Water reuse in the Gaza Strip, Palestine

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ABSTRACT

The Gaza Strip suffers severe constraints in water supply due to its location, confinement, high population density and semi-arid coastal climate. To improve water and agricultural resources, a study was undertaken 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. Particular attention is paid to economic, financial and socioeconomic analysis. This paper discusses the impact that wastewater reuse will have on the water resources as part of the overall water balance in the Gaza Strip.

Key words | aquifer recharge, effluent management, irrigation, socioeconomic impact, wastewater treatment, water reuse

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INTRODUCTION

The Gaza Strip suffers severe constraints in water supply due to its location, confinement, high population density and semi-arid coastal climate. The high rate of population growth is putting the limited water resources for sanitation and agriculture under severe and increasing stress, resulting in groundwater depletion, degradation of water quality, particularly of potable water supply, and reduced crop productivity. Many previous studies have highlighted water and wastewater as high priorities for action to improve public health and the sustainable development of the area (Hamdan *et al.* 2011; Shomar 2011). Groundwater remains the principle source for both potable and agricultural irrigation. However, the aquifers are under extreme stress through over-abstraction and contamination, resulting in increased incidence of waterborne diseases and salinity. The water supply is currently adequate, but aquifer abstractions are estimated to be 300% of the sustainable yield, and less than 10% is considered to be of satisfactory quality, meeting WHO standards (World Bank 2009). By one estimate, aquifer failure could occur as early as 2016 (Phillips 2011).

Integral to the regional water strategy, three regional wastewater treatment plants (WWTPs) are planned to provide complete coverage of the northern, central and southern areas. The WWTPs will produce substantial quantities of treated effluent and sludge; these are valuable alternative resources but their treatment and reuse require careful planning and management to ensure that appropriate quality standards are achieved and the maximum sustainable benefits are realized economically (FAO 1985, 1992; USEPA 2004).

A feasibility study was funded by the German Government and the German Development Bank Kreditanstalt für Wiederaufbau (KfW), which considered the potential for and planning of the reuse of the treated effluent and sludge that will be produced by Buriej WWTP. This is the largest of the three WWTPs which will serve Gaza City and the Middle Area communities, and will be developed in the coming years, depending on the political situation. The reuse project will be the first of its kind in Palestine. Since there are two further WWTPs planned for the Gaza Strip and several in the West Bank, the successful development of the Central Gaza reuse project will provide a framework on which further reuse projects can be developed.

The feasibility study proposes practicable concepts for the reuse of treated effluent and sludge and long-term strategies were developed aimed at maximizing the socioeconomic value of effluent and sludge and minimizing potentially negative environmental impacts.

Justification for the reuse project is predicated on effluent and sludge reuse being an integral component of a wider strategy to achieve sustainable and independent development within the Gaza Strip. This paper concentrates on the reuse of treated effluent.

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METHODOLOGY

The feasibility study deals with constraints, specifications and local conditions for wastewater treatment, irrigation and recharge first. The corresponding design follows an effluent management strategy. Reasonable assumptions had to be found.

Results of the feasibility study show the impact on required agricultural areas for irrigation and areas for infiltration. Implications for the designated wastewater treatment layout are presented. Finally, economic and financial results of an analysis within the water reuse study are presented; the capital expenditure of all eligible scenarios are listed.

Process overview and design parameter

Wastewater flow is expected to reach the design capacity of Buriej WWTP by 2015 with future expansion for flows projected by 2025. Initially, the excess flows will be handled in the recently renovated and expanded Sheihk Ajleen WWTP, serving Gaza City. Average daily dry weather wastewater flows to Buriej WWTP are given in Table 1.

The effluent quality will be based on the standards recommended to the Palestine Authority, with the key parameters as outlined in Table 2.

The effluent standards include limits for heavy metals (HM). However, with only light industries and a geology which is naturally low in HM, all analyses of the wastewater, effluent and sludge showed negligible levels, all well within accepted limits. This will need to be monitored in the future but is not considered a constraint.

Treatment will be by activated sludge process to achieve effluent quality that complies with standards for safe discharge to Wadi Gaza, equivalent to the quality for recharge by infiltration. The plant is designed to achieve an average effluent quality for total nitrogen of 25 mg/l throughout the year. This will be the determining factor, which achieves the project goal for all other effluent quality standards. Additional treatment will be provided for any effluent to be used for irrigation. For process design see Table 3.

Table 1 | Effluent quantities of Buriej WWTP

Quantity	Start-up	Current design capacity	Future design capacity
Effluent – annual average [m^3/d]	76.700	115.700	170.300
– summer [m^3/d]	89.700	135.400	199.300
– winter [m^3/d]	65.200	98.300	144.800

Table 2 | Required effluent quality

Recommended criteria	Recharge by infiltration	Restricted irrigation	Unrestricted irrigation
BOD [mg/l]	20	20–60	20
SS [mg/l]	30	30–90	30
Total N [mg/l]	100	45	45
Helminth [no/l]	–	<1	<1
Faecal–coliform [no/100 ml]	200–1,000	<1,000	<200

Effluent management strategy

The effluent reuse strategy developed by the feasibility study comprises:

1. Direct irrigation of effluent via a conveyance system that delivers effluent to strategically located metered farm off-takes at appropriate volume and pressure to meet peak crop irrigation demand in the contiguous agricultural areas closest to Buriej WWTP.
2. Artificial recharge of effluent to groundwater by infiltration ponds for effluent that is surplus to irrigation demand, or full flow of effluent if agricultural reuse is not developed.
3. Additional treatment of effluent to a standard that is safe for unrestricted agricultural reuse and recharge.
4. Discharge to Wadi if effluent quality is not achieved or the project is not implemented.

The existing reliable yield of drinking water from the Gaza aquifers is estimated at 55 million cubic metres (MCM) per year, which, after allowing for agriculture and

Table 3 | Units for wastewater and sludge treatment of Buriej WWTP

Main wastewater treatment units	Main sludge treatment units
Inlet structure	Return and waste activated sludge pumping station
Faecal sludge acceptance station	Sludge thickeners
Flow measurement	Sludge storage tanks
Screens	Mechanical dewatering (centrifuges)
Grit & grease chambers	Sludge stacking beds
Primary clarifiers	Emergency sludge lagoons
Activated sludge tanks and blower house	
Final clarifiers	
Outlet to Wadi Gaza	
Wadi wetland polishing	

other uses, equals 35 l/d per capita. supplemented from other limited sources. Agriculture is largely rain fed but relies on pumped groundwater in the dry summer months for irrigation. Providing good quality treated effluent as an alternative source of irrigation water in summer months and supplementary ground water recharge in winter months will significantly improve the aquifer resources. However, wastewater treatment will have little impact on the increasing salinity levels, which are becoming critical in many areas and will affect the range of crops that can be grown. Therefore, the long-term sustainability of effluent reuse relies on the introduction of lower salinity water into the supply to control the maximum salinity. This is proposed to be provided primarily by the two large-scale desalination plants in the current plan.

An essential initial activity is to initiate public and farmer awareness campaigns and involvement programmes (USEPA 2004). With each phase of the development, detailed discussions with farmers should be held to maximize acceptance of effluent. A user's agreement should be signed between farmers and system operator to ensure mutual commitment to accept and supply effluent and agree compensation measures if supply is interrupted.

Geological/hydrogeological conditions

Gaza is essentially part of a foreshore plain, gradually sloping westwards towards the sea, underlain by a series of geological formations from the Mesozoic (65 to 245 million years BP) to the Quaternary (0 to 2 million years BP). These deposits consist of aeolian and fluviatile material forming the Continental Kurkar Complex. This complex is composed of calcareous sandstone and alternating red loamy sand. Only Wadi Gaza intersects the landscape of parallel Kurkar ridges and interspersed deep depressions filled with alluvial deposits. Active sand dunes are found near the coast.

The coastal aquifer extends along some 120 km of Mediterranean coastline, from Gaza in the south to Mount Carmel in the north. The width of the aquifer varies from 3 to 10 km in the north to about 20 km in the south. The depth to groundwater in Gaza ranges from 60 m in the east to 8 m or less near the shore and the flow is generally from east to west. The aquifer is composed of sands, calcareous sandstone and pebbles. Semi-permeable and impermeable layers are sandwiched in between, dividing the system into sub-aquifers. This subdivision is especially well developed in the western part of the coastal plain, where one borehole may pass through several separate sub-aquifers, each having a different water level and quality. Further inland, the sub-aquifers effectively merge to form one system. The aquifer stretches over the entire length of Gaza from north to south and over its total width, but varies significantly in depth. It has a wedge-shaped cross section with a maximum thickness of 180 m near the coast, and tapers towards the east. In the south, the saturated part of the aquifer appears to be negligible near the eastern border of Gaza.

Groundwater is only recharged by rainfall and the yield in Gaza relies heavily on inflows from the parts of the aquifer underlying Israel. The yield in Gaza of 55 MCM is estimated to be 15% from the total yield from the aquifer.

This open, active aquifer is at risk of saline intrusion from the sea, with abstractions reaching 300% of the reliable yield, and from surface contamination, mainly from wastewater. The treated effluent standards are proposed to control the contamination, and infiltration will contribute to reducing over-extraction and the risk of saline intrusion. However, already increasing salinity in the water supplies, which will not be reduced by conventional wastewater treatment, remains a concern which can only be alleviated by the planned desalination projects.

Design assumptions

The process calculations of the wastewater treatment units are based on the following assumptions.

1. The design temperature of 15 °C for N removal and 28 °C for O_2 consumption.
2. The process design according to the German A 131 Standard (ATV/DVWK 2000), with the following exceptions:
   - 8% of the biological sludge production has been used as the value of nitrogen incorporation in biomass.
   - 4.6 × nitrogen to be nitrified determines the oxygen demand for nitrification.

Design assumptions for the irrigation conveyance system include:

- Peak irrigation demand of 4.9 mm/d, allowing for the range of crops grown, and climatic and soil conditions in relation to predicted effluent quality. A leaching fraction of 20% to control salinity below level that inhibits potential crop yield.
- System and irrigation efficiency of 75%. On this basis, the quantity of effluent from Buriej WWTP is sufficient to irrigate 27,700 dunum (1 dunum equals 1,000 m^2).
- Urban development to 2025 is restricted to the areas designated by the regional development plan (i.e. no encroachment in effluent reuse command areas).

- A high proportion of farmers within the command areas convert to effluent reuse (high willingness expressed in farmer survey), adopt efficient irrigation techniques (already widely adopted) and are willing to pay a volumetric charge for effluent consumed (high willingness expressed in farmer survey).

Design assumptions for aquifer recharge include:

- Daily infiltration rate is in the range 0.5–5 m^3/m^2 and on this basis 20–200 dunum will be required to infiltrate 100,000 m^3/d (average winter flow), or 27–270 dunum if the irrigation system is not established (average summer flow). Detailed site investigations are required to determine actual infiltration rate and area required.
- Privately owned land is acquired at suitable locations for the recharge basins.

Financial analysis

A separate financial analysis was conducted for each of the two components (sub-projects), namely, effluent irrigation and effluent recharge.

Integrated financial statements were used in deriving the economic and financial indicators for constructing and operating the components in the selected sites. The analysis for each sub-project was based on deriving and utilizing the indicators from Table 4. These indicators were used to determine if the proposed sub-projects are feasible. To evaluate the project financially, several discounted measures were used, namely the NPV, the IRR and the benefit/cost ratio.

A replacement interval of 15 y was assumed for pumps and blowers and associated electrical components, 2 y for UV lamps and 10 y for sludge handling equipment.

The operations and maintenance (O&M) costs were based on estimating the total operational costs for each sub-project to include cost of energy and materials and wages of direct labour and administration.

Energy was the most significant cost: for irrigation, this is estimated at EUR 972,829/y, and for recharge only, the estimate is EUR 1,683,669/y. Labour costs for effluent and sludge management were estimated at EUR 283,200/y and EUR 322,800/y, respectively.

Table 4 | Components and sub-components of the financial analysis

Calculation of initial investment costs	Site infrastructure; machinery and equipment; auxiliary equipment; engineering services; price and physical contingency; total initial investment
Total operational costs	Materials; utilities requirements; wages of direct labour and administration
Total fixed costs	Maintenance; fixed assets depreciation; annual total fixed costs
Incremental working capital	
Project benefits	Sale of effluent for reuse; income from abstractions
Cash flow analysis	
Financial evaluation	Net present value (NPV); benefit/cost ratio; internal rate of return (IRR); payback period

RESULTS AND DISCUSSION

Effluent conveyance system: allocation of land

Six command areas for effluent reuse are identified as shown in Figure 1. These will allow phased and economical

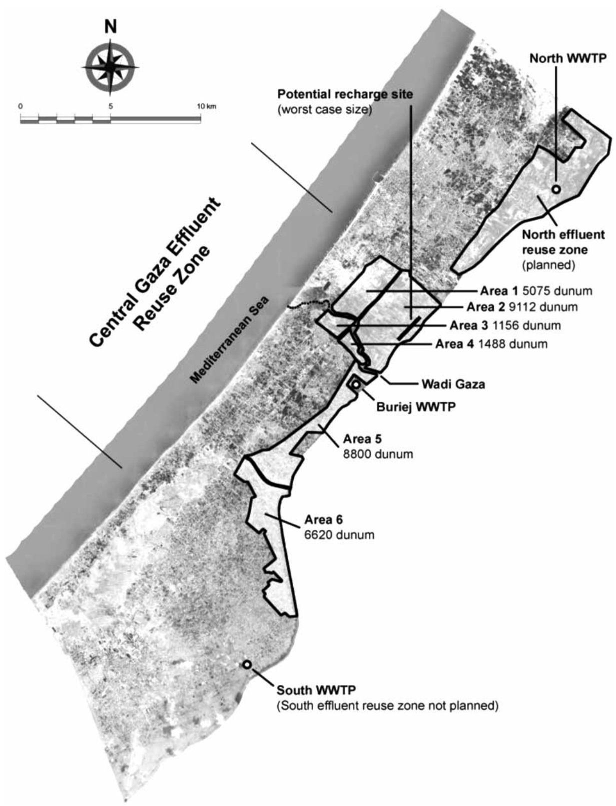

Figure 1 | Effluent irrigation areas and location of aquifer recharge facility (1 dunum equals 1,000 square metres).

development of the effluent supply network according to farmer demand and as wastewater flow to the WWTP increases. Based on currently cultivated land within these areas, the total available area is 30,200 dunum and this is increased to 32,250 dunum assuming that additional land in Area 5 is recultivated.

Three main phases of development are foreseen. The incremental areas available and the areas that could be feasibly irrigated are as follows.

- Start-up flow: Areas 1, 2, 3 and 4–16,830 dunum (flow sufficient for 18,400 dunum).
- Design flow: plus Area 5–25,630 dunum (flow sufficient for 27,700 dunum).
- Future flow: plus Area 6–32,250 dunum (flow sufficient for 40,800 dunum).

Progressive development of the conveyance system should:

- ensure that there is sufficient land available for maximum reuse of effluent up to the design flow of the WWTP;
- allow a margin of safety in ensuring that peak farmer demand is reliably satisfied; and
- avoid the need for 24 h scheduling of irrigation during peak demand periods.

If the capacity of Buriej WWTP is extended in the future, the feasibility of developing Area 6 should be evaluated further in the light of experiences gained in operating the conveyance system and the benefits achieved. The alternative option would be to increase the quantity of effluent recharged within the current project area.

Effluent conveyance system: design and investment

The effluent conveyance system will be realized as two systems.

System A: Effluent is discharged from the Buriej WWTP to Wadi Gaza where it receives additional natural treatment in constructed wetlands in the Wadi bed (constructed by WWTP project). The Wadi is used as a means of conveying the effluent at no cost to a lift station located near the central pumping station (CPS). Filtration (if necessary) and disinfection takes place at this location, and an effluent pumping station (EPS 1) supplies Areas 1, 3 and 4 through two mains. Main 1, to serve Area 1, is based on the existing 600 mm pipeline that was installed under a previous effluent irrigation project, currently used to discharge Gaza WWTP effluent to Wadi Gaza. Main 2 crosses Wadi Gaza via the road bridge to supply Areas 3 and 4. Additional land will need to be acquired for the treatment facilities unless these can be installed within the area of the CPS.

System B: Filtration, disinfection and EPS 2 are installed within the area of the WWTP to supply effluent to Areas 2, 5 and 6. Main 3 serves Area 2, north of Wadi Gaza, and this pipeline will also convey effluent to the recharge facility proposed in this area. Main 4 serves Area 5 to the south of Buriej WWTP.

For the northern areas to be served by Systems A and B, two options were considered. Under Option 1, effluent supply to Area 2 would be divided between System A and B (topographical considerations), whereas, for Option 2, System B would supply all of Area 2. Option 1 is selected as the most practicable and has slightly lower cost.

For the southern part of System B, two options were considered. Under Option 1, Main 4 would serve only Area 5, and a separate parallel pipeline (Main 5) would be required to serve Area 6. Under Option 2, Main 4 would be dimensioned for possible future flow to allow extension of this pipeline to Area 6. Since the future development of Area 6 is uncertain, dependent on WWTP extension, Option 1 was selected as the cheaper and more secure option.

All main pipelines are proposed to be ductile iron and laid in or alongside roadways. All secondary systems are DN 200 uPVC pipes, to be laid along farm access roads and field boundaries with farm off-takes spaced at 200 m intervals. The minimum pressure at the off-take is 3 bar, sufficient to operate drip irrigation systems. Each off-take is to be fitted with a meter.

Total investment costs for Option 1 (recommended) are estimated at EUR 16.9 million for start-up flow, increasing by EUR 7.4 million for design flow. Future extension to Area 6 would cost a further EUR 6.2 million.

Aquifer recharge

In accordance with positive operational results of similar large-scale soil–aquifer treatment facilities (Bouwer 1991; Kanarek & Michail 1996), aquifer recharge is an essential component of the policy of water resources management in the Gaza Strip. A potentially suitable area for groundwater recharge by infiltration basins is identified 3 km north of Buriej WWTP (Johr El Deek district), close to the green line, and about 500 m east of the alignment of Main 3. Given that information on underground conditions is inadequate to develop precise specifications but based on known conditions, the best and worst case scenarios of infiltration capacity are expected in the range 5–0.5 $m^3/(m^2 \cdot d)$. A detailed site investigation with pilot- and small-scale systems is required for confirmation of site suitability and detailed design (Bouwer 2002).

The operation of the recharge ponds is considered under two scenarios.

No.1: Assuming the effluent conveyance system for agricultural irrigation of effluent is installed, the effluent surplus to irrigation demand is recharged. This will amount to 50% of the annual amount of effluent. Effluent flow will peak in the winter and the full flow of effluent will be recharged. At design capacity of the WWTP, this is expected to be about 100,000 m^3/d and an infiltration area in the range 20–200 dunum will be required.

No. 2: If there is no direct reuse of effluent by irrigation, effluent would be continuously recharged. Peak flow will occur in the summer and an area in the range 27–270 dunum will be required at the design capacity of the WWTP.

Each basin will have an area of approximately 6,000 m^2 and the number of basins will be in the range 4–33 for scenario 1 and 5–45 for scenario 2, depending on site and reuse conditions. The basins should be aligned parallel to the green line but the arrangement will depend on detailed site investigation and land acquisition from the private land owners. There is no government-owned land in the immediate area.

Total investment costs (excluding land acquisition) for the recharge facility, operated only for effluent surplus to irrigation demand, are estimated at between EUR 1.55 million and EUR 6.72 million, depending on the results of the detailed site investigations.

If there is no irrigation project, costs are estimated at between EUR 9.43 million and EUR 16.3 million, including costs of effluent treatment and conveyance to the recharge location.

Required additional effluent treatment

The additional effluent treatment required is determined as follows.

- **Filtration** necessary to remove nematode ova and improve the effectiveness of effluent disinfection (Bouwer 2002). Filtration also reduces suspended solids that may clog drip-irrigation systems and reduce the infiltration rate of recharge basins. Rapid sand filtration is considered, with the backwash water discharged to the WWTP.
- **Disinfection** to achieve the required level of pathogen removal to allow unrestricted reuse of effluent (Chrtek & Popp 1991; Nasser *et al.* 2006; Oparaku *et al.* 2011). A faecal coliform standard of 200 MPN/100 ml is to be achieved by UV lamps.
- **Additional nitrogen removal** is not required in the short term, as the current design is expected to perform better than the discharge standard (25 mg N/l). This should be kept under review depending on actual performance of the WWTP. Options for enhancement are dosing with additional carbon source for post-denitrification (in the case of periodic non-compliance at low temperatures) or early installation of an additional aeration tank volume for pre-denitrification (in the case of continuous non-compliance). On expansion of the WWTP, facilities to achieve N removal to achieve 10 mg N/l will be installed.

The total investment cost for provision of additional treatment and pumping stations for EPS 1 Option 1 is EUR 3.09 million and for Option 2, EUR 2.66 million. For EPS 2, the cost for Option 1 is EUR 5.98 million, and Option 2, EUR 6.24 million. The combined costs for EPS 1 and 2 are similar (Option 1 EUR 9.07 million and Option 2 EUR 8.90 million). Option 1 is recommended as this integrates with Option 1 for the effluent conveyance system and is cheaper overall by EUR 1 million.

Economic and financial analysis

The economic and financial analysis shows that there is strong economic justification for effluent reuse to irrigate fodder, vegetable and tree crops because this mixed cropping indicates a benefit/cost ratio of 1.5 at a discount rate close to the opportunity cost of capital. The economic IRR, which is useful in comparing economic performance with other opportunities for investment capital, was estimated as 16%. Bouwer (1991) confirms the economic feasibility of soil–aquifer treatment in comparison to equivalent WWTP purification.

The financial analysis conducted for the irrigation project indicates that effluent irrigation will be financially viable, provided that farmers receive appropriate technical support. During the early years of system operation, it is recommended that the tariff for effluent should be limited to NIS 0.5/m^3 (NIS: New Israeli Shekel) to encourage high farmer acceptance and this is close to the rate that farmers have stated they are willing to pay. Full cost-of-service rates have been estimated at NIS 0.64/m^3 (EUR 0.12/m^3) and this charge would be less than the current farm cost for groundwater irrigation. The economic improvement for farmers in this regard was analysed in other studies, too (Nassar *et al.* 2009). It is recommended that effluent charges are gradually adjusted upward after the development period to cost-of-service rates (Table 5).

Table 5 | Summary of financial indicators of the effluent irrigation project at different effluent tariff charges, e.g. at 0, 4 and 10% discount rates

	Proposed water tariff per m^3		
Financial indicator	NIS 0.4 (€0.074)	NIS 0.75 (€0.138)	NIS 1.0 (€0.184)
Discount rate	**0%**		
Benefit/cost ratio	0.59	1.10	1.47
NPV [€]	−44,659,419	11,054,284	50,849,786
Financial IRR	<0	0%	6%
Discount rate	**4%**		
Benefit/cost ratio	0.46	0.87	1.16
NPV [€]	−33,457,496	−8,124,240	9,970,943
Financial IRR	<0	0%	6%
Discount rate	**10%**		
Benefit/cost ratio	0.33	0.61	0.82
NPV [€]	−25,178,793	−14,448,472	−6,783,957
Financial IRR	<0	0%	6%

If the irrigation project was not accepted by farmers after the initial development phase, the full flow of effluent would be recharged to groundwater. The analysis shows that a charge within the range of NIS 0.255–0.313/m^3 (EUR 0.047–0.058/m^3) would be required to cover the investment and O&M costs, respectively. This may be recovered through an additional charge on the wastewater tariff or from the farm well tariff to be imposed by the Palestinian Water Authority (PWA). This compares with the rate of up to NIS 3.4/m^3 (EUR 0.8/m^3) which is currently considered affordable for potable water supplies.

Socioeconomic impact

A socioeconomic study showed that substantial income and employment benefits can be realized from implementing the project. The main benefits are from the employment and expenditures associated with the installation of facilities and training programs at the project sites. It provides an alternative summer irrigation supply in a sustainable manner to support the existing agriculture, and in winter adds to the depleted groundwater resources.

A survey of farmers in the project area within the study showed a general and widespread willingness to use treated effluent for irrigation at the tariff rates proposed above. The farmers considered this to be comparable to their existing borehole registration and pumping costs. The farmers expressed a natural concern to ensure the quality of the effluent, although there was recognition that some level of nitrogen and phosphates in the effluent would be beneficial to reduce their dependence on fertilizers. The farmer survey revealed that anticipated cost reductions for irrigation are the most important factor determining farmers' willingness to use effluent. However, the feasibility study recognized, that a comprehensive stakeholder acceptance programme is needed to ensure successful implementation.

The two-stage treatment arrangement will allow the effluent quality to be monitored. In the event that the quality is not to standard, by malfunction or other reasons, then the effluent can be diverted to discharge, not to irrigation.

Other constraints to reuse are that there is no clear agency for administering the system and collecting the tariffs. A number of options have been considered with preference to form a separate agency managed jointly by the Coastal Municipalities Water Utility (CMWU), the Ministry of Agriculture and a Farmers Union.

However, the main impact will be the contribution to ensuring sustainable groundwater supplies and indirect contribution to the long-term plan for providing potable water supplies. The water supply situation in Gaza today has reached the situation where waterborne diseases are increasing and families have to pay NIS 35/m^3 for limited amounts of desalinated water from private vendors to ensure safe drinking water.

CONCLUSIONS

The expected key physical outputs of the project would be as follows.

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 by groundwater.
2. Water quantity related: Effluent that is surplus to irrigation demand is recharged to the Coastal Aquifer by infiltration basins to reduce and ultimately reverse the decline in groundwater quantity and quality.

The anticipated key institutional 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 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 project 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.

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