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COSTEA
Ensemble pour relever les défis de l'agriculture irriguée

COSTEA "REUSE - WASTEWATER REUSE IN AGRICULTURE" INITIATIVE

'PALESTINE' SYNTHESIS REPORT

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SCP

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EXECUTIVE SUMMARY

The **water sector in Palestine has been under severe pressure**, due to the persistent political situation, climatic change, demographic and urbanization trends, inefficient management, lack of financial support and governance modalities. While struggling to get their water rights, Palestinians are trying to adapt with the water scarcity through finding non-conventional water resources such as the treated wastewater. Despite the governmental interest and the efforts in the reuse during the last 20 years the reuse level is still not satisfactory.

Water sector stakeholders include government, Water Service Providers (WSPs) (mainly local councils), non- governmental organizations (NGOs) and private sector. Together they developed a regulatory framework, with standards, rules, and laws to govern the sector. The water law was enacted 2004. The water Sector Regulatory Council (WSRC) was formed with clear mandate to monitor all matters related to the operation of WSPs. Such framework should be efficient to manage the water in an integrated approach, however, the Integrated Water Resource Management is not applied in a framed approach, albeit the reform efforts.

The **total generated WW in Palestine is 114 MCM annually**, where only 54% of the households are connected to the sewer networks. Over 90% of the collected wastewater in Gaza and around 35% in the West Bank are treated at different levels (secondary, tertiary). However, not all treated wastewater fulfil the relevant specifications and standards due to the lack of proper management of WWTP and the inability of covering treatment costs. The **trans-boundary water** is estimated at 15MCM annually, such water is usually collected and treated in Israeli WWTP. Though this water is used by Israeli farmers, the cost of treatment is charged on the Palestinian budget through deducting the cost of treatment from the Palestinian tax money.

While there are **52 WSPs collecting wastewater in West Bank and Gaza** only **22 have treatment facilities** (17 in WB and five in Gaza). There are few planned and unplanned reuse activities in only eight urban treatment plants and 15 rural small scale WWTP. Almost all reuse is in West Bank, while in Gaza there are two pilots of reuse and a large aquifer recharge Beit Lahia, this water could be recovered and used indirectly for irrigation. However, the recovery is still not functional.

The volume of annually used **RWW for agriculture in Gaza** was around **1.0 million cubic meter** out of 77.7 MCM treated, while **in WB the reused volume did not exceed this limit** out of 8.0 MCM of treated wastewater treated annually. Number of WWTP and consequently the volume of treated water increase year after year. Many of the rural ruse schemes were not sustained for a reason or another.

TWW reuse is planned in Jenin, Ramallah and Nablus where water distribution systems were installed. While it is unplanned reuse in **Jericho**, as farmers are connecting on their own without a well-designed and unified system. Only three WWTP were found to be compliant with the

irrigation requirements. If all of the wastewater generated were to be reused, it would be possible to save 14% of the supply and demand gap.

Only one out of the five large scale urban WWTP in WB, Jericho WWTP effluent (1600 cubic meters per day) is totally reused, while in other areas the effluent is only partially reused. However, a large reuse project in Nablus is being implemented by KFW and expected to reuse treated wastewater by 2023. Only WWTP in Nablus, Ramallah and Jericho fulfilled the high treatment efficiency required by Palestinian Water Authority, While, in Gaza none of the WWTP fulfilled the needed efficiency. This fact could affect the reuse potential and future success.

Local Governmental Units (LGUs) derive 15-16% of their total revenue from water services, part of this revenue is diverted to general expenses such as salaries, especially after shifting the electricity service to electrical companies in all Palestinian communities except Tulkarem. This is reflected on the ability to pay for water treatement. The "polluters pay principle" entails that households cover part of the full cost recovery of the wastewater collection and treatment as there are many elements determining costs of treatment such as the storm water, the wastewater collection, storage, and reuse. As well farmers should also contribute to make treated wastewater available for irrigation. The adoption of this principle in the environmental law (1999) helped LGU's to add tariff and ask households to pay for sewage collection and treatment of wastewater.

Service providers are suffering from the lack of good practices of **sludge management**, all practices and projects related to the sludge management are either on pilot level, or individual research projects, without practical solution. Only Nablus municipality is using dewatered sludge to produce biogas to heat the digester and use the methane gas for electric generators. But later the resulting sludge/ slurry is transported at high costs to landfills in Jenin area without proper reuse. Standards and regulations for sludge reuse are very strict. The need to successfully address the **risk health problems** involved in the reuse of sludge is crucial, especially as worldwide health problems related to pathogens have appeared in many cases of people living around and near the sites of application of sludge.

Since the establishment of the Palestinian Authority in 1994, Palestinians has conducted several studies related to water, wastewater management, reuse of treated wastewater, and water governance. Studies included **sanitation master plans**, many strategic water and wastewater plans for the future interventions. While the **scientific research** in the water sector is mainly conducted by the water and environmental departments in universities who have higher studies programs in water and environmental engineering, with good capacity and curricula of researchers and university professors.

Reuse of treated wastewater is the responsibility of **Ministry of Agriculture**, however, the monitoring of the quality of water is a mixed responsibility between **Ministry of health**, **Environmental Quality Authority**, Ministry of Agriculture, and the **service provider**. While the treatment facility is controlled by **PWA**, and EQA. MoA is responsible for issuing licenses for farmers to use the TWW. On farmers' level, and before approving the **water user's**

association (WUA) law (2018), farmers used to form cooperatives to run water projects. WUA are governed to MoA.

In the past the reuse of TWW for irrigation was limited due to health aspects, socio-economic conditions, religious considerations, and public and farmer perceptions psychological aversion of farmers. However, currently the unsatisfactory lever of reuse is explained by the **very strict laws and regulations**, the inadequate quality of TWW and the socioeconomic issues. Inteviews of 115 large-scale farmers (growing more than 50 dunums (i.e. 5 ha)) in most common agricultural areas of WB found that only 11% of them are using TWW. The low percentage was explained by availability of fresh water in areas where TWW is available at reasonable prices (0.43 $), on the contrary, the unavailability of TWW in other areas.

The water and wastewater **tariffs** are complex and vary from area to another. WSRC reported that 13 SPs out of 54 in the WB, have no tariff for WW, 19 SPs out of 54 recovered their costs (without depreciation) by generating higher revenues than costs. this situation is different than Gaza, where more than 80% of SPs have a WW tariff as a percentage of the water bill (15-25%). The Water and Sewerage Services Authority (WSSA) in Bethlehem, which serves Bethlehem, Beit Jala, Beit Sahur, and part of Bethlehem rural areas, is the only SP across the WB that applies a tariff to the WW as a percentage of the water consumption bill (approximately 28% of water bill). Ramallah, on the other hand, is the only SP in both the WB and the GS that applies a tariff based on built area (0.45 JD per m^2).

It is mandatory that every service provider **monitor quality parameters** of effluent and influent. However, most of the service providers do not have a lab or cannot afford the routine periodic needed tests in private sector labs. All WWTP treat water to secondary level except Teireh/ Ramallah. To meet standards for irrigation of wider scale of plants the effluent need further treatment. Current reuse is for trees and alfalfa like the cases in Jenin, Jericho and pilots in Nablus,.

There are **good prospects and opportunities** to develop the reuse sector. Many new WWTP are being constructed or just finished. The failure in reuse in different communities is being studied and problems solved.

1 INTRODUCTION

To be completed by the coordination team

1.1 OBJECTIVES

1.2 TERMINOLOGY

REUSE

TWW reuse

Planified

Unplanified

Direct

Indirect

1.3 LIST OF ACRONYMS AND ABBREVIATIONS

AFD	French Development Agency
Applied Research Center	American Near East Refugee Aid
ARIJ	Applied Research Center- Jerusalem
BoD	Biological Oxygen Demand
BOT	build-operate-transfer
C/B = CBA	Cost Benefit Ratio
CBOs	Community-Based Organizations
CM	Cubic Meter
CMWU	Costal Municipality Water Utility/ Gaza
CoD	Carbon Oxygen Demand
CSO	Community Services Organization
CW	Constructed Wetland
EQA	Environmental Quality Authroity
EU	European Union
GS	Gaza Strip
INGO	International Non-Governmental Organization
IWRM	Integrated Water Resources Management
JD	Jordan Dinner
JICA	Japan International Cooperation Agency
KfW	German Development Bank
KPIs	Key Performance Indicators
LGU	Local Governmental Unit
MCDA:	Multi-Criteria Decision Analysis
MCM	Million Cubic Meter
MEDRC	Middle East Desalination Research Center
MoA	Ministry of Agriculture
MoLG	Ministry of Local Governance
NARC	National Agriculture Research Center
NGEST	North Gaza Emergency Sewage Treatment
NGOs	Non-Governmental Organization
NPV	Net Present Value
O&M:	Operation and Maintenance
OFID	OPEC Fund For International Development
PA	Palestinian Authority
PHG	Palestinian Hydrology Group
PPP	Private Public Partnership
PSI	Palestinian Standards Institute
PWA	Palestinian Water Authority
RWW	Reclaimed Waste Water
SP	Service Provider

TN	Total Nitrogen
TSS	Total Soluble Solids
TWW	Treated Wastewater
UN:	United Nation
USAID:	United States Agency for International Development
USD:	United States Dollar
VCs:	Village Councils
WASH:	Water and Sanitation, Hygiene
WB&G:	West Bank and Gaza
WB:	West Bank
WHO:	World Health Organization
WSPs:	Water Service Providers
WSRC:	Water Sectorial Regulatory Council
WSSA	Water and Sewerage Services Authority) in Bethlehem
WUA	Water Users Association
WW	Wastewater
WWTP	Wastewater Treatment Plan

2 NATIONAL STATE OF THE ART DESCRIPTION

Water is not scarce in Palestine but rather access to water is denied by Israeli occupation and control on natural resources. Palestinians follow adaptation measures to cope with **reduced access to water**. Non traditional water resources like desalination of sea water and brackish water and treated wastewater (TWW)[1] are necessary solutions under study and implementation.

2.1 INSTITUTIONAL FRAME

An important element in the sustainable treatment and reuse of wastewater is the formulation of standards and regulations (AHT Group AG, 2009). Most wastewater reuse standards in the Middle East and North Africa region "are based either on the United States Environmental Protection Agency (**USEPA**) or World Health Organization (**WHO**) **guidelines**" (WaDImena, 2008). The Palestinian wastewater management strategy is to eliminate raw wastewater discharge to the environmental through implementation of collection and treatment systems and where possible to reuse wastewater for irrigation purposes and aquifer recharge. The major Palestinian regulation documents (i.e. laws) regarding wastewater treatment and reuse are the Palestinian water law No.14 of year 2014 , the Palestinian Environmental law No.7 of year 1999 and recently in 2018 the Palestinian government approved the Water users Association Law #4 to facilitate the organizing of farmers willing to run water resources. (Abu Sultan 2015).

The main stakeholders are the Palestinian Water Authority (PWA) whose mandate is to secure water supplies and regulate the whole sector the Ministry of Agriculture (MoA) is responsible for irrigation water use and TWW reuse after it leaves the treatment plant , Environmental Quality Authority (EQA) ensures treatment of sewage water and disposing no treated water in best way possible, and contricute to the regulations, Palestinian Standards Institute (PSI) is the organization responsible for setting standards and specifications of RWW and sludge and Ministry of Health test the contamination of all water sources for health parameters. TWW regulations were approved in 2012, while for sludge regulations were approved in 2014.

2.2 IWRM

Water does not stop at administrative or political boundaries, therefore cooperation and mainstreaming of efforts of stakeholders is crucial for IWRM. The Israeli Palestian Conflict is main obstacle facing the water sector.

The different water strategies of Palestinian water-related organizations including Water Authority, which are the guiding plans of the water sector do not mention explicitly the IWRM.

[1] Water sector Strategy. 2016-2018

It is only mentioned as an opportunity to use these principles in developing water resources[2]. The Aspects of IWRM in the water policies and strategies can be described as follows:

2.2.1 ENABLING ENVIRONMENT

An IWRM policy is being used by the Palestinian responsible authorities (Palestinian Water Authority (PWA), Water Sector Regulatory Council (WSRC), and Water Service providers (WSPs). The water law has been ratified and implemented in 2014, with several limitations because of the lack of control over the limited available water resources due to the Israeli occupation. [3] PWA in its strategic plan 2016-2018 adopted the IWRM as an approach to developing the water and wastewater sector in Palestine.[4]

2.2.2 INSTITUTIONS AND STAKEHOLDER PARTICIPATION

Thee Decree-bylaw No. 14 of 2014 entails formation of the Water Sector Regulatory Council (WSRC) with the mandate of "*monitoring all matters related to the operation of water Service Providers including production, transportation, distribution, consumption, and wastewater management, with the aim of ensuring water and wastewater service quality and efficiency to consumers in Palestine at affordable prices*". The same law has defined the roles and responsibilities of WSRC as the main party for managing Water Resources in Palestine, following principles of integrated and sustainable management of water resources.[5]

Different sectors and stakeholders contribute to the decision making process for policy development, planning and management, allowing for some long-term initiatives to be implemented with appropriate coverage. However, communication and buisness between the government and the private sector is still limited, though the legal framework regulate such communication, and relations.

The law also considered the representations of the marginalized groups such as vulnerable people, unemployed men and women, and People with disability (PwD), and formulated gender-specific objectives as a part of the national water plans.

2.2.3 MANAGEMENT TOOLS

At national level, management tools for sustainable use of water are being implemented on a long-term basis with acceptable coverage and appropriate use by stakeholders. The management tools are being implemented also for pollution control in risk areas, but this use

[2] Water sector stratgy 2017-2022.
[3] United Nations Economic and Social Commission for West Asia (2019). Status Report on the Implementation of Integrated Water Resources Management in the Arab Region: Progress on SDG indicator 6.5.1.
[4] Palestinian Water Authority (2016), The Palestinian Water Authority Strategy 2016-2018.
[5] Decree No. (14) for the year 2014 Relating to the Water Law

is limited for water related ecosystems, management tools are also applied at the basin level, , with acceptable geographical and stakeholder coverage, except for transboundary water.[6]

Sefficiency as IWRM tool

An example of water management tool is the Sefficiency. A Ph.D resereach study[1] in 2020 used this tool to assess the sustainable effeciency (Sefficiency) of water use in Jordan valley. The Sefficiency is a composite indicator to estimate efficiency using the law of mass conservation (water balance), considering two types of total flows: total inflow and total consumption. The preliminary steps are to characterize a water use system (WUS), whether that system was a farm, basin, region, city, or something else. WUS characterization in Sefficiency is to locate WUS boundaries; distinguish between the different inflow and outflow water path types (WPTs); and define the associated attributes, namely: quality and benefits—the useful dimension. The tool help decides on factors affecting the efficiency factors and the potential to improve it in a specified basin or watershed.

2.2.4 FINANCING.

The revenue base of Local Governmental Units (LGUs) is weak,. LGUs are currently diverting the revenues of water to general revenues such as salaries. Municipalities derive 15% of their total revenue from water services, while Village Councils (VCs) derive 16%. In overall municipal financing, water revenues comes second after electricity, which makes up 33% of revenues. As electricity reforms are progressing, District Electricity Companies (DESCOs) have been established, consequently, depriving LGUs from utilizing electricity revenues, therefore the load became higher on water. Although few LGUs derive an accounting surplus from their water operations, many simply retain a share of the water revenues to finance other operations and do not pay for their bulk water and contributing to the net lending problem.[7]

Polluters pay Principle: Palestine has enacted Environmental Law No. 7 (1999), which regulates all environmental issues and incorporates the "polluter pays principles" (PPP)[8]. The law entails that any **hazardous or toxic waste** should be kept away from the municipal sewerage system. Where possible that waste should be treated on site and rendered harmless before it is released. What cannot be treated on site could be transported to a waste-treatment facility with all costs borne by the **industry** concerned. The principle also entails that **households** cover part of the full cost recovery of the treatment as there are many elements determining costs of treatment (the storm water, the wastewater collection, storage and reuse). When there is a gap between full cost and affordability of the household the government

[6] United Nations Economic and Social Commission for West Asia (2019). Status Report on the Implementation of Integrated Water Resources Management in the Arab Region: Progress on SDG indicator 6.5.1.
[7] World Bank. 2018. "Securing Water for Development in West Bank and Gaza." World Bank, Washington, DC.
[8] BirZeit University. 2005. Prospects of Efficient Wastewater Management and Water Reuse in Palestine.

should contribute and cover the gap. As well farmers should also contribute to make treated wastewater available for irrigation. The adoption of this principle in the environmental law helped LGU's use tariff and ask households to pay for sewage collection and treatment of wastewater. However, the PPP had its negative impact on Palestinians on the macro level as Treatment plants in Israel operate according to PPP since ages. Therefore, Israel deducts the cost of treating Palestinian transboundary wastewater treated at Israeli facilities from jointly collected Palestinian custom and trade taxes before transferring the remaining funds to the Palestinian Ministry of Finance.

2.2.5 RIVER BASIN APPROACH

There is **no framework adopted in the IWRM like the River/watershed basin Approach**. Even it is not mentioned per se in different documents. Most watersheds in Palestine are transboundary (at leat 16)[9] which means mixed control Israeli/ Palestinian,. A watershed approach need control on resources which is lacking in case of West Bank and Gaza as occupied areas. However, the components and interventions planned in the strategies and programs implemented on the ground form "unframed river basin" approach. For example there are many water resources management studies, master plans, feasibility studies, land use studies, water supply and demand assessment, environmental impact assessment and database development activities. Wastewater is also considered an important component of the watersheds, not only fresh water.

2.3 WASTEWATER TREATMENT STATE

2.3.1 MAIN NUMBERS

Palestinians considereded treated wastewater as one of the sources of water that can be used for different purposes such as agriculture, this was proved through a study conducted by the Environmental Quality Authority in 2005, which emphasizes that using RWW for agriculture production will help in alleviating food shortages and reduce the gap between supply and demand. The study concluded that given the blooming water resource crisis, wastewater must be recognized as part of the total water cycle. If all of the wastewater generated were to be reused, it would be possible to save 14% of the supply and demand gap. Onsite systems at household level with the effluent used for irrigating fruits and flowers are the proposed systems to be applied in most of the rural Palestinian areas and must be maintained and monitored to control pollution and to recover water for non-potable water uses. [10]

[9] Clive Lipchin and Tamee Albrecht. 20000. Water Security in the Middle East. https://www.jstor.org/stable/pdf/j.ctt1jktqmk.10.pdf

10 Y. Mogheir, T. Abu Hujair, Z. Zomlot, A. Ahmed and D. Fatta (2005), Treated Wastewater Reuse in Palestine, Environmental Quality Authority, Gaza, Palestine

According to WSRC, more than two thirds of the wastewater collected in the West Bank and Gaza are treated in wastewater treatment plants (WWTP). Over 90% of the collected wastewater in GS and around 35% in the West Bank are treated at different levels of treatment. However, not all treated wastewater follows the relevant specifications and standards due to the lack of proper management of WWTP in different locations.[11]

The total generated WW in Palestine is 114 MCM annually, where only 54% of the households are connected to the sewer networks.[12] The total volume of treated wastewater is 47.9MCM[13] annually, by utilizing 22 WWTP, 17 in the WB and 5 in GS, where the technologies used are shown in table 1:

Table 1: Classification of WWTP in WB and Gaza [14]

Type of Treatment System	**Number**	**Volume TWW (CM/day)**	**Population served**
Activated Sludge	8	32,000	220,000
Anaerobic/Aerobic Stabilization Ponds	3	58,000	540,000
Hybrid system	3	100,000	1,100,000
Rotating Biological Contractor	1	450	2,500
Constructed wetland	5	1,000	11,000
Sedimentation tanks	3	150	1,000
Membrane Bio Reactor	2	2,500	20,000
Trickling filters	1	15	250

2.3.2 TREATMENT OF TRANS-BOUNDARY WATER

When sewage water is collected in some communities and sent to flow in Wadies as there is no WWTP or no reuse the water crosses the borders between Palestinian and Israeli controlled areas, this is called the trans-boundary water. This is estimated at 15MCM annually (Anne Dare, 2019). Such water is usually collected and treated in Israeli WWTP. Though this water is used by Israeli farmers, the cost of treatment is charged to Palestinian budget through deducting the cost of treatment from the Palestinian tax money. This was agreed in the Paris Accord signed as part of the peace process. The trans-boundary water flows and crosses the border in five main points in WB and one main in Gaza.

[11] Water Sector Regulatory Council (2019), The Establishment of the Wastewater Monitoring Program
[12] Applied Research Institute - Jerusalem (2020), Wastewater Management infographic, https://www.arij.org/files/arijadmin/weruinfographics.pdf.
[13] Ibid
[14] Water Sector Regulatory Council (2019), The Establishment of the Wastewater Monitoring Program

The wastewater flow toward areas controlled by Israelis, without the possibility of treatment and reuse is considered one of the main challenges for PWA. This transboundary WW is expected to be treated and utilized in WB and Gaza, on the contrary Palestinians pay for the treatment and Israeli agriculture use it.

2.4 REUSE STATE

2.4.1 GENERAL SITUATION

Treating and reusing wastewater presents opportunities for agricultural development, job creation in the water sector, reduced pollution, better quality of life, increased volume of water for irrigation, and avoiding costs/ fines incurred when Palestinian wastewater reaches Israeli treatment plants. Reuse protect the limited water resources and enrich the quality and quantity of groundwater and surface water.

With the scarcity of water resource and loss of access to available water in the realm of Israeli occupation, and while insisting on getting water rights, Palestinians adopted the non-conventional water resources including reuse of Reclaimed wastewater (RWW) as a strategy to partially fill the gap in the water supply[15]. **PWA** considers the increasing number of reuse facilities as one strength for the water sector. **One of the five strategic objectives (SO) for the water sector was devoted for wastewater treatment and reuse**, "Improving wastewater services and structure (collection, treatment, and reuse)", similar SO used to be adopted in the two earlier strategic objectives 2012- 2016.

A study in 2012[16] investigated the use of grey water as a strategy of decentralized water facilities to manage water resources to combat the Israeli confrontation and constraints to large-scale wastewater treatment facilities. The focus of grey-water reuse projects was best recommended for the rural and peri-urban communities of Palestine which represent 60% of the total population and lack appropriate management for their wastewater[17].

Through the assessment of wastewater reuse potential in Palestinian areas a study[18], conducted in 2010, showed that given the blooming water resource crisis, wastewater must be recognized as part of the total water cycle. If all of the wastewater generated were to be reused, it would be possible to fill 14% of the supply and demand gap.

[15] PWA, 2016. Water sector strategy (17-22)
[16] MAS, 2012. Encouraging use of grey water in Palestine.
[17] Abu-Madi, Maher, Rashed Al-Sa'ed, Nidal Mahmoud and Jamal Burnat. 2010. Comparative Socioeconomic study of Greywater and Cesspit systems in Ramallah,Palestine. In "Greywater use in the Middle East: Technical, Social, Economic and Policy Issues". Eds. McIlwaine, S and Redwood, M. Warwickshire: Practical Action. pp: 89-101.
[18] O. Adilah, 2010, Assessment of Wastewater Reuse Potential in Palestinian Rural Areas, Birzeit University, Master Thesis

While there are 52 service providers (SP) collecting wastewater in WB&G only 22 have treatment facilities (17 in WB and 5 in Gaza),[19]. However, only eight SP have reuse schemes (7 in WB and 1 in Gaza). There are few planned and unplanned reuse activities in West Bank and Gaza. The volume of annually used RWW for agriculture in Gaza was around 1.0 million cubic meter[20] out of 77.7 MCM reclaimed, while in WB the reused volume did not exceed this limit out of 8.0 MCM reclaimed[21]. Table (2), shows the functioning WWTP with reuse component.

RWW reuse is planned in Jenin, Ramalah and Nablus where water distribution systems were placed, while it is unplanned reuse in Jericho as farmers are connecting on their own without a well-designed and unified system.

2.4.2 NABLUS WEST

Currently a large project is underway with multimillion fund of **KFW,** the irrigation and management plan of Nablus West reuse project (IMOP)[22] show the aim of **Nablus municipality** and **Water Users Association (WUA)** to irrigate an area of **more than 3,000 dunums**.

The study is holistic and covers different aspects, starting with description of the environmental and geographical characteristics, the socio-economic aspects of potential beneficiaries, the scenarios of cropping patterns with economic feasibility, crop water requirements, irrigation scheme, the water tariff and governance structure.

The project adopted growing **fruit trees** such as new olive pickling varieties, stone fruits, figs, grapes, and pomegranate. Such pattern was agreed upon with different stakeholders. Nablus municipality plans the actual use of water in this project to commence by end of 2022. However, the plan expected that farmers will use 100% treated water effluent by the year 2032, that's during the peak irrigation requirements. The project includes a main carrier, pumping station, reservoirs, tertiary treatment, water distribution network to the farm gate, and assistance for farmers to establish fruit tree orchards.

During the period 2015-2019 two **pilots** were implemented inside the WWTP and in the bordering land parcels. Pilots were funded by KFW and USAID, in two separate projects. A small-scale tertiary treatment and filtration system was installed to further treat **600 CM** per day for the use in this pilot. To the time of this report, more than **10,000 CM** of water is meeting the irrigation standards at the secondary treatment level, but still running in Wadi Zoumer and considered as trans-boundary water, subject to Israeli fines.

[19] WSRC, 2020, The establishment of wastewater monitoring Program
[20] This does not include the aquifer recharge in NGEST
[21] UNEP, 2020. State of Environment and Outlook Report for the Occupied Palestinian Territory 2020.
[22] GFA, 2020. Irrigation Management and Operation Plan. *Published plan*.

2.4.3 JERICHO

Jericho municipality with fund from **JICA** constructed the WWTP in parallel with the sewerage system in Jericho city, which means no treated wastewater was disposed in creeks. Jericho municipality treated water from the first collection.

The plant is situated in a **date palm growing area**. Nearby orchards were panting for water. Farmers themselves coordinated with Jericho municipality as service provider of the treatment plant and started using the water from the first day. Each farmer installed his own pump. Farmers pay 15 cents per cubic meter of water and they are responsible for the pumping.

During dry season, (February-November) all the quantity of treated effluent is being used (1 200CM per day (Hamdan, 2021)). However contacts with the treatment plant operator[23] indicated an average daily flow of **1,600 cubic meters** during hot summer months. Currently 82% of the annually produces effluent of Jericho WWTP is used (WSRC, 2020) for irrigation of date palms (which requires a lower standard of water) and tolerates high salinity levels. Jericho WWTP is the only large-scale facility where all RWW is used (except during December and January) and with no need for additional tertiary treatment. TWW is **chlorinated**, and the quality is suitable for all crops as it is complying with **grade A** TWW (Abo Seiba, 2016)[24]. The volume of effluent is increasing year after year with more connections of houses. Currently 40% of Jericho area houses are connected to the sewer system.

2.4.4 RAMALLAH

Ramallah Municipality operates two WWTP, one large scale **Tiereh** producing **1400 CM/day** of effluent and one small-scale, **Reehan** neighborhood **150CM/day**[25]. Both plants use **membrane technology** producing high quality tertiary-treated effluent. With Support from Anera, Ramallah municipality installed two water pumping and distribution systems with approximately 20km of main pipes to serve 60% of Ramallah **public landscape and green spaces** of roadsides, **public gardens** and some home gardens. The water is also used for **road works and street cleaning** purposes. The system started operating spring 2020 and is using around **800-1,000 CM/Day** in the peak time. This water replaced fresh water which was used for irrigation and civil works. The municipality estimated the saved fresh water at 300 CM/Day[26].

[23] Ibrahim Abo Seiba, August 2021.
[24] Abo Seiba, I. 2016. Agricultural Reuse of Treated Effluent and Stabilized Biosolids from Jericho Wastewater Treatment Pl. M.Sc, Thesis.
[25] Newly established housing area Northwest of Ramallah city.
[26] Anera, 2019. Ramallah Reuse Project, final report.

2.4.5 JENIN

The Jenin WWTP is a set of aeration lagoons treating wastewater to the **secondary level**. In 2015/2016 Jenin Reuse **project** started operating after upgrading. It was the first large-scale reuse project in WB. OPEC Fund for International Development (**OFID**) funded the four-years project. **Anera** co –funded and implemented the project during 2013-2017. The water distribution system covers an area of 5,000 dunum, however the total irrigated area in 2018 was around 400 dunum of fodder crops, mainly alfalfa and 100 dunum of fruit trees. This is the maximum area to be irrigated with the effluent volume of **2,200 CM/Day**. Farmers used TWW during the dry period (April-November). The scheme includes 25km of main pipes, a reservoir with capacity of 5,500 CM as well as filtration and chlorination System. Marj Ben Amer cooperative was established specially to run the system[27]. At that time the water users' association law was not approved yet. The Jenin WWTP has the highest treatment cost per CM and has the highest net deficit in treatment cost coverage[28], consequently the treatment is not done properly, and the quality of effluent is low. The monitoring of the RWW is not sufficient due to the lack of well-equipped lab testing facility. Only **62% of the annual effluent of TWW is reused** for irrigation purposes. Jenin case need to be evaluated as the consumption of water went back[29].

2.4.6 SMALL- SCALE RURAL REUSE SCHEMES:

The low-cost onsite treatment systems in rural areas are unsustainable and causing annual environmental degradation, due to overloading, faulty design and implementation, absence of monitoring, maintenance and repair, poor public awareness, lack of administrative and legal control measures (Al-Sa`ed, 2007[30]).

There are **15 small scale WWTP** in some villages and towns (WSRC,2020)[31] where water is partially or fully used in irrigation. In all cases the TWW is used for **fodder and fruit trees** irrigation. No other uses have been recorded.

2.4.6.1 ANNZAH/ JENIN

The treatment plant capacity is **340 cubic meters per day**, currently it receives 100-130 cubic meters of sewage. The whole volume is treated and used to irrigate approximately 100 dunums of mix varieties of crops like almonds, apricots, supplementary irrigation for olives and small parcel of alfalfa. Farmers are ready to use any additional volume of TWW[32].

[27] Anera, 2016. Jenin Reuse Project. Final Report.
[28] WSRC, 2020, The establishment of wastewater monitoring Program
[29] Amjad Abu Farha, 2021, Marj Ben Amer cooperative. Personal communication.
[30] Al-Sa'ed, R., (2007b): Sustainability of natural and mechanized aerated ponds for domestic and municipal wastewater treatment in Palestine. Water Int. 32(2), 310-324.
[31] Meslieh, Rawabi and Rihan WWTP are not mentioned in this study.
[32] Personal contacts with Abo Mohammad/ operator of the WWTP in Anzza/ Jenin.

2.4.6.2MYSIELYEH/ JENIN

Mysielyeh treatment plant uses the Wetland system, it is functioning well. Despite the good start of reuse, currently only 5-10 dunums are being irrigated with the TWW. The daily flow of treated water is **150-200 cubic meters**. The original reuse of fields towards Qabatia area failed due to rejection of Qabatia farmers who have fresh-water irrigated vineyards and fields. The village council tried to send the water to a recently established public garden but the line failed as it was installed at lower technical standards. The future reuse is only possible through conveying TWW to areas where no fresh water is available, which is 3-5km away. The feasibility of such action need to be studied, however as the treated water created conflict with Qabatia farmers down the stream, proper reuse is expected to solve the conflict. Just recently the village council received a French grant to improve the reuse scheme, the project is expected to solve the technical and social issues[33].

2.4.6.3SMALL SCALE REUSE IN GAZA

Though there are four larger scale treatment plants operating in Gaza, reuse is limited for aquifer recharge in North Gaza Emergency Sewage Treatment (NGEST) and **some small scale pilot projects**. NGEST treats around 35,000 CM/Day (secondary treatment) and recharge it to the aquifer through 9 infiltration basins.

In southern Gaza OXFAM[34] implemented a project to irrigate 200 dunum of productive land using TWW. The project included institutionalization through activation of legal framework and governance model including equitable tariff system. The project team monitored the treatment and reuse cycle from application to soil to the harvested produce.

In 2011Austria funded another pilot project in **Sheikh Ejleen/Zaytoun** area middle Gaza, where a further treatment of the effluent through sand filtration was introduced. The additional treatment daily capacity is **1,000 cubic meters**. The water is stored in a pond of 600CM, that is distributed for 30 farmers to irrigate 176 dunum of citrus and olive groves

[33] Personal contacts with Ahamad abo Naim, deuty head of village council.
[34] Oxfam. 2018. Reuse of treated wastewater for agriculture irrigation in southern part of Gaza Strip. Published Project Report

Table 2: Functioning WWTP with reuses schemes[35]

Treatment Plant	% RWW reused year round	**Volume of RWW**	**Use of Water**	**Notes**
Jenin	62%	2,400	Fodder crops, Fruit Trees	Water distribution network existing
Annzah/Jenin	100%	100	Fruit trees	Small scale water distribution network
Nablus West	5%	5290	Fruit trees	A large Reuse project is going on
Jericho	81%	800	Date palm	Unplanned use
AL Biereh	1%	6427	Green spaces	Through tanks
Ramallh[36]/ Teireh and Rihan	50-60%	1550	Green Spaces, Home gardens Civil work	Water distribution network existing and tankers
Bidyah	31%	45	Currently not in use	Wet Land, currently overloaded not functional
Beit Lahia/ Gaza	100%	35,000	Recharge of Aquifer	Well Planned recharge system recovery wells

2.4.7 TREATMENT AND REUSE OF GREY WW

In 2010 there were over **800 household grey/ black water treatment units**, **usually associated with use for irrigation**. (ARIJ, 2015). Some systems depend on separation of the grey water from the black water with modification in the design of the interior mechanical connections of houses, other systems treat both the black and the grey water together (Micro Station developed by ARIJ). The effluent is used for **irrigating fodder crops and fruit trees**. Some local NGO's even connected the effluent to small scale home garden greenhouses. This level of treatment was common in the first decade of the millennium. The treatment system include filtration and precipitation over 2-4 successive containers/ septic tank, and includes a settling phase. The different systems are considered relatively expensive to middle to low income households[37]

[35] WSRC, 2020, The establishment of wastewater monitoring Program
[36] Ramallah Municipality wastewater department
[37] ARIJ,2015

2.4.8 TREATMENT TARGET AND EFFICIENCY

The results of the monitoring activity of WSRC[38], 2020 showed that all WWTP's in the **WB** which followed the quality of their influent and effluent have achieved a **high efficiency** (higher than 95%) of reducing the (BoD, CoD and TSS). The list included Nablus, Tiereh and Jericho, while Jenin and El Biereh did not achieve the threshold. In **Gaza none of the WWTP achieved the needed efficiency**. This is related to lack of energy and overloading of facilities.

The compliance with irrigation standards depends mainly on BoD, CoD, TSS, Total nitrogen (TN) and phosphorus (P). Again **only the three WWTP who fulfilled the efficiency threshold were found to be compliant with the irrigation requirement**. However, no documented results of the quality parameters were available for the smaller scale WWTP.

2.5 SLUDGE MANAGEMENT

Service providers are suffering from the lack of good practices of sludge management, all practices and projects related to the sludge management are either on **pilot level**, or **individual research projects**, without practical solution.[39]

Only **Nablus municipality** is using dewatered sludge to produce biogas to heat the digester and use the methane gas for electric generators. But later the resulting sludge is transported at high costs to landfills in Jenin area.

The Palestinian regulations for sludge treatment and reuse are very strict, none of service providers fulfilled the needed levels of indicators for reuse in agriculture. **Trans-boundary water treatment** by Israeli facilities involve **sludge as well**. For example wastewater collected from Wad Elsamen/ Hebron and treated by Israeli treatment plant collects 20 tons of grade "B" sludge every day. This is further treated through dehydration to lower moisture content to meet grade "A" at a cost of 200NIS/ ton, so it becomes fitting reuse in agriculture per Israeli requirements, the whole costs are charged to Palestinians[40].

2.6 PERSPECTIVES

To the moment the percentage of reuse of reclaimed water is in convenient. Some WWTP have been running for decades without reuse like El Biereh. The Israeli occupation is the main but not the only obstacle. Year after year, the volume of RWW increases with the increased number of WWTP at different levels and the more houses connected to sewerage systems. Though a

[38] WSRC, 2020, The establishment of wastewater monitoring Program
[39] Ibid
[40] Anne Dare, 2018

number of treatment facilities is still not functioning, **the potential for use is high**. There are ongoing or just finished treatment and reuse projects the main are:

1. **Villages north of Tulkarm** project is being implemented by UNDP with fund from Netherland Representative office. It will connect sewage of five villages to Israeli treatment plant.
2. New WWTP is being constructed with fund from AFD and EU in **Hebron** area
3. **North Gaza Emergency Treatment Plant (NGEST)**: Funded by AFD and EU. TWW is injected through basins to **recharge aquifer**. Once recovery wells are operated the potential of reuse in North Gaza would be tremendous.
4. Tyaseer/ Tubas WWTP started operation March, 2021, it includes a reuse component.

The different studies in the reuse suggested a list of strategies with list of interventions to improve the status of reuse:

- The use of **treated grey-water for household agriculture**. Away from the Israeli imposed obstacles, this small scale technology can help to alleviate short-term water insecurity in rural communities, and save fresh water. The widespread adoption of grey-water recycling techniques in Palestine should be adopted and promoted with incentives (MAS, 2012). However, the national strategy 17-22 did not mention the grey water.
- **Trade the fresh water in some locations with the RWW in another**[41] Trade-off could be across governorates, across sectors and even with Israeli water companies. Such scenarios should be politically, technically, economically and socially assessed before selection of the scenario.
- The **existing guidelines**, controlling the reuse of sludge and wastewater, **must be reconsidered**, in the light of the new research results, due to fact that health risk problems appear even in cases where the reuse is applied in compliance with the existing official guidelines and regulations[42]

[41] Ahlam Bushkar, 2015. Impact of Trade of reclaimed wastewater on Management of water in Palestine, master thesis.

[42] Kalavrouziotis, I. K., & Koukoulakis, P. (2016). Wastewater and Sludge Reuse Management in Agriculture. EQA - International Journal of Environmental Quality, 20, 1-13.

3 BIBLIOGRAPHY

3.1 NATIONAL MAIN STRUCTURING STUDIES

Since the establishment of the Palestinian Authority in 1994, Palestinians has conducted several studies related to water, wastewater management, reuse of treated wastewater, and water governance. Studies were conducted by the disgnated authorities such as Palestinian Water Authroity, Palestinian Environmental Quality Authroity, and Ministry of Agriculture, furthermore, some studies were conducted by external parties for the benifit of the disignated authroities, such as donors (e.g. KfW, USAID, World Bank Group, etc.), INGOs (Action Against Hunger, GVC, Oxfam), UN Agencies (OCHA, UNICEF, FAO), local NGOs (EcoPeace, ARIJ, PHG, etc.).

3.1.1 MASTERPLANS AND FUTURE PROJECTS

Studies included **sanitation master plans for Ramallah, Al-Beireh, Jericho[43], Nablus, Jenin, Salfit, Hebron, and Bethlehem,** all of those studies were aiming at improving sanitation services, and intervention on local and national scales Master plans included technical aspects, designs, governance, tariff, reuse opportunities, and private sector interventions.[44]

Furthermore, many strategic water and wastewater plans were conducted in both West Bank and Gaza that considered the **future intervention projects**[45], Wastewater Management [46]and TWW opportunities in Palestine[47], in addition to the PWA action plan that relied on different need assessments by INGOs, and local CSOs.[48]

3.1.2 WSRC MONITORING PROGRAM

An important example reflecting the importance of national studies: the **Water Sector Regulatory Council (WSRC)** has conducted a study on **establishing monitoring program for wastewater in both West Bank and Gaza**; the study aimed at conducting technical and financial analysis of existing and current wastewater system including the WWTP technologies applied in Palestine, identification and inventory analysis of WW service providers in West Bank and Gaza Strip. It also identified key data to be collected from the service providers and how to verify each data entry before uploading to the WSRC database. An important component of the study is the **baseline field survey which included 64 water service providers**, the survey

[43] EcoPeace ME, 2015, Regional NGO Master Plan for Sustainable Development in the Jordan Valley
[44] WSRC, 2020, The establishment of wastewater monitoring Program
[45] EcoPeace ME, 2015, Regional NGO Master Plan for Sustainable Development in the Jordan Valley
[46] S. Samhan, 2010, Wastewater Management Overview in the Occupied Palestinian Territory
[47] P. Hansen, 2012, Encouraging the Use of Treated greywater in Palestine, Palestine Economic Policy Research Institute
[48] PWA, 2016, National Water Sector Strategic Plan and Action Plan (2017-2022)

focused on 21 Key performance indicators (KPIs) according to wastewater performance monitoring index developed by WSRC. The survey showed detailed information about water and wastewater indicators such as tariff, consumption of water and production of wastewater, cost of collection and treatment.[49]

3.1.3 OTHERS

Other research studied encouraging the reuse of treated effluent for both West Bank[50] and Gaza[51], and the willingness of farmers to use the TWW for irrigation, and others to scale the impact of trade of reclaimed water in the country, some of those studies results were presented in Chapter 2 and 4.

⇨ Synthesis files for the most important studies are attached in annex (1)

3.2 SCIENTIFIC RESEARCH

3.2.1 ACTORS AND TOPICS

The scientific research in the water sector in general is mainly conducted by the water and environmental departments in the main universities (Alquds, Birzeit , AnNajah, and to less scale the Bethlehem University, and Arab American University of Jenin). However, major sponsor of research is **Birzeit University**. All universities have higher studies programs in water and environmental engineering, with good capacity and curricula of researchers and university professors. The same case applies to Gaza universities (Azhar and Islamic University).

This explains the large number or researches conducted in the WWT and reuse themes to fulfill the Master degrees requirements. For example of the 41 papers included in the synthesis files of this report 17 were Master thesis researches, and 2 were Ph.D researches. Another factor explaining the high number of master researches is the existence of international funded programs supporting research in water sector namely the MEDRC[52], the Austrian Project[53] and the SMART[54] programs. The three programs supports 176 researches in water sector, of which 26 are in reuse and agriculture.

[49] WSRC, 2020, The establishment of wastewater monitoring Program
50 P. Hansen, 2012, Encouraging the Use of Treated greywater in Palestine, Palestine Economic Policy Research Institute
[51] R. J. Vestner, K. Brooke and L. Nicolet-Misslbeck, 2013, Water reuse in the Gaza Strip, Palestine, Water Science & Technology Journal
[52] was under the title "Scholarship Program- Palestinian Water Authority, (2012 -2016), the program funded by Middle East Desalination Research Center (MEDRC).
[53] "Building Capacity and Institutional Reform for an Integrated Management of Water and Sanitation Services in Rural Communities (2009-2014), and it is funded by Austrian Development Agency (ADA)".
[54] Sustainable Management of Available Water Resources with Innovative Technologies (SMART) (2006 2016), the program funded by the German Ministry of Science and Education, BMBF

The scientific research varies from evaluating the efficiency of treatment methods in existing WWTP, to more specific topics. The agronomic theme is also very more common in research, where the impact of reuse of TWW is studied on crops growth, quality of produce, irrigation systems or on the soil quality. Another research theme is the effect of reuse of sludge/ biosolids on soil quality. There are at least three master research on this topic (Maisa Mohamad, 2018, Abu Seiba, 2016, and Slahab, 2014).

3.2.2 IMPACT ON SOILS AND CROPS

Example of the specialised studies is research entitles "the **effect of reuse of RWW on** physiochemical charactarestics of **soil** and the quality parameters of the plants, on olive orchards soil and **olive oil quality** in **Zatoun area/ Gaza**"[55]. A similar research was conducted in Khanyounes/ Gaza[56]. Results of both researchs showed no significant bad effects on either the soil or the plant. However, such researches were conducted in fulfillment of Masters requirements and conducted for a short period, which is not enough to judge, such researches even recommended a 10 years monitoring plan to end with reliable results.

The efficiency of utilizing treated effluent was examined on olive orchard through research conducted by **National Agricultural Research Center** (NARC)[57], where the research results showed **no change on olive oil while using treated wastewater**, or fresh water, Moreover, soil analysis showed that organic content and cation exchange capacity were improved in soil irrigated with treated wastewater in comparison with that irrigated with freshwater.[58]

3.2.3 ALTERNATIVE TREATMENTS EFFICIENCY

Two studies were conducted by Birzeit University on the effect of wastewater quality in arid region on the **performance of constructed wetland** (CW) (2012)[59], and on CW-SAT (Soil Aquifer Treatment) hybrid systems (2015)[60], both studies assessed the effect on COD, BOD5, NH_4, NO_3 and TSS, where the results showed that utilizing hybrid system have removed the mentioned compounds to the level of Palestinian standards, and much better than utilizing either CW, or SAT systems.

55 Khayri, Ayttalah. 2013. Effect of Irrigation with Reclaimed Wastewater on Soil Properties and Groundwater Quality in Zaiton area, Gaza, Palestine.

56 Abdelazzia Sahar. 2015. Impacts of Using Treated Wastewater in Irrigated Agriculture on Efficiency of Farming Resources and Activities in Imawasi, Khan Younis, Gaza Strip, Palestine.

57 Barghouti, 2020. Using Nonconventional Water in Irrigation of Olive Trees and Its Effect on Olive Oil Properties.NARC.

58 NARC, 2020, Using Nonconventional Water in Irrigation of Olive Trees and Its Effect on Olive Oil Properties

59 Sh. Abed, 2012, Birzeit University, Effect of wastewater quality on the performance of constructed wetland in an arid region, Master Theis

60 M. Shahadeh, 2015, Birzeit University, Effect of Wastewater Quality on the Performance of a CW-SAT Hybrid System in an Arid Region, Master Theis

3.2.4 OTHERS

There were also researches evaluating **on-site systems at household level** with the effluent used for irrigating fruits and flowers. Such systems were recommended to be applied in most of the rural Palestinian areas, but these system must be maintained and monitored to control pollution and to recover water for non-potable water uses.[61]

There are some very technical studies published in international Journals as refereed research. Example is the recent study on the assessment of the agricultural water use in Jericho utilizing the **Sefficiency[62] approach** (discussed in IWRM section).[63]

⇨ Synthesis files for the most important papers are attached in annex (1)

3.3 SPECIFIC STUDIES RELATED TO SPECIFIC PROJECTS

3.3.1 WATER REUSE IN GAZA

There are some detailed feasibility studies dealing with reuse on national level, example is the study[64] conducted **2013 by R. J. Vestner, et.al. "Water reuse in Gaza".** The study attempted to show the requirements in planning and management for wastewater treatment, irrigation conveyance and aquifer recharge to meet high technical standards and sustainable economic benefits in Gaza. It is a feasibility study that assessed constraints, specifications and local conditions for wastewater treatment, irrigation, and recharge.

The recommendations formed the bases for later implemented major projects in Gaza. If the later projects in Gaza are reviewed one can observe that this was a guiding study many donors and stakeholders followed. The study recommended that any future project should consider the following points:

1. **Water quality related**: Effluent treated to a standard that will be suitable for **unrestricted reuse**, achieved by the provision of filtration and disinfection of WWTP effluent and its conveyance by pipeline to conveniently located off-takes from which farmers may withdraw irrigation supply to meet their crop requirements and thus replace irrigation using groundwater.

[61] O. Adilah, 2010, Assessment of Wastewater Reuse Potential in Palestinian Rural Areas, Birzeit University, Master Thesis

[62] Sefficiency Method : Sefficiency is a composite indicator to estimate efficiency using the law of mass conservation (water balance), considering two types of total flows: total inflow and total consumption.

[63] N. Tuqan , N. Haie , and M. Ahmad (2020), Assessment of the Agricultural Water Use in Jericho Governorate Using Sefficiency, MDPI (Multidisciplinary Digital Publishing Institute), Sustainability Journal.

[64] R. J. Vestner, K. Brooke and L. Nicolet-Misslbeck. 2013. Water reuse in the Gaza Strip, Palestine. Water Science & Technology Journal.

2. **Water quantity related**: Effluent that is surplus to irrigation demand should be recharged to the Coastal Aquifer by infiltration basins to reduce and ultimately reverse the decline in groundwater quantity and quality.
3. **Institutional**: The anticipated key institufional outputs of the project are:
   - Revision of the effluent reuse standards to make reuse practicable under the conditions in the Gaza Strip.
   - Establishment of effluent management units under the Costal Municipality Water Utility (CMWU), that in the longer term may become autonomous, to maximize safe and economical reuse.
   - Establishment by CMWU of effluent monitoring systems that may be independently audited by the Palestine Environmental Quality Authority.
   - Besides social and political benefits the principal economic output of the reuse projects will be an increased agricultural production due to the nutrient values derived directly or indirectly from the use of effluent. This will increase farm profitability, ensure and enhance sustainable agricultural production in the Gaza Strip and reduce the importation of fertilizers and manures**.**

A specific study[65] conducted by Al'Saed in 2016 investigated feasibility of several **wastewater treatment alternatives** including natural and mechanised treatment technologies. Vertical flow constructed wetlands and sequencing batch reactor (SBR) were analyzed. The study included a baseline environmental and an environmental impact assessment for the wastewater treatment plant, chemical analysis of wastewater obtained from treatment plants, field survey questionnaires were developed, and economic feasibility analysis on proper wastewater treatment technologies.

Results showed that low cost treatment options were neither sustainable nor cost effective compared with mechanized biological systems; major stakeholders (village council members, women and farmers) are willing to accept and pay for environmentally sound and cost effective sanitation facilities; early community participation in the planning process facilitated proper technology selection considering the socio-political, financial and environmental aspects.

3.3.2 NABLUS WEST REUSE PROJECT

A unique implementation plan was prepared for a German funded progect in Nablus. Most of the similar studies are usually not published or shared It is published under the name "Irrigation Management and Operation Plan/ Wastewater Reuse Project in Nablus" . The municipality employed a team of experts and conducted field survey and soil analysis to reach the best plan for reusing the TWW. It involved feasibility analysis of all possible crops. The plan describes the Wadi Shaeer irrigation area, land suitability, it includes estimates of a tariff that

[65] Al Sa'ed, M. 2016. Anzah and Beit Dajan Wastewater Treatment Plants: Impacts of Wastewater Reuse on Agricultural Farms. Bir Zeit University.

will cover the costs of treating wastewater and delivering it to the farmers and the operation of the system by Nablus Municipality (NM) and The Wadi Shaeer Water User Association (WUA)., It also briefly discusses the organizational aspects of the Wadi Shaeer operation. And give guidance to farmers on what crops to grow.

3.3.3 WILLINGNESS TO USE

The impact was reflected from a published study on the willingness of farmers to use the treated WW for irrigation in Palestine, where the study aimed at invistigating the farmers' perceptions and willingness to use treated wastewater (TWW) for irrigation, through a set of **interviews with 115 farmers** from different areas in West Bank, the results showed that Despite the availability of large quantities of TWW, just 11% of the interviewed farmers use it in irrigation. Only 24% of them confirmed that they had participated in awareness workshops related to TWW, but 75% stated they would be willing to use TWW for irrigation. The study concluded that the main obstacles to the use of TWW in irrigation are availability of freshwater, non-availability of TWW and psychological aversion.[66]

[66] (Hamdan M. , 2021). Willingness of farmers to use treated wastewater for irrigation in the West Bank, Palestine

4 NATIONAL SITUATION ANALYSIS FOLLOWING

4.1 TH1: UNPLANNED WATER REUSE, DECENTRALIZED TREATMENTS, SLUDGE MANAGEMENT

The debate on the reuse of Treated Waste Water (TWW) has been going on for many years (Afifi, 2006) [67], Many studies and researches took place on the feasibility of reuse of the treated effluent by the Palestinian Water Authority (PWA) and other organizations.

4.1.1 CENTRALIZED AND DECENTRALIZED REUSE

In 2011 PWA conducted a research to investigate the feasibility of the reuse of household TWW in the southern West Bank (Hebron and Bethlehem). Results showed that the household decentralized treatment systems are affordable for the reuse in agriculture. Birzeit University has recently published a research on the reasons on accepting **Grey Water Treatment in the West Bank** results showed that 24% of the GWTP are operated totally by women, and 68.9% are operated by men. Additionally, the majority of GWTP beneficiaries (70.4%) are satisfied with GWTPs[68].

THe **agriculture sector strategy** 2014-2016 explicitly mentioned the reuse and set a **prime target "*providing 15 MCM of non-traditional water includes* *inter alia TWW*". However,** up to **2020 the volume of reused TWW for irrigation** did not exceed **2.0-3.0 MCM** limit in both West Bank and Gaza (WBG).

Beyond the use of TWW in decentralized treatments, **no planned reuse of RWW was recorded before 2015/ 2016** when actual planned reuse started in peri-urban areas. Effluent from the Nablus West, Jericho, and Jenin wastewater treatment facilities is reused in a formal scheme: totaling about 1.5 MCM/yr[6]. In 2020, Ramallah started using TWW of Al Teireh treatment plant for irrigating green public spaces and roadside gardens. As well in the same year Ramallah municipality started using effluent from Rihan neighborhood treatment plant/ North of Ramallah (producing 150 CM/Day. However, not all the water is yet used[69]. Quantities of used effluent are very limited and did not meet the strategic objectives of the Ministry of

[67] Afifi 2006. Wastewater reuse status in the Gaza Strip, Palestine, Int. J. Environment and Pollution, Vol. 28, Nos. 1/2, 2006

[68] Rehab A. Thaher, Nidal Mahmoud , Issam A. Al-Khatib , and Yung-Tse Hung (2020). *Reasons of Acceptance and Barriers of House Onsite Greywater Treatment and Reuse in Palestinian Rural Areas,* Water 2020, 12, 1679; doi:10.3390/w12061679

[69] Ramallah municipality, personal communication

Agriculture[70]. There is absence of large scale treated water reuse projects and practical reuse experience in the Gaza strip while the wastewater reuse in agriculture is currently limited to a small- scale pilots (Abu Sultan 2015).

The **Water Sector Regulatory Council (WSRC)** has conducted in **2020** a **survey for service providers (SP)** in WB&G to **plan and monitor key indicators** of wastewater treatment and reuse. Out of the 54 surveyed SP, there were only seven large-scale treatment plants using TWW for irrigation in WB, and only one in Gaza (Beit Lahia). While there are 15 rural small-scale WWTP with reuse for irrigation. In Gaza the Beit Lahia WWTP use TWW to recharge the aquifer with the secondary treated wastewater, this water could be recovered and used indirectly for irrigation.

The results of the **monitoring activity of WSRC**[71], **2020** showed that all WWTP's in the WB who monitor the quality of their influent and effluent have achieved a high efficiency (higher than 95%) of reducing the (BoD, CoD and TSS). The list included Nablus, Tiereh and Jericho, while Jenin and El Biereh did not achieve thresholds. In Gaza none of the WWTP achieved the needed efficiency. This is related to lack of energy and overloading of facilities.

Of the five **large scale urban WWTP** in WB, only Jericho WWTP effluent (800 cubic meters per day) is totally used, while in other areas the effluent is only partially used. However, a large reuse project in Nablus is being implemented by KFW and expected to use water by 2023[72]. Only WWTP in Nablus, Ramallah and Jericho fulfilled the high treatment efficiency[73] required by Palestinian Water Authority, which is 95% of standard values of quality parameters. While in Gaza none of the WWTP fulfilled the needed efficiency. This fact could affect the reuse potential and future success. The compliance with irrigation standards is much less, and in most cases not monitored due to lack of capacity or even absence of labs in the treatment plants[74].

4.1.2 SLUDGE TREATMENT AND UTILIZATION:

The dewatered sludge production depends on water treatment method. While daily production is the rule in classical aerated sludge or membrane treatment technology, sludge is extracted in aerated lagoons years after first operation. Service providers of WW treatment suffer from the disposal of sludge. Ramallah municipality pays NIS180 to dispose one ton of sludge[75].

[70] Ministry of Agriculture, 2016. Agriculture Sector Strategy 2017-2022. Second strategic objective: Natural and agricultural resources sustainably managed and better adapted to climate change

[71] WSRC, 2020.

[72] IMOP, Nablus Municipality, 2020

[73] The efficiency of the wastewater treatment process to remove BOD, COD, and TSS from the wastewater.

[74] WSRC, 2020

[75] Nael, Tahseen. Head of wastewater department. Ramallah Municipality. Personal communication.

No reuse of treated sludge was recorded in Palestine. **Standards and regulations are very strict**[76]. International reviews[77] showed that despite agricultural reuse of wastewater and biosolids (sludge) is a routine practice in several countries, especially in Mediterranean area, the "safety" of land disposal of sludge is questionable. The need to successfully address the risk health problems involved in the reuse of sludge is crucial. Health problems related to pathogens have appeared in many cases in people living around and near the sites of application of sludge[78].

The recent survey of WSRC showed that **no achievement has been observed in sludge utilization**. The only utilization of sludge is in Nablus WWTP the plant daily produces 12-15 Tons (70% moisture) of dewatered sludge, the sludge is used in the bioreactor to produce 2500 CM/day of methane biogas, the latter is utilizing in producing 60% of the need of power for operating the WWTP. The dewater sludge is then dumped in Zahret Fenjan landfill. The quality parameters of sludge do not meet national standards; therefore no further use is allowed, this trial utilization has become a positive sign from different investment groups such as Palestinian Investment Fund [79]. which invest in Zahrat Al-Finjan landfill in two **energy generation projects**. As well Palestine Prosperity Investment and Development is willing to invest in the sludge to generate energy in Hebron WWTP.[80]

4.2 TH2: GOVERNANCE, USERS' ORGANIZATION, ACCEPTABILITY, TRAINING

4.2.1 GOVERNANCE

The water sector in Palestine has been under severe pressure, due to geo-climatic particularities, demographic and urbanization trends, inefficient management, and governance modalities as well as the persistent political situation.[81] The Government embarked into a **water reform process in 2010** (which was enacted in 2014), including concrete legislative actions for the management of its resources through the application of integrated and sustainable water resources management principles, for improving the provision of water

[76] Imad Ghenmeh, 2021. Ministry of Agriculture. Personal communication

[77] Kalavrouziotis, I. K., & Koukoulakis, P. (2016). Wastewater and Sludge Reuse Management in Agriculture. EQA - International Journal of Environmental Quality, 20, 1-13.

[78] Can J Infect Dis. 2001. The case against land application of sewage sludge pathogens.; 12(4): 205–207. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2094820/

[79] Mohammad Homeidan, Operating engineer. 2021. Personal communication

[80] PPID personal communication, 2021.

[81] World Bank. 2018. "Securing Water for Development in West Bank and Gaza." World Bank, Washington, DC.

services to all citizens[82]. The Government, committed to effectively reform the service subsector, established WSRC in 2014 as an independent regulatory entity. The new Water Law also included a clause indicating PWA willingness to improve the governance structure needed to attract private investment into the sector.

The Palestinian Authority (**PA)** adopted good governance as one of its strategic objective since 2012 and continued to be explicitly mentioned **strategic objective (SO's)** in all strategies. In (2017- 2022) strategy. SO4 states: *"**Development of Water Sector institutions** to reinforce good governance bases within an integrated legal and institutional framework"*. Main stakeholders are PWA, Environmental Quality Authority (EQA), Ministry of Agriculture, WSRC which was formed within the new water law (2014) Non governmental organizations (NGO's), and community based organizations (CBO's) like cooperatives and water users associations and of course, the LGU's as service providers. On farmers' level, and before approving the water users association law (2018), farmers used to form cooperatives to run water projects. WUS are governed to MoA law, while cooperatives are monitored by Ministry of Labor.

The governance structure in Palestine is understudied. It is characterized by **weak coherence** among actors, reflected in **overlapping and unclear responsibilities**; **unviable legal instruments**, and **insufficient resources and infrastructure**[83].

Reuse of treated wastewater is the responsibility of Ministry of Agriculture, however the monitoring of the quality of water is a mixed responsibility between Ministry of health, Environmental Quality Authority, Ministry of Agriculture and the service provider. While the treatment facility is controlled by PWA, and EQA. MoA is responsible for issuing permits for farmers to use the TWW.

Though substantial donor aid was made available to the sector, it could not meet the demand due, inter alia, to the rising demand from Government for social and emergency projects especially in Area C. There are **limited funds available** to the Government for covering source development costs, along with substantial deficits in operational and maintenance costs from the national budget. Hence, the need for private sources of finance of the type that brings with its expertise seems pertinent, but it requires further investigations.

Good governance, and solid regulatory mechanisms, attract private investments[84]. Should the right governance conditions be in place, **private sector participation** (PSP) could play an important role in bridging the financing gap of Palestine's water sector. The latter, entails significant potential for small-scale and large-scale PSP projects. The water sector has had experience in management contracts, and can replicate the experience but, it has yet to test other project modalities such as service contracts, operation and maintenance (O&M), performance-based projects, and build-operate-transfer (BOT). The Government is aware of the **important contribution PSP has had in the development of neighboring Jordan's**

[82] Palestinian Water Authority (2015), National Report on Water Governance in Palestine: Sector Reform to Include Private Sector Participation

[83] Al Khatib, N. Et. al. 2018. Governing the reuse of treated wastewater in irrigation: the case study of Jericho, Palestine. International Journal of Global Environmental Issues 16 (1–3), 135–148

[84] Ibid

water sector and elsewhere in the region and beyond. It has thus, endorsed PSP as a tool that can attracts and introduces investments, especially those that bring in the needed technical knowledge and expertise.[85]

Regulatory capacity is being developed but faces sustainable challenges. The **WSRC** is responsible for overall monitoring and regulation of all matters related to the operation of water and sanitation SPs. These responsibilities include approving tariffs, licensing and regulating SPs, and protecting consumers. The WSRC also collects valuable data by SP and has initiated a benchmarking process.[86] It publishes a summary of these data in an annual report. However, most of these legislative functions have not yet been transferred to the WSRC, including the approval of the licensing bylaw which would give the WSRC the eligibility to collect fees for its financial sustainability from licensed SPs. Since neither the PWA nor the WSRC has technical or administrative control over LGUs, there is a governance gap in the sector. The MoLG exercises administrative supervision of LGUs, but water service delivery is loosely supervised[87].

The interest and coordinatin among TWW stakeholders is not conducive Still each WSP think in a competitive approach as a matter of reusing the treated effluent, which make duplications of interventions, and make unfair interventions in areas that don't need or in-need of reuse. While service providers (municipalities) need to make income from treated water, farmers and farmer organizations believe that they should receive treated water free of charge. This difference in perception is affecting the willingness to use the TWW.

4.2.2 ACCOUNTABILITY

The **2014 Water Law** was designed to **clarify accountabilities** and establish autonomous utilities but implementation has been slow due to an **incomplete legal structure**, lack of financing, and lack of clarity of rules and responsibilities at the local level[88]. Previous water laws and strategies have also called for the establishment of regional utilities, but there has been no progress.

The 1997 MoLG Law (Ministry of Local Government), assigns the water services to the local government units (LGUs). PWA recognizes water services as a free-standing service that can be provided in partnership with the private sector, while the MoLG recognises water services as part of the local government's allocated responsibilities.[89]

LGUs use revenues from water service to cover their deficits on the provision of other services. In the interim, the lack of clarity will continue regarding accountabilities among the central agencies (PWA and MoLG) and the accountabilities of SPs upward and at the local level.

[85] Ibid
[86] Water Sector Regulatory Council 2020, The Website, https://www.wsrc.ps/about-us/24.html, last access 20/6/2021.
[87] World Bank. 2018. "Securing Water for Development in West Bank and Gaza." World Bank, Washington, DC.
[88] The Decree of Law Number (14): The Water Law (2014)
[89] World Bank. 2018. "Securing Water for Development in West Bank and Gaza." World Bank, Washington, DC.

Different interpretations of the 2014 Water Law by stakeholders both at the national and local levels suggest that the stakeholder consultation process has not yet resulted in ownership feeling within the MoLG and LGUs. The ambiguity in the rules will continue until the establishment of draft utilities by law is approved.[90]

4.2.3 ACCEPTABILITY AND PERCEPTION OF REUSE:

Acceptability of reuse or TWW is important on two levels first: to use TWW by farmers and second to use the products of farms irrigated with TWW. The willingness of the end users is necessary for success of reuse (Salgot, 2008). As the costs of treatment is relatively high and multi- factorial governmental, funding becomes fundamental for reuse (Centre for International Economics, 2010).

There are **several studies about acceptability and willingness to pay**. Ghanem (2012) noted that more than half of the respondents in wadi[91] Nar area located in the southern region of the West bank are willing to pay for treated wastewater for irrigation. (A study with sample of 30 farmers from AlZaitoun District and Khan Younis Governorate showed that most of the surveyed farmers were willing to use treated wastewater with average acceptance of 81% (Abu Sultan 2016). In other more recent study (Hamdan, 2021), it was fund that 75% of farmers in (Nablus, Jenin and Jericho) West Bank are willing to use the TWW. Similar results were obtained in similar studies in Gaza middle area (Nassar et al. 2010a) and Tulkarm (World Bank, 2004).

In Palestine the reuse of TWW for irrigation is limited due to health aspects, socio-economic conditions, religious considerations, and public and farmer perceptions[92]. The study about reuse in most important agricultural areas (Nablus, Jenin and Jericho) (Hamdan, 2021), found that 11% of large scale farmers (growing more than 50 du) are using TWW. The low percentage was explained by:

1- availability of fresh water in areas where TWW is available at reasonable prices (0.43 $),
2- on the contrary, the unavailability of TWW in other areas
3- psychological aversion of farmers
4- laws and regulations regarding use of TWW are very restricted
5- quality of TWW is inadequate.

Other studies confirmed this trend like Ibrahim Abu Seiba, 2016[93] .

Madi, et al., 2021 found that the perceptions and attitudes of farmers towards using TWW for irrigation depends on a **number of factors**. The most prominent are the availability of fresh water in the area, laws and regulations regarding use of TWW, quality of TWW, direct communication of professional experts with farmers and their guidance. Farmers are willing to

[90] WSRC, 2020
[91] Wadi means creek
92 (Hamdan M. , 2021). Willingness of farmers to use treated wastewater for irrigation in the West Bank, Palestine
93 Ibrahim Abu Seiba. 2016. Agricultural Reuse of Treated Effluent and Stabilized Biosolids From Jericho Wastewater Treatment Plant.

pay up to 50% of the fresh water tariff for treated water. The average cost of fresh water in the three governorates included in the study was US$0.45, while that for the TWW was $0.25.

4.3 TH3: INTEGRATED WATER RESOURCE MANAGEMENT AND REUSE ECONOMY

4.3.1 WATER AND WASTEWATER TARIFF IN PALESTINE

According to the **National Report on water governance in Palestine 2015**, the water tariffs should be set to cover investment and operational needs, once these are known. Although setting tariff may appear simple, yet the implementation is formidable as it is governed by more than mere socioeconomics but also by cultural and historical determinants.[94] The spectrum of pricing structures for water across service providers does not promote strategic matching of water resources to specific activities.

The Strategy and Policy document of 2013, Article 22.2, states that the **production and distribution costs vary from region to region and from system to system**, according to physical features such as elevation, groundwater quality and quantity, additionally, according to the conditions of the water network such as leakages, faults, and breakdown frequency. The water tariff implemented by each water utility would reflect these differences and the tariff would, therefore, vary from one municipality to another. Having a valid set of d-ata and information that would allow proper determination of tariffs is not easy. In all events, however, principles and procedures behind the setting should be uniform across all utilities.[95]

The **WSRC has conducted a survey on WW Service providers**, showing the percentages of charge on WW in both WB and Gaza. As the results reveal, 38% of SPs in the WB charge a monthly fixed fee for WW service; 13% charge a yearly fixed fee, and 17% charge a fixed volumetric tariff based on the water consumption. [96]

The Water and Sewerage Services Authority (WSSA) in **Bethlehem**, which serves Bethlehem, Beit Jala, Beit Sahur, and part of Bethlehem rural areas, is the only SP across the WB that applies a tariff to the WW as a percentage of the water consumption bill (approximately 28% of water bill)[97]. Ramallah, on the other hand, is the only SP in both the WB and the GS that applies a tariff based on built area (0.45 JD per m2)[98].

The survey reported that 13 SPs out of 54 in the WB, have no tariff for WW, this situation is different than GS, where more than 80% of SPs have a WW tariff as a percentage of the water

[94] Palestinian Water Authority (2015), National Report on Water Governance in Palestine: Sector Reform to Include Private Sector Participation
[95] Palestinian Water Authority (2013), National Water and Wastewater Strategy for Palestine
[96] WSRC, 2020
[97] Eng. Akram Nassar, Direct communication.
[98] WSRC, 2020

bill (Approximately 15-25% of the water bill), the 20% of the SPs in the GS pay a monthly fixed fee for WW service. [99]

According to Coastal Municipalities Water Utilities (CMWU) in Rafah the charge of WW is NIS 30 per month for domestic consumption and NIS 60 for commercial consumption, and Beit Hanun municipality charge 25% of the value of water bill for domestic use and 30% for industrial use.[100]

4.3.2 COSTS RECOVERING

The Ability of service providers to cover their costs

The WSRC adopted an indicator (cost coverage ratio of service provider) the survey conducted by WSRC in 2020 showed that 34% of surveyed SP totally cover their costs while 50% do not cover more (20-60% of cost). This cost does not include the depreciation. One of the main challenges and obstacles for planning of WW treatment and reuse is the lack of records of the cost of collection of WW and the absence of separate accounts for water treatment. The cost of collection efficiency is 100% only in Ramallah and Bethlehem of the Urban WWTP, and from the smaller size rural/ sub-urban communities only 9 SP who link collection with prepaid electricity charging. The others efficiency vary from 13% to 82%. In Gaza the best efficiency is 58% (in Rafah).

The Ability of SP to recover the WW Cost

WSRC survey showed that 19 SPs out of 54 recovered their costs (without depreciation) by generating higher revenues than costs. This means that the rest of the SPs are operating in deficit. As a result, the wastewater tariff structure for more than 70% of the SPs shall be reformed to optimize the recovery of the cost.

Operating Cost Coverage Ratio

According to the same survey only 25 SPs recovered their operational costs during 2017 (without depreciation). Comparing this result to the ability of the SPs to recover their WW cost; among these 25 SPs there are 6 SPs able to recover their operational costs only, but when it comes to the total costs, they started to operate in a deficit. So, according to these results, the wastewater tariff structure for SPs shall be reformed to optimize the recovery of the cost.[101]

[99] Ibid
[100] Direct communication with the CMWU, 2021
[101] WSRC 2020

4.3.3 COST BENEFIT ANALYSIS

On 2016 a master thesis was conducted to assess the **Cost Benefit Analysis (C/BA) of three beneficial uses of reclaimed wastewater in Palestine**. Results showed that the 10 years net present values[102] (NPV) of C/BA for reclaimed water reuse projects in irrigation were 5,172,963 (NIS) for **Alteireh/ Ramallah**, 1,150,380 (NIS) for **Anza/ Jenin** and 1,294,206 (NIS) for **Al-Taybeh and Rammun** reclaimed water reuse projects in irrigation. The C/B ratio for the reclaimed water reuse projects were 5.04 for Alteireh, 2.55 for Anza and 1.94 for Al-Taybeh and Rammun.

For Al-Taybeh and Rammun reclaimed water reuse project in **concrete mixing industry**, it showed low NPV and C/B ratio, which indicates that the reuse of reclaimed water in irrigation have more benefits due to the socio-political and environmental benefits involved in the agriculture projects in Palestine. Furthermore, the study showed that higher reclaimed water quality has higher NPV and C/B ratio.[103]

The cost effectiveness of a reuse project depends on the volume of reclaimed water used; where the more water utilized, the more the cost-effective the project (Urkiaga et al, 2008).

The valuation approach suggests that cost benefit analysis must incorporate socioeconomic, health related and environmental impacts of wastewater reuse in agriculture, for proper assessment. When evaluating wastewater reuse projects, the initial approach is to categorize all benefits into two groups, direct and indirect benefits. For the former, increased crop production, savings on fertilizer costs and on water supply as well as generating job opportunities, are just a few. For the latter they are minimized environmental damages ,controlled soil erosion and protection of groundwater which reduces waste and enhances water conservation (Al-Dadah, 2008). Water reclamation and reuse is technically possible but often it is not a cheap option. The infrastructural requirements are usually high, in particular because of the need to construct and/or retrofit the distribution system (Bixio et al., 2008).

4.3.4 DONOR APPROACHES TO PROMOTING REUSE

Donor agencies of Water, Sanitation and Hygiene (WASH) vary in their approach to promoting reuse. The reuse schemes implemented so far in WB has no common policy or procedures. While **beneficiary farmers are requested to contribute both in cash and in kind** (Anera, and KFW), **farmers in the pilot projects got everything free of charge**. This fact affected the acceptance of the potential beneficiaries when they were requested to pay contribution. This

[102] NPV is the difference between the present value of cash inflows and the present value of cash outflows over a period of time

[103] M. Abu Ayyash, (2016), Cost-Benefit Analysis of Beneficial Uses of Reclaimed Water: Three Case Studies from Palestine, Birzeit university, Master Theis.

is harder even when farmers feel that they make a favor in using the RWW, since they know that the there are fines impsed by Israeli government for non used wastewater.

4.3.5 LACK OF STORAGE FACILITIES:

Wastewater is produced constantly, but irrigation is only needed seasonally, thus **intermediate storage facilities would be required** AHT GROUP AG (2009)[104]. Such storage facilities need relatively huge funding and licensing from Israeli Authorities. The rainy season extends from November to April and in some years even November is dry. Rainfall average fluctuates depending on the geographical location. Therefore, irrigation is not needed during a period of 2-5 months of the year depending on the zone. During this period TWW is not needed. With lack of storage capacity, the only option is to let the effluent flow in its natural water courses (creeks), and sometimes considered as trans-boundary, subject to Israeli fines system. On the other hand the peak crop water requirement is July August. This peak is considered the base for planning irrigation scheduling, which means even during the period when irrigation is needed not all water is utilized.

4.4 TH4: EQUIPMENT EFFICIENCY, ENVIRONMENTAL AND SANITARY RISK

4.4.1 REUSE IRRIGATION TECHNIQUES AND USES

The mandatory instructions for the reuse are very conservative and strict in terms of irrigation methods. Only **drip irrigation** is so far used in reuse. For sprinklers, the irrigated area should be at least 50 meters away from any pathways, which is very hard to find in small fields of Palestine agriculture. The drip irrigation is most common, in some cases the sub-soil irrigation method is used, link the case of alfalfa crop in Jenin, The system is irrigation efficiency is high, however, no researches were found on this topic.

4.4.2 QUALITY OF RECLAIMED WASTEWATER:

Of the many factors, the reuse of RWW depends on the quality of the treated effluent. The latter is dependent on the quality of influent, treatment method and the efficiency of the WWTP. It is mandatory that every service provider monitor quality parameters of effluent and influent. However, most of the service providers do not have a lab or cannot afford the routine periodic needed tests in private sector labs.

[104] AHT Group AG (2009), Identification and Removal of Bottlenecks for extended Use of Wastewater for Irrigation or for other Purposes, MEDA-Countries, Summary Report.

The results of the **monitoring activity of WSRC**[105], **2020** showed that all WWTP's in the WB who monitor the quality of their influent and effluent have achieved a high efficiency (higher than 95%) of reducing the (BoD, CoD and TSS). The list included Nablus, Tiereh and Jericho, while Jenin and El Biereh did not achieve thresholds. This could be explained by the difference in treatment method, the age of the treatment plant, the availability of power (in case of Jenin) as in summer the municipality cannot operate all the aerators due to the insufficient electric capacity. In Gaza none of the WWTP achieved the needed efficiency. This is related to lack of energy and overloading of facilities.

The compliance for irrigation depends on BoD, CoD, TSS, Total nitrogen (TN) and phosphorus (P). Again only the three WWTP who fulfilled the efficiency threshold are compliant with the irrigation requirement. Of the smaller scale WWTP, no documented results of the quality parameters were available (WSRC, 2020).

4.4.3 CONSISTENCY IN QUALITY AND QUANTITY OF EFFLUENT:

All WWTP except Teireh need further treatment to be suitable for wider range of crops. Jericho WWTP is used for irrigating dates which are tolerant to salinity, while in Jenin reuse is mainly for trees and alfalfa, it is used with chlorination and filtration, but the RWW quality is fluctuating in case of Jenin . Tertiary treatment is further needed to minimize the concentration of heavy metals, lower salinity levels and biological pollution indicators, so it becomes suitable for wider range of crops according.

4.4.4 LACK OF FRESH WATER FOR MIXING

When the TWW has high salinity a good practice is to mix it with fresh water . In WB and Gaza Water is scarce and not available in most reuse areas like Jericho, Nablus and Gaza. In Gaza the water salinity is very high. Leaving farmers with limted options of crops to grow

[105] WSRC, 2020.

4.5 SWOT ANALYSIS

S	W
1. Good Capacity / HR 2. The knowledge and experience in the history of reuse possibilities and technical willingness 3. Good number of WWTP, some are huge like NGEST[106] in Gaza 4. Good number of pilots with failure/ some success	1. Political will is not supporting 2. Hardware capacity is weak / lab testing… 3. Coordination among service providers is not conducive 4. The Tariff is variable or absent 5. Governance structure is not yet well fledged (Roles/ Responsibilities) 6. Standards are very conservative
O	**T**
1. Funding opportunities 2. Experience in Ag. Of farmers 3. Scarcity of Water for irrigation 4. Israelis treat the trans-boundary water and PA is charged/ fines for this. Such fines could act as an alert or incentive to adopt the reuse	1. Occupation constraints 2. The lack of proper Sludge treatment facilities 3. High cost of electricity/ inability to cover treatment costs 4. Community engagement and acceptance 5. The trans-boundary WW, delays licencing on WWTP and affect the site selection 6. Climate Change

Strengths:

1. Good capacity and availability of **human resources**, The experienced human resources are available on different levels:
   A. **Municipalities and water service providers** (WSPs) level: both municipalities and WSPs have the human resource capable to manage treatment plants once they have the sufficient financial resources and conducive governance framework.
   B. **Government level** (the regulator): both PWA, and WRSC are having very good capacity to manage macro scale treatment and reuse project, and have the

[106] North Gaza Emergency Sewage Treatment Project.

capacity to construct and make proper procurement plans (the new Hebron Regional WWTP) project which is funded by the World Bank, EU, AfD, and others is a very good example.

2. The **history of reuse possibilities** and **technical willingness** are full of lessons learned to shape future reuse schemes. Palestinians start their reuse project from the mid 1990s just after the operation of Al-Beireh WWTP on urban level, and have their own first policy on reuse in the year 2000. However, the reuse in El Biereh did not sustain.
3. **Number of WWTP**: As mentioned in the previous chapters there are more than 30 WWTP between urban and rural, most of the treated effluent is or could be suitable for ruse especially in Nablus West, Jericho, and North Gaza.
4. In the last 10 years there were a good number of **reuse pilot projects**. PWA, WSPs and academic institutions has conducted several pilots of reuse of reclaimed water, especially on research level, which shows the possibility of reuse and the implications on certain plants species. Such pilots form a wealth of knowledge to gear future reuse.

Weaknesses

1. **Political well** is not supporting: The Palestinian authority is still in between heading toward full and proper reuse of treated effluent, while imposing very strict standards and guidelines. At the same time no sufficient public budgets are allocated for reuse.
2. **Hardware capacity is weak / lab testing**: The Palestinians has a limited access toward proper lab testing for the quality of treated effluent especially the one related to biological pathogenic bacteria.
3. **Coordination among service providers and potential TWW users** is not conducive this lead to duplications of interventions,For example in Nablus and Jenin pilot projects coinsided from different donors each has same scope, one asked for cash and in kind farmer contribution, while the other did not ask for any contribution.
4. The **tariff** is variable or absent: The water tariff in the northern part of the West Bank is low comparing to south or to Gaza, which hinders the opportunities of proper treatment by service providers and consequently reuse of treated effluent. Around 62 percent of Palestinian customers pay their water bill. The fee collection rate for wastewater treatment is even lower. Most service providers are Indebted. Poor services lead to customer dissatisfaction and reluctance to pay. The Water Sector Regulatory Council (WSRC) is responsible for the tariff structures across the West Bank, To the moment no clear policy have been reached for tariff..
5. **Governance structure** is not yet well fledged: Roles/ Responsibilities are mixed. Lack of governance and variety of different governance approaches between the WSPs, municipalities, and/or water utilities is weakness because it make the issue of quality uncertain, and un assured.
6. Standards are very conservative and strict: The treated effluent standards, and the way that farmers think about it is very conservative, although the quality is good for restricted agricultural patterns, but still the social aspects become as a barrier toward proper reuse of treated effluent.

Opportunities:

despite the weaknesses and the inconvenient status of treatment and reuse there are good opportunities for improvement

1. **Funding** opportunities: Several donors are investing into the reuse of treated effluent in Palestine, especially the Germans, and French donors (Nablus West funded by KFW, Hebron funded by AFD, Jericho funded partially by AFD and JICA, North Gaza funded by AFD and other European donors and many others
2. **Experience of farmers**: Farmers have the capacity of implementing the best practices of reuse of treated effluent, as a reuslt of many NGOs efforts into this sector and they are ready to use the water.
3. **Scarcity of Water for irrigation** in many areas: Although, it is a scarcity, but it become an opportunity to improve the wiliness of farmers.
4. The **fines** imposed by the Israeli government on the treatment of the trans-boundary water could be a deriving force of stakeholders to stop this exploitation of budgets and losss of treated and untreated water. This can be also a reason to advocate the request of budgets from the Palestinian Authority.

Threats

The water sector on general and the treatment and reuse in particular faces big challenges and threats:

1- **Occupation constraints**: The political challenge resulted from the militant occupation and the followed permits regime decrease the opportunities of having proper treatment of the wastewater, and then utilizing the treated effluents in land under the permits regime (Area C). Israel stopped and retarded the building of many treatment plants through denying permits.
2- **Limitations on building wastewater treatment facilities**: either in what is called Area C where it's very hard, if possible even, to get permit from Israeli authorities, or in Areas A, and B where Palestinian communities are reluctant to have such infrastructure in close to their residence "Not in my backyard principle"[107]
3- **Sludge treatment**: The sludge treatment is one of the most expensive and resource consuming in the treatment plant, which requires a financial subsidiary. The service providers headache is the sludge.
4- **High cost of electricity**/ inability to cover treatment costs: The cost of electricity still one of the challenge of having proper treatment, not only as a financial cost (0.5-0.65 ILS/KWh), but also as availability of electricity all the time, which is a challenge toward proper treatment not only in Gaza but also in Jenin.
5- **Community engagement and acceptance**: People are still not engaged into the treatment conditions of wastewater, and yet not all farmers are accepting the reuse of treated effluent especially in Places where tariff of fresh water is less cost than the treated effluent.
6- **The trans-boundary WW**: Spilling wastewater into creeks towards the West is another threats of the proper sustainability of wastewater treatment plants, and any associated

[107] Anne Dare. 2017.

reuse project, as it may lead to a political crises when the wastewater is running into creeks, and eliminates the role of treatment plants.

7- **Climate Change**: The aspects of climate change especially heavy rain events, may lead into flooding of wastewater treatment plants, which will lead into treated water pollution, and may lead to farms floods with wastewater.
8- **Sustainability of donor investments**: Demonstrated capacity by the service provider and a realistic business plan for cost recovery and sustainability of operation should be a precursor to investments in wastewater infrastructure. A viable model of sustained funding to cover cost of operation (energy, salaries, handling of by-products, etc.), maintenance, upgrades, and future expansion is critical to long-term impact in the sector[6].
9- **Trans boundary protocol for wastewater:** There are approximately 33 trans boundary wadis (creeks). Five of these wadis carry a combined estimated volume of 15 MCM/year of wastewater from the West Bank into Israel. The cost of collection and treatment of this wastewater is deducted by Israel from the PA's customs and VAT tax revenues. Israeli authorities have their estimates without transparent billing process. On the hand, there is no control on the discharge of settlement wastewater into West Bank wadis,
10- **Environmental regulatory capacity:** Discharge of industrial wastewaters –olive press, stone cutting, leather tanning, and food processing – place an acute burden on wastewater treatment facilities and the environment. Industrial effluents threaten to compromise investments in wastewater collection and treatment infrastructure and make it difficult for wastewater utilities to meet discharge and reuse standards. This is despite the law obligations of primary treatment of industrial water before connection to sewerage system.