percent, respectively).[103]

The continued decrease in the share of agriculture since 1994, on the other side, reflects real decline in agricultural GDP (in Gaza and the West Bank, Charts 5.1 and 5.2).

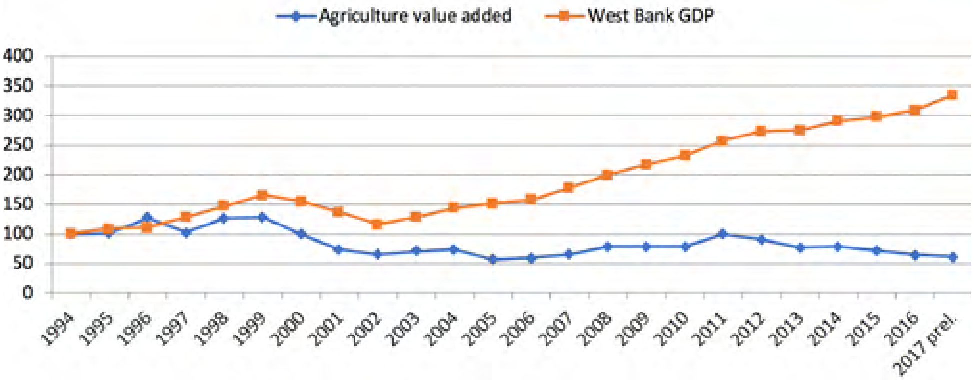
Chart 5.1: Gaza: Development of Agricultural Value Added in Comparison to the GDP 1994 - 2017 (index 1994 = 100, constant 2015 prices)



Source: computed from PCBS, National Accounts Statistics

103 Arie Arnon et al, *The Palestinian Economy Between Imposed Integration and Voluntary Separation* (1997), p. 172

Chart 5.2: West Bank: Development of Agricultural Value Added in Comparison to the GDP 1994- 2017 (index 1994 = 100, constant 2015 prices)



Source: computed from PCBS, National Accounts Statistics

d. Agricultural exports

Historically, agriculture had been the mainstay of Gaza exports. Prior to 1967, it contributed 90% of all exports, with citrus and fruits constituting the main exported products.[104] That changed gradually since the 1980s. Gazan mix of agricultural exports shifted towards vegetables and the contribution of agriculture to exports declined to around one quarter by 2000.[105]

Gazan agricultural exports remained significant in the first half of the 2000s but stopped almost totally in June 2007, with the advent of Hamas to power in Gaza. To punish the Hamas government, Israel banned exports from Gaza. Exports to Israel, at a monthly magnitude of 2,000 tons of fruit and vegetables were blocked as well as 700 tons a month of exports to the West Bank. Agricultural exports declined to a symbolic volume of 32 tons a month (1–2 trucks per month), between 2008 and 2014, almost exclusively to markets abroad.[106]

Since 2015, Israel relaxed its restrictions on agricultural exports to the West Bank, Israel and abroad. The number of export trucks carrying agricultural products increased to 94 a month in 2015 and 141 in 2016, reaching an average of 201 truckloads per month of fruits and vegetables between October 2018 to September 2019.

According to Israeli Crossing Authority data, the total volume of agricultural exports

104 Paltrade, ibid, p. 1.

105 Paltrade, ibid, p.1 (citing USAID, Sector Report: Agriculture, WB/Gaza, USAID, https://goo.gl/KmqQKQ)

106 Paltrade, ibid, p.2 (citing Gisha, Made in Gaza, March 2015 https://goo.gl/uLz7SK)

grew by 70 percent from 2016 to 2018: more than 50% in 2017, and close to 20% in 2018. As of 2018, at a total volume of more than 30,000 ton, almost all of it to the West Bank and abroad (only 10 percent to Israel), it has come close to the pre-2007 agricultural export magnitude. In monetary value terms, it is estimated at USD 30 million for 2019. Though still a relatively small volume, it is significant – 15 percent of 2016's total value of agricultural production.

Export-driven agricultural development: the rise and fall of Gaza citrus exports as a case study

This affair took place mainly in the 1970s and the 1980s, under totally different economic and political conditions. Nevertheless, being probably the most important case study of export-driven agricultural development in Gazan modern economic history, it is still of importance as a source of lessons, inspiration and insights, in the context of water and agriculture.[107]

The acceleration in the development of citrus exports from Gaza began in the late 1960s. Encouraged by the Israeli Government, thousands of dunoms of citrus groves were planted in Gaza using new citrus varieties that are more resistant to disease and pests. Advanced cropping and irrigation methods with intensive Israeli agricultural training were also used. As a result, Gazan citrus growers achieved high production rates – close to Israeli average and much higher than other Middle Eastern competitors. By the early 1970s, citrus groves contributed about half of total agricultural output in Gaza, and it took one third of all cropped area. Citrus fruit production more than doubled from 1968 to 1973; almost entirely destined for export (close to 95 percent in 1972-1973). Export volume of citrus fruit stabilized in the second half of the 1970s at about 200 thousand tons per year. At a value of USD 70 million a year, Gazan citrus exports were three-quarters of Palestinian agricultural exports and contributed over 20 percent of total Palestinian export of goods.[108]

The primary destination of Gazan citrus exports through Jordan were Arab markets, at a total of USD 50 to 60 million per year, and sometimes even beyond. Exports to European markets and other international markets (via Israel) amounted to USD 15-10 million a year.[109]

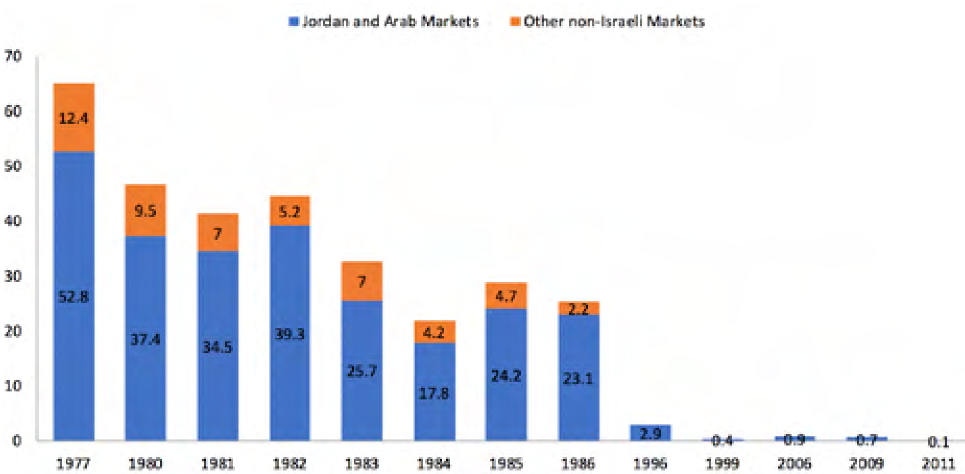
107 This section is based on various sources and analyses, mainly in Hebrew, including: Arie Bergman, Bank of Israel (Research Department), Economic Growth in the Administered Territories 1968 – 1973 (1973), p. 55-56; Yaacov Liphsitz, Structural Changes in the Administered Territories: Agriculture (1976), p. 60-65, Shlomo Gazit, The Sick and the Carrot: Israeli Administration in Judea and Samaria (1985), p. 204 – 222. As well as UNCTAD, *Palestinian External Trade Under Israeli Occupation*, 1989, pp. 42-46.

108 UNCTAD, *Palestinian External Trade Under Israeli Occupation*, 1989, pp. 42-43.

109 Arie Bergman, ibid, p. 73-80, UNCTAD, ibid, p. 43

In the first half of the 1980s, Gazan citrus production and exports started to decrease, reflecting change of Israeli policies, in conjunction with limitations of water supply for Palestinian agriculture. By 1984-1986, citrus exports were already below USD 30 million per year. The First Intifada turned the descent into a sharp fall. Water limitations, in combination with the cumulative effect of other barriers on agricultural exports, brought citrus exports from Gaza Strip to fall as low as USD 3 million in 1996. In the second half of the 1990s citrus exports diminished to insignificant figures.

Chart 6.1: Exports of Citrus Fruit from Gaza to Arab Markets (through Jordan) and Abroad (through Israel) 1977 – 2011 (selected years, USD millions)



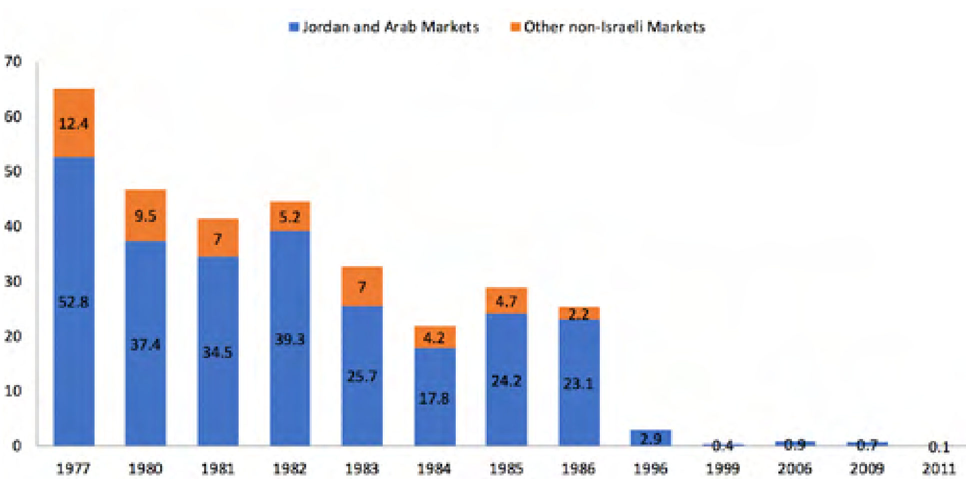
Source: UNCTAD, *Palestinian External Trade Under Israeli Occupation*, 1989, p. 43 (for 1977 – 2006, based on Israeli statistics); PCBS, detailed trade statistics database (for 1966 – 2011)

e. Centrality of water availability: the irrigation – productivity relationship

Lack of water for irrigation is, by far, the most dominant factor impacting productivity and income in Gazan agriculture and the Palestinian agriculture at large. The large gap in productivity between irrigated and rain-fed crops is evident across all categories of agricultural products. Production per donum of vegetable crops was found to be 2–8 times higher under irrigation than in non-irrigated plots. For main fruit crops (olives, grapes, etc.) the output per donum of irrigated plots is twice that of rain-fed plots, and similar gaps were found for potatoes and onions.[110] It is estimated that over 85 percent of total Palestinian cropped area, which is not irrigated for lack of water, generate only 5 percent of value added in agriculture.[111]

Moreover, irrigation is also the key to application of advanced cropping methods and adequate fertilization. Application of such methods (cropping in structures, use of advanced irrigation systems, targeted "fertigation", etc.) enhances productivity much further. As shown in Chart 7 below, for certain vegetable crops it increases production per donum 2–3 times, in comparison to irrigated cropping in open field. Adequate fertilization has been conservatively estimated to increase production per donum by at least 25 percent (net impact over and above irrigation and other improvements in cropping methods).[112]

Chart 7: Production per Donum – Comparison between un-Irrigated and Irrigated Plots (open field and in agricultural structures) (Kg. per donum)



Source: PCBS, 2007/2008 Agricultural Survey

Furthermore, the availability of water for irrigation would enable Gazan farmers to improve their crop mix. That includes shifting from relatively low-production, low-value olives and field crops (that can be rain-fed) to higher-production, high-value vegetable and fruit crops (that require sufficient, continuous and reliable irrigation).

110 PCBS, 2007/2008 Agricultural Survey, p. 56-57, 77-78, 110-111

111 PNA, Ministry of Agriculture, *x* (July 2010), p. 28

112 OQ, IPE: Agriculture (2013), Slide 32

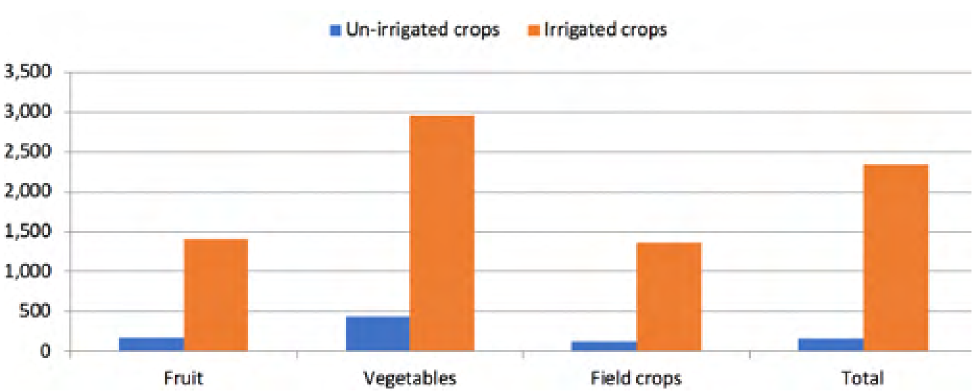
Un-irrigated olive groves generate income of about USD 100 a year per donum, against USD 1,500 a year per donum of irrigated grapes or USD 1,200 to 4,700 per per donum of irrigated citrus (depending on the type of citrus). A donum of un-irrigated field crops – such as wheat, barley and clover – generates USD 100–300 a year, while a donum of irrigated potatoes and onions generates USD 1,500 a year. A donum of irrigated vegetables generates, on average, USD 3,000 a year (see Charts 8.1 to 8.4).

In all, the average income generated for Palestinian farmers, as found in the 2007/2008 agricultural survey, was USD 162 per donum of un-irrigated cropped areas (86% of the total in 2007/2008); against USD 2,343 on average per donum of irrigated areas – a striking gap of 20 against 1 per donum.

A detailed calculation of the cumulative impact of all the factors mentioned above was conducted by the World Bank in relation to agricultural land in Area C (West Bank), using another methodology (based on detailed data of the PCBS' 2007/2008 agricultural survey). The bottom-line of this analysis was that availability of water (which would enable shifting currently rain-fed plots to irrigation, improved crop-mix) can increase average income derived by Palestinian farmers from a donum of currently rain-fed agricultural land by as much as 14 times.[113]

These huge gaps reflect the cumulative impact of losses in productivity and value of production that stem from lack of water for irrigation, as described above.

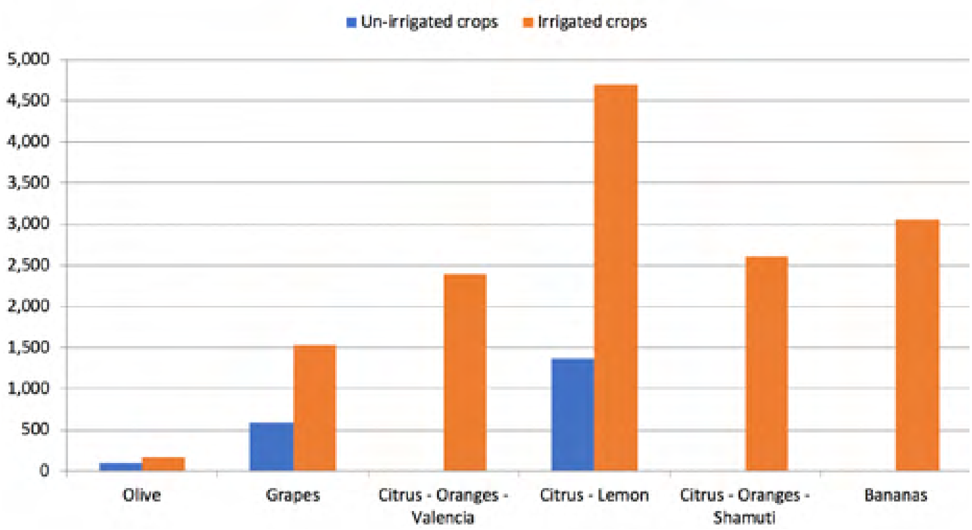
Chart 8.1: Income per Donum – Comparison between un-Irrigated and Irrigated Plots
(USD, agricultural year 2007/2008)



Source: World Bank, *Area C* (October 2013) pp. 47-50

113 World Bank, Area C and the Future of the Palestinian Economy (October 2013) p. 36-37, 47-50.

Chart 8.2: Income per Donum – Selected Fruit Crops: Un-Irrigated and Irrigated Plots
(USD, agricultural year 2007/2008)



Source: World Bank, *Area C* (October 2013) pp. 47-50

Chart 8.3: Income per Donum – Selected Vegetable Crops: Un-Irrigated and Irrigated Plots
(USD, agricultural year 2007/2008)

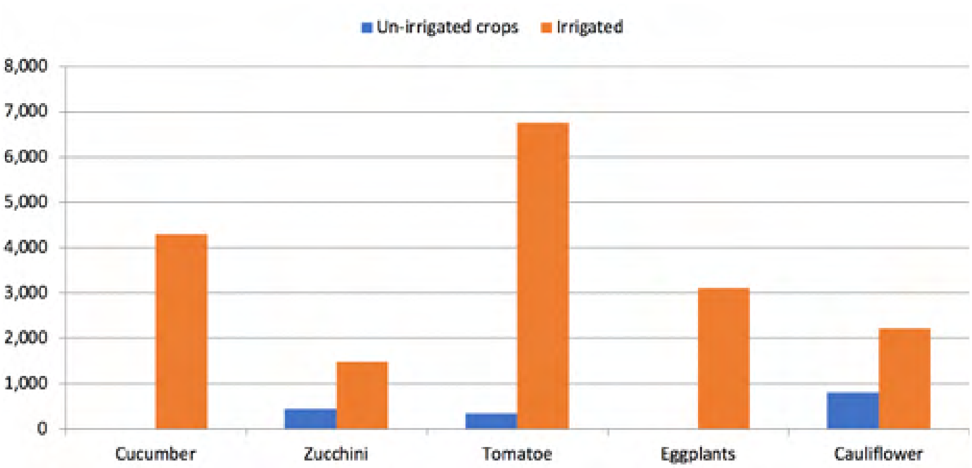
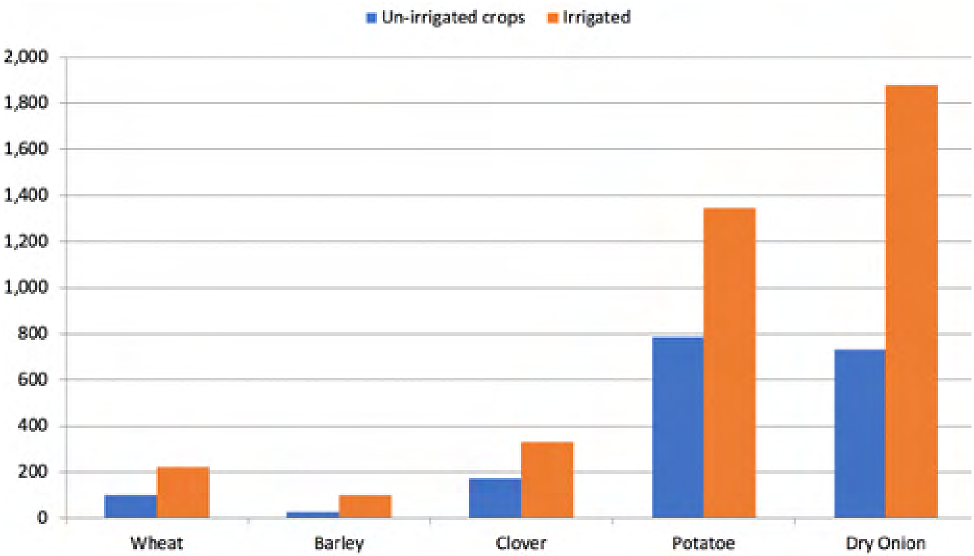


Chart 8.4: Income per Donum – Selected Field Crops: Un-Irrigated and Irrigated Plots
(USD, agricultural year 2007/2008)



Source: World Bank, *Area C* (October 2013) pp. 47-50

Annex B: Decentralized Wastewater Solutions - A Model Project

The proposed project aims to provide a low-energy-use, decentralized local solution for the wastewater treatment needs of villages in Gaza, while reusing treated water for irrigation.

This solution is based on technologies that:

- Do not require large Capital Expenditure (Capex) for expensive infrastructures and machinery or long pipeline systems for the transportation of wastewater to regional WWTPs;
- Save on O&M costs by reduced use of electricity, simple operation procedure, and almost no use of chemicals and other expensive inputs.

These proposed local solutions would also have two secondary benefits:

- Local job creation in the villages through the construction and operation of the systems, which would predominantly be undertaken by a local workforce;
- As a by-product, the system can be utilized for local beautification, creating neighborhood parks, “green corridors”, etc.

This new source of water will be used by local farmers for the irrigation of near-by agricultural lands. These lands are either unused today, because of lack of irrigation water, or are used for rain-fed, low-value crops. This new water source will support the irrigation of primarily fruit trees. Palestinian regulations limit the use of treated wastewater, grain crops, fodder and fruit trees. This is similar to Israeli regulations and those of other countries. Additionally, the treated water can also be used for the irrigation of vegetables in certified farms, after tertiary treatment, and blending with drinking-quality water, as is done in Israel, and elsewhere. For that purpose, the proposed project also plans to provide advanced irrigation systems to the farmers who will use this new source of water. Use of this source of water would enable much higher productivity and may increase value of production by 5 to 20 times.

- For olive orchards, the value of production of irrigated olive trees, that produce fruit for production of high-quality olive oil, can be 4-5 times higher per dunom than that of low-quality, low-productivity rain-fed trees.
- Moreover, the availability of reliable, steady irrigation water would enable farmers to switch from low-value olive and field crops to other fruit trees, and in certain cases increase their vegetable crops. For example, in the north of Gaza

Strip, treated wastewater can be mixed with available fresh water. The value of production of these crops ranges between $2,000–$ 4,000 per dunom per year, in comparison to roughly $ 100 to $ 400 of unirrigated olive orchards or field crops.[114]

The Proposed Model Project

The model project aims at demonstrating the technological applicability, the benefits, and the economic viability of decentralized wastewater treatment solutions and the re-use of treated water in intensively irrigated agriculture. The village proposed for the model project is in the southern part of the Gaza Strip. Population served with water is close to 30,000. Water consumption is about 100 liter/person/day, with fluctuations between years. Estimated wastewater volume is 2,500–3,000 m^3/day. This flows from houses to approximately 4,000 "active" cesspits.[115] The project is designed to produce 3,000 m^3/day.

The project includes the following components:

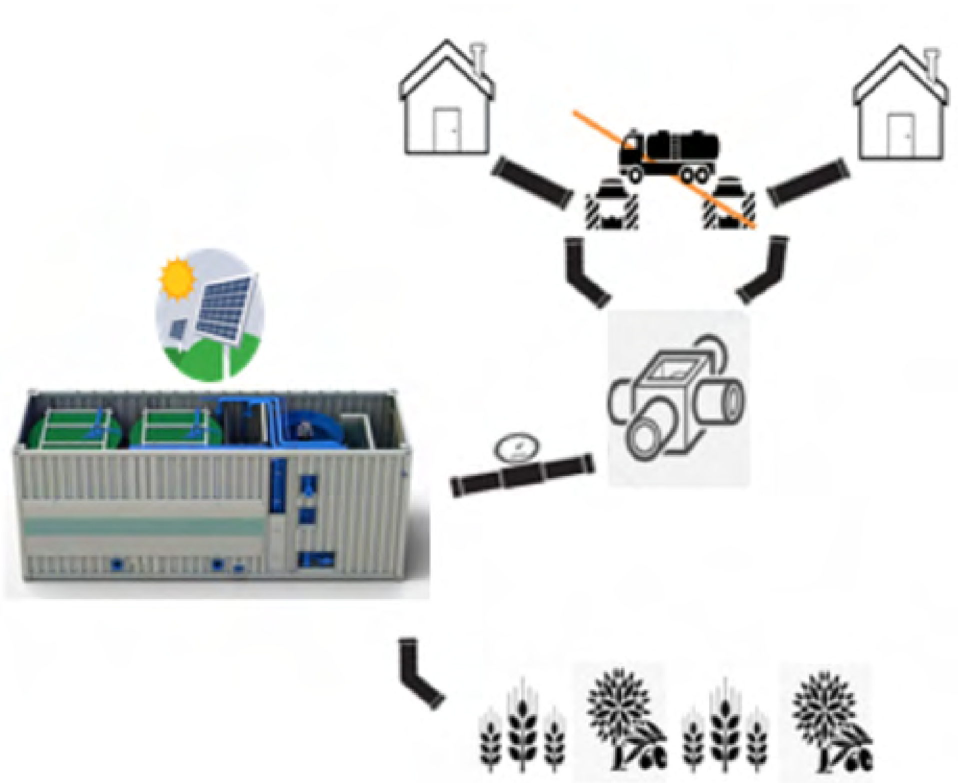
- **A set of decentralized WWTPs,** each serving a neighborhood or a cluster of houses. The WWTP will be located close to the neighborhood it serves, and treated water will be used for irrigation of adjacent agricultural areas
- **Small solar PV systems for each of the WWTPs** – a stand-alone off-grid system with electricity-storage batteries; which would make the WWTP self-sustainable and enable 24/7 operation. The solar system will also power irrigation pumps, and other associated smart monitoring systems
- **Short conveyance Wastewater piping systems**. The houses will be connected to the WWTP by short conveyance pipes that take wastewater from the neighborhood or cluster. This system will be connected to the present pipes that take wastewater from the houses to their cesspit. The new piping system will take the wastewater instead to the neighborhood's main pipe that will take it a few hundred meters further to the new neighborhood WWTP
- **Irrigation system**. Treated water will be pumped from the WWTP to adjacent agricultural areas, which will be served by an advanced irrigation system. That way, the new source of irrigation water will enable best results in terms of increased productivity and high-value crops

114 IPE: Agriculture (2013), slides 8, 18, 29, 34; : PCBS, 2007/2008 Agricultural Survey; World Bank, Area C and the Future of the Palestinian Economy (October 2013) p. 36-37, 47-50.

115 The total number of cesspits is estimated at 5,000, but part of them are not active, while some cesspits serve more than one household.

- **Neighborhood parks/"green spots".** Part of the treated water will be used for development of recreational parks and other green spots around the village

These main elements of the project are illustrated in the following schematic.



The WWTP technology and solar energy systems:

The set of small low-energy-use WWTPs will be built using several types of WWTPs: containerized WWTPs using Membrane Aeriated Biofilm Reactors (MABR), advanced Constructed Wetlands and Vertical Solution systems. These technologies are described and demonstrated below.

The advantages of the proposed WWTPs can be defined as:

- Easy and fast to install. Planning requires deep professional and scientific know-how and experience, but installation on site is simple.
- Able to cope with a large variety of pollutants simultaneously when

professionally planned.

- Water produced by the proposed WWTPs is of excellent quality. Again, professional design and training is critical.
- Huge difference in total life-time cost in comparison to "conventional" WWTPs (per m^3 of treated water). Capital cost is usually lower; but the main difference is in the operation and maintenance costs: Low energy costs and low maintenance costs. As a result, overall operation and maintenance costs (O&M) are dramatically lower than O&M of "conventional" WWTPs.

The Project will be executed as per the following three phases:

- Phase One: Proof of Concept small project that will treat 100 m3/d of WW, and serve a cluster of 120–150 houses (around 1,000 persons) in the designated neighborhood
- Phase Two: Expanding the project to cover the entire designated neighborhood (around 3,000 people)
- Phase Three: expanding the project to cover the entire village

Economic Model, Investment, Operation Cost and Pricing:

Given the special economic conditions of Gaza, the Capex of the Project will be financed by donor aid. However, its operation and maintenance (O&M) will be based on an economically viable model, whereas the Municipality will manage the set of WWTPs as a fully self-financed and sustained utility, by:

- Collecting wastewater treatment fees from the households (with explicit subsidies to poor households);
- Selling the product (treated water) to farmers (or farmers' association) at an agreed price.

Benefits for households, Farmers and the Municipality:

Households:

- At present, households incur high costs for the pumping and trucking of wastewater from their cesspits by private wastewater-pumping contractors as well as other related costs. The rate per m^3 is $ 1.5 - $ 2; while high one-time costs (flooded cesspits, digging new cesspits) significantly increase this figure (when computed per m^3, on average).

- Additionally, households suffer health, smell and other problems and risks associated with the cesspit system.
- The proposed Project will stabilize their wastewater treatment costs at around NIS 1.5 (less than $ 0.5) per m^3, while eliminating present health, smell and other problems, and upgrading their environment.

The Municipality:

- The immediate benefits for the Municipality will be in upgrading its services to the residents, eliminating health and other hazards associated with cesspits, and beautifying the village.
- Additionally, the project will become an important source of net income, enabling the Municipality to financially rationalize and balance its water operation.
- If the Municipality succeeds, over time, to significantly reduce subsidies on WW treatment and freshwater tariffs, its revenues from selling the treated water to farmers can become an important source of net income that can be used for other activities.

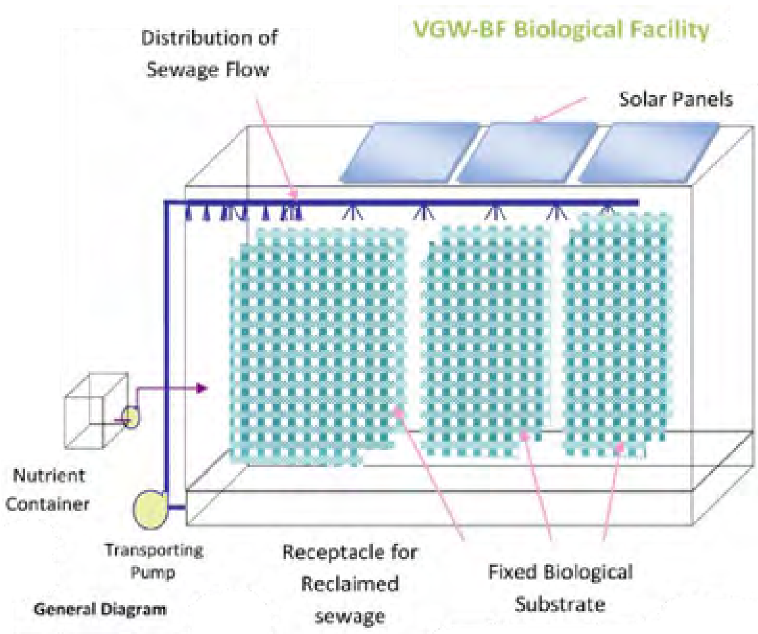
Farmers:

- The village farmers are going to gain the most from the proposed project. The 2,500 m^3/d new irrigation water would enable development of intensively-irrigated agriculture on 3,000–4,000 dunom and create more than 4,000 new jobs (including related processing and services).
- Even considering the lower side of the income estimates mentioned above (value of production of $2,000–$4,000 per dunam), that would generate (over time) aggregate additional income of $ 6–8 million a year for the village.

More on the proposed technologies

Containerized WWTPs using Membrane Aeriated Biofilm Reactors (MABR) will be the main solution for the project, with some other small low-energy-use WWTPs – advanced Constructed Wetlands (CW) and Vertical Solutions (VS) being utilized.

The " A "smart mix" of biological, physiological and other elements installed in the CW and VS systematically degrade, accumulate, extract and volatilize the various contaminants of the wastewater. At the entry point, there is a pre-treatment module, which screens and removes heavy particles like sand, etc. If needed, this module also includes specific components for treatment of specific contaminants.

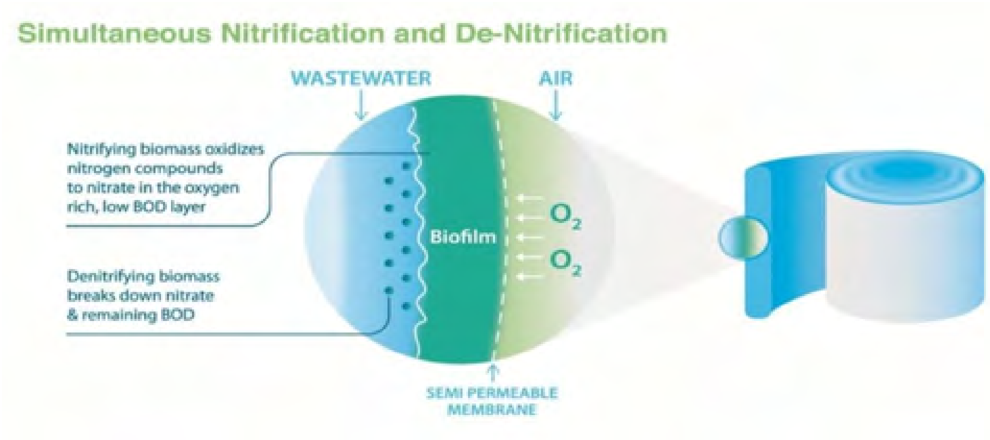


Containerized MABR WWTPs work as follows:

The MABR process utilizes an enclosed patented spiral membrane aerated biofilm reactor. This MABR treatment significantly reduces energy consumption by eliminating the need for compressed air for aeration of the wastewater.

A biofilm forms on the breathable membrane assembled in a continuous spiral. A constant stream of low pressure air distributes oxygen to the wastewater through the MABR spirals, which consist of membrane sheets and spacers. This structure produces optimal oxygen transfer efficiency using air diffusion from one side of the membrane to the wastewater on the other side.

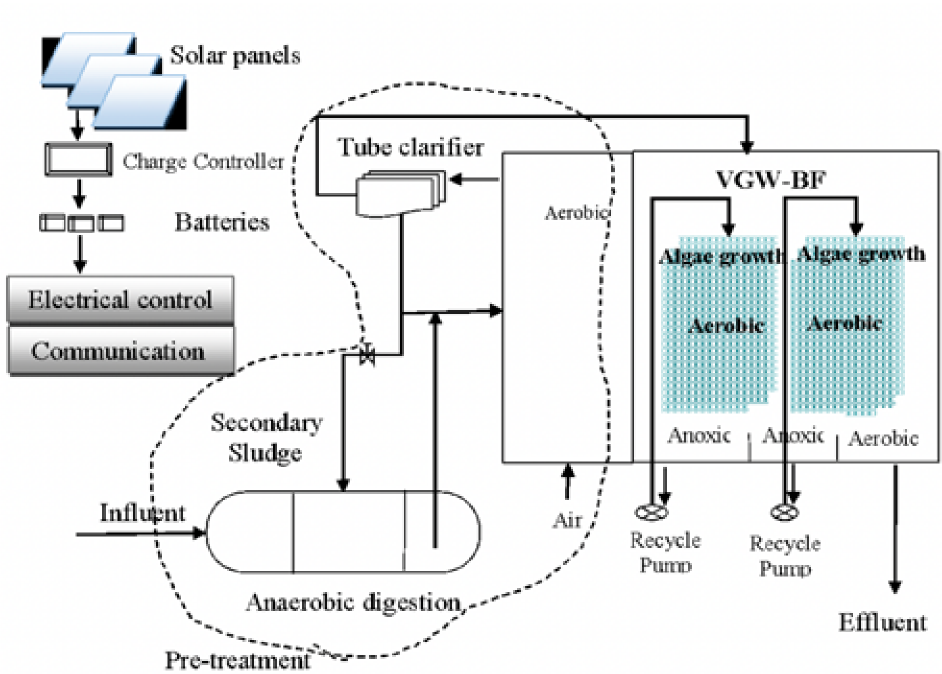
The oxygen is consumed by nitrifying bacteria on the membrane, creating an anoxic area on the further side of the membrane, where de-nitrification and BOD removal occur.

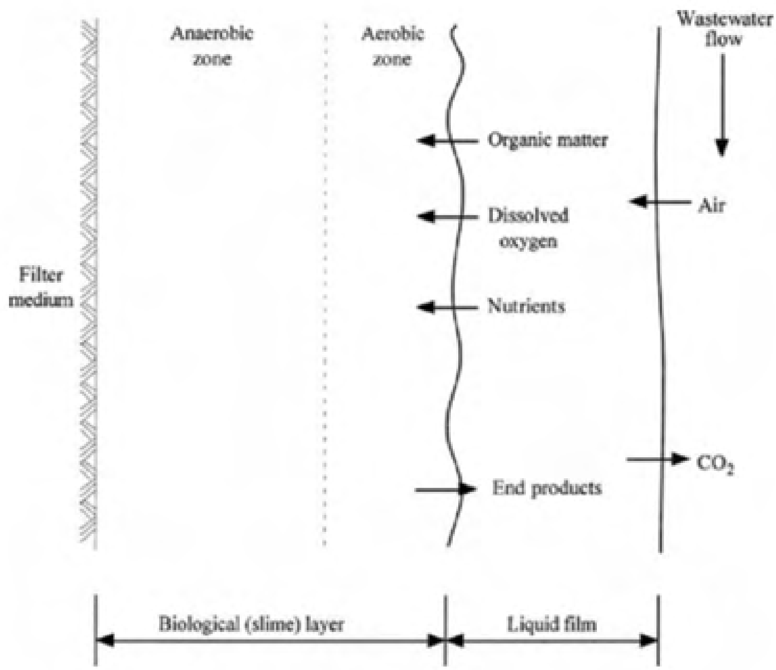


VGW works as follows:

Pre-treatment stage: anaerobic digestion via plastic polypropylene (PP) fixed substrate to reduce by 50% the organic load (e.g.: fats, oils, grease), tube clarifier for organic biomass settling, the secondary sludge breaks down to CO^2 and CH^4 (no sludge build-up).

Treatment stage: vertical green wall bio-filtration trickling filter that produces effluent for irrigation.


Solar panels
Charge Controller
Batteries
Electrical control
Communication
Tube clarifier
Aerobic
VGW-BF
Algae growth
Algae growth
Aerobic
Aerobic
Anoxic
Anoxic
Aerobic
Secondary
Sludge
Influent
Air
Recycle
Pump
Recycle
Pump
Anaerobic digestion
Effluent
Pre-treatment

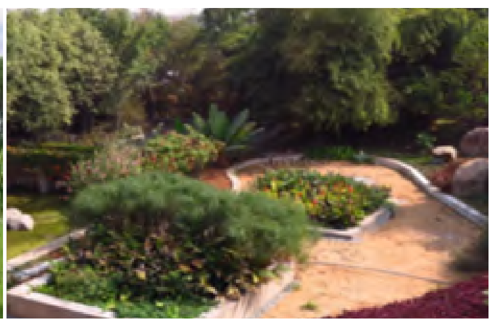

Anaerobic
zone
Aerobic
zone
Wastewater
flow
Organic matter
Dissolved
oxygen
Air
Filter
medium
Nutrients
CO2
End products
Biological (slime) layer
Liquid film

Integration of WWTPs into green spots or eco-parks – examples

Larger-scale Sewage Stream Treatment, Hyderabad, India (Musi River Catchment); 5,000 cm/d for the Hyderabad Golf Authority

Integrated with the Hyderabad Golf Course

Small scale under-ground sewage treatment installations in villages



A neighborhood eco-park around Tel Aviv with an under-ground sewage treatment system

Small scale urban / industrial under-ground sewage treatment installations

KONRAD ADENAUER STIFTUNG
PALESTINIAN TERRITORIES

The Konrad Adenauer Stiftung Palestinian Territories

About us

Freedom, justice and solidarity are the basic principles underlying the work of the Konrad-Adenauer-Stiftung (KAS). The KAS is a political foundation, closely associated with the Christian Democratic Union of Germany (CDU). As co-founder of the CDU and the first Chancellor of the Federal Republic of Germany, Konrad Adenauer (1876-1967) united Christian-social, conservative and liberal traditions. His name is synonymous with the democratic reconstruction of Germany, the firm alignment of foreign policy with the trans-Atlantic community of values, the vision of a unified Europe and an orientation towards the social market economy. His intellectual heritage continues to serve both as our aim as well as our obligation today.

In our European and international cooperation efforts we work for people to be able to live self-determined lives in freedom and dignity. We make a contribution underpinned by values to helping Germany meet its growing responsibilities throughout the world.

We encourage people to lend a hand in shaping the future along these lines. With more than 100 offices abroad and projects in over 140 countries, we make a unique contribution to the promotion of democracy, the rule of law and a social market economy. To foster peace and freedom we encourage a continuous dialog at the national and international levels as well as the exchange between cultures and religions.

Since 1996, Konrad-Adenauer-Stiftung has been present with its office in the Palestinian Territories where it promotes democracy and the rule of law as it does throughout the region and worldwide.

The work of KAS aims at implementing social and market based structures as well as promoting human rights. By offering political education, KAS supports the development of political thinking, local self-administration and free and independent media.

In the Middle-East, KAS is taking part in the political, economic and social stabilization of the region. It intends to provide a sustainable contribution to the establishment and strengthening of democracy, rule of law and civil society. Furthermore, it aims at contributing to the development and deepening of social and market based structures, the prevention of violent conflicts, the consolidation of cooperation within the region and with Europe as well as to the constructive dialogue of cultures and religions.