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Seawater desalination transforming the Gaza Strip

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There are no easy conventional solution to Gaza's chronic water crisis and impending environmental catastrophe. Seawater desalination is one of the key transformative interventions strategically considered to address both these issues. UNICEF, with European Union funding, therefore initiated the implementation of a seawater desalination programme in late 2012. The first phase of the seawater desalination plant producing 6,000 m^3/d, is the largest to be completed in Gaza and is to be extended to produce 20,000 m^3/d to ultimately serve a population of 250,000 people. Seawater desalination remaining an energy intensive process, focus has been on identifying innovative means of generating and conserving energy to tackle the energy-water nexus, given the limited availability of electricity within Gaza. Advance renewable energy and energy recovery technologies have been incorporated to maximise the plant's viability. Such transformative technologies is essential to ensure that Gaza remains a liveable place in the years to come.

Purpose

The Gaza Strip (Figure 1) has an estimated population of around 2 million inhabitants, mostly urban with over of 97 percent connectivity to water networks. However, recent estimates indicate that 95 to 97 per cent of the water from the Coastal Aquifer in the Gaza Strip is now unfit for human consumption (WHO, 2016), and it is predicted that the damage to the Aquifer will be irreversible by 2020 (UN, 2012) if immediate action is not taken. Furthermore, the water supply is intermittent with water supplied for only 1.5 days per week on average.

The supply of fresh water to the population of Gaza depends overwhelmingly on the groundwater drawn from the Strip's Coastal Aquifer. The Coastal Aquifer basin stretches along the eastern Mediterranean coast from the northern Sinai Peninsula in Egypt, via the Palestinian Gaza Strip into Israel. As Gaza's population continues to grow at a steep annual rate of about three percent, a 2012 United Nations report (UNRWA, 2012) predicted that water demand would increase by 60 percent over eight years, to reach 260 million cubic metres in 2020. Historical records and observations indicate an annual average water deficit of 60 MCM between the groundwater exploitation and its recharge with over 180 million m^3 (MCM) extracted from the aquifer in 2014. As a result of the groundwater's over-exploitation, sea water intrusion, sewage, fertiliser and pesticide infiltration together with the natural soil conditions have had an adverse effect on ground water quality.

The only other source of potable water available to Gazans is through importation of bulk quantities from outside the Gaza strip. Gaza currently imports 5-10 MCM of potable water from Israel which is by no means a secure or reliable supply, particularly during periods of conflicts when it is most needed.

In 2011, a study carried out under the Gaza Emergency Technical Assistance Programme (GETAP) referred to as the Comparative Study of Options – Gaza (CSO-G) identified medium and long term measures to address the water crisis. Among the strategic interventions recommended, construction of three Seawater Desalination Plants (SDP), also referred to as Short Term Low Volume (STLV) have been identified as the key interim intervention to provide urgent relief and implemented within a short term with a relatively low volume until a large scale desalination plant, referred to as the Gaza Central Desalination Plant (GCDP) is implemented. This paper aims to discuss and elaborate the need for such a technically advanced intervention as a means of providing this basic human need through the municipal water system, despite the poor economic conditions and significant constraints faced within the context of Gaza. It also aims to discuss the process, challenges and opportunities presented during the construction of this complex SDP project, which is also the largest of this magnitude to be implemented in the Gaza strip in recent times.

Figure 1. Israel, West Bank and Gaza

Source: UN OCHA Palestine 2016

Literature and experience review

The quality of the ground water extracted has deteriorated steadily over the years with over 95% of the water no longer considered fit for human consumption. Chloride levels of water extracted from the Coastal Aquifer in over 80% of the area is often over 8 times, while Nitrates levels in areas in the southern part of the strip is over 5 times the WHO guideline levels (WHO, 2006).

Over 150 small capacity brackish water desalination plants operate within the Gaza strip with just around 25 operated by public the utility authorities and the remainder by commercial operators which are largely unregulated. The brackish water desalination plants continue to exacerbate the deterioration of the Coastal Aquifer, the only naturally available source of fresh water for Gazans. Following successful intervention by UNICEF to install over a dozen small capacity ($50m^3/h$ to $50m^3/d$) brackish water desalination plants, UNICEF embarked on the construction of Gaza's so far largest seawater desalination plant, in line with the PWA's adopted strategy to implement three SDPs, totalling 35,000 m^3 of daily production, as an urgent interim measure. The three SDPs (Figure 2) consist of the $20{,}000m^3/d$ Southern Gaza SDP, North Gaza SDP to produce $10{,}000m^3/d$ and the Middle Gaza SDP with a $5{,}000m^3/d$ capacity. The longer term Gaza Central Desalination Plant (GCDP) is planned for implementation in two phases to produce a total of 110 MCM of desalinated water annually, with 55MCM/year (150,000 m^3) daily during each phase.

The first phase of the Southern Gaza SDP (SG-SDP), has now been completed to produce 6,000m3/day and is in the process of being extended to produce its full capacity of 20,000m3/d (Figure 3).

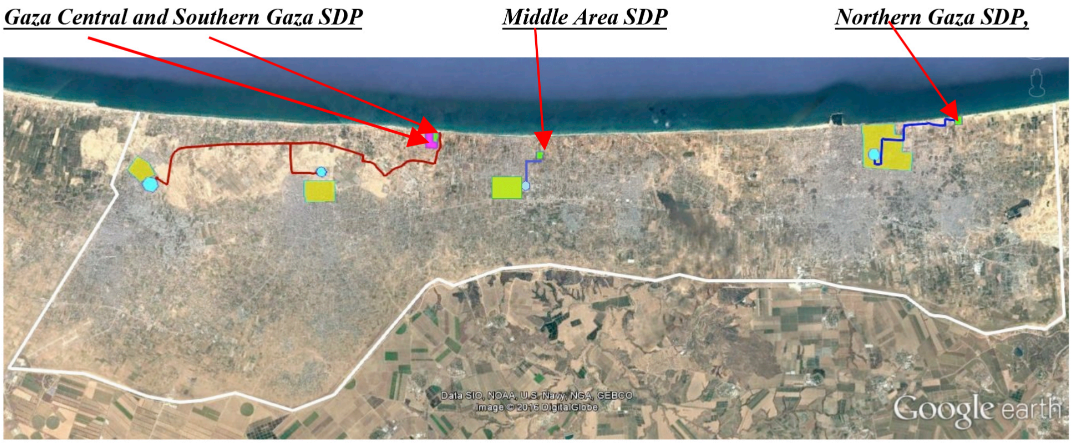

Figure 2. Location of Seawater Desalination Plants (SDP) in the Gaza Strip

Source: CMWU, Gaza, Palestine

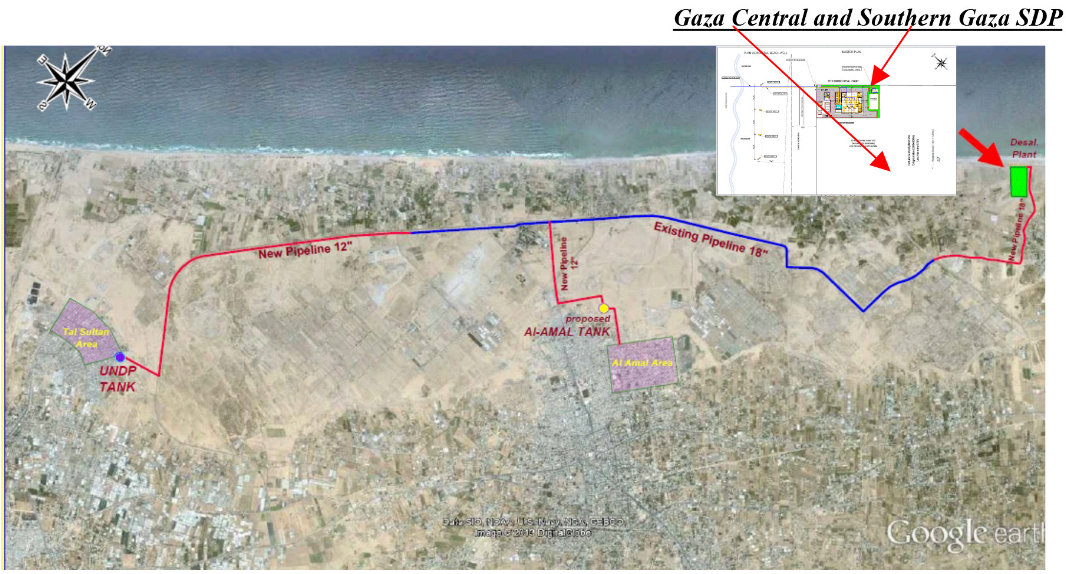

Figure 3. Southern Gaza SDP on corner of Gaza Central Desalination Plant (GCDP) site and Water Supply zones for phase 1 SG-SDP project

Source: CMWU, Gaza, Palestine

Strategy and implementation

The European Union (EU) finalised a Financing Agreement with the Palestine Authority and a Contribution Agreement with UNICEF to execute the first phase of the SG-SDP p project. The agreements embodied a Memorandum of Understanding between EU, UNICEF, The Palestine Water Authority (PWA) and the Coastal Municipalities Water Utility (CMWU) as the key stakeholder partners on the modalities and responsibilities for the implementation led by UNICEF.

A dedicated project management team was established at UNICEF to lead the project and work in close coordination with the key stakeholder partners. Joint committees between partners were set-up at various technical, management and strategic levels to ensure undertaking the implementation process jointly. Both the project owner, PWA and operator, CMWU, were an integral part of the decision making process at all levels and at each stage with CMWU also being a part of the onsite supervision and monitoring team during the construction stage.

A local engineering consultancy firm with an international joint venture partner was contracted to carry out feasibility investigations and preliminary design component.

An independent Environmental Engineering Consulting firm was also contracted to carry out an Environmental and Social Impact Assessment (ESIA), the recommendations of which were incorporated into the detailed/outline designs and bid documents produced.

The development of the tender/bidding aspects of the project were separated and progressed under 4 distinct contract packages based on the fields of specialisation, technical skills and resource requirements for each of the packages.

The four contract packages consisted of: i. Seawater desalination plant utilizing the Reverse Osmosis process and associated works; ii. The bulk desalinated water transfer pipeline. ; iii. Civil works; iv. Power supply and electrical works.

The main objective of adopting this approach was to enhance competitiveness for advancing cost efficiencies, risk reduction and ensuring closer financial control over respective packages, as well as introducing the concept of successfully managing critical interfaces between various contractors and packages jointly and collaboratively. The adopted method facilitated three out of the four contract packages to be completed in 2015 and the other in mid-2016, despite significant challenges faced with the importation of crucial materials into Gaza and the long and disruptive period of increased hostilities in summer 2014.

Results

In the absence of any other secure, viable potential for the sustainable provision of potable water, the desalination project has brought about a multitude of positive outcomes, foremost of which is the glimmer of ‘hope’ that Gaza could, still be a liveable place in 2020.

Innovations

Several innovative and environmentally sustainable initiatives during the planning, design and implementation stages of this project have been rigorously advocated and successfully implemented by UNICEF.

A package implementation strategy with critical interfaces between packages, were adopted for the first time in Gaza. Having witnessed the success and significant advantages on a project of this magnitude and complexity, the strategy is now being replicated elsewhere on similar projects.

During the feasibility/design stage, the selection of materials focused on assessing various alternatives not only considering their appropriateness, suitability, durability and environmental sustainability but most critically identifying materials permitted to enter into Gaza without being classified as restricted or prohibited dual use materials by the Israeli authorities.

Internationally tried and tested materials and techniques which are innovative and revolutionary to Gaza have been successfully introduced during the implementation of this project. Convincing partners to introduce High Density Poly-Ethylene (HDPE) pipes in preference to the traditionally used PVC or the import restricted steel and ductile/cast iron pipe materials has been a significant result in the advancement of pipeline construction in Gaza. This has led to partners specifying HDPE pipes as the preferred choice and local manufactures converting their production lines from uPVC to HDPE.

Introducing the use of close circuit television (CCTV) techniques to assess the condition of long disused existing pipelines for rehabilitation, has resulted in making use of available assets with significant cost savings.

Advocating and incorporating solar energy systems for this project, for the first time, has given the strength, courage and impetus for the ongoing transformation of Gaza’s landscape in the recent past. An off-grid solar energy system to sustain the entire needs of the operations and administration building was initially implemented which was subsequently extended to harness the maximum renewable energy potential at the site.

Energy and efficiency

A performance oriented design and build contractual modality to harness the latest energy efficient reverse osmosis seawater desalination technological advancements with inbuilt energy recovery systems was pursued. In the absence of high voltage electricity in Gaza, Variable Frequency Drives (VFD) have been introduced for the pumping system to further mitigate the energy requirements and to allow pumps to operate under medium voltage power supply. In line with industry standards, the performance efficiency of the plant was set at a maximum of 4kW per cubic meter of desalinated water. The modality adopted has facilitated enhancing the plant efficiency by over 5% of the set target, with the energy requirement for producing a cubic meter of desalinated water at less than 3.8kW.

Currently only 60% of the 400Mw of power required is available in Gaza. Over 50% of the avaible power is from Israel with 15% from Egypt and the reminder generated at the Gaza Power Plant (GPP) with fuel imported from Israel. (El Sheikh and Nigim, 2016) To mitigate impact on the grid power system, PV solar systems have been installed on roof of structures to generate up to 12% of the peak 1.2MW power requirement of the plant. A feasibility study has been conducted by the EU to further expand the share of renewable energy to up to 80%, with advances in technology and availability of funds (EU, 2016).

Project management

UNICEF and key partners worked as a joint team and formed the Project Steering Committee, Project Management Committee and Technical committees. The committees met periodically as defined within the memorandum of understanding between the project partners, to address strategic, progress and technical issues respectively.

A first-of-its-kind design and build contract format was introduced for the key contract package of the process plant, with a local contractor forming a joint venture partnership with a reputed international contractor. As a result, this helped to build the capacity of the local contractors to undertake similar complex projects with confidence in the future.

Construction management and monitoring

A four tier construction supervision and project monitoring mechanism involving the relevant stakeholder partners, engineering consultant and contractor was established to manage day to day activities during the construction stage of the project.

Engagement of the plant operator, CMWU in the construction supervision activities from the outset resulted in the operator taking full ownership of the plant.

Environment

The potential adverse environmental impact of the high carbon footprint and the discharge of effluent consisting of the hypersaline brine and waste discharges, have been substantially mitigated by optimizing the use of renewable energy as well as the installation of an off-shore sea outfall with a multiple seabed diffuser arrangement that enhance the dilution and dispersion of the discharged brine, which mitigates any significant impact as per the Computational Fluid Dynamics (CFD) model.

Costs and socio-economic impact

From the social impact assessment conducted for the project (EU/UNICEF, GVC 2013), it was evident that consumers paid exceptionally high prices of over $US 10/m^3 to purchase safe drinking water from private (mostly unregulated) vendors supplied through water tankers. This is not only a heavy burden on already impoverished families, but it also represents a health hazard; studies demonstrated that 72 percent of the population in Gaza depends on water that is contaminated in 68 percent of the cases (CEP, PWA, GiZ, 2015). In brief, unregulated drinking water supply in Gaza had compounded the households' economic situation further exacerbating poverty while contributing to poor health conditions; it had become a tool for poverty creation.

The cost of water production is around 0.7 USD/m^3 and pumping, mixing and distribution of water is around 0.2 USD/m^3. The tariff in the area is currently 0.3 USD/m^3 on average while the revenue collection efficiency is around 35% due to the social and economic situation, with many consumers currently failing to pay their water bills due to the current sub-optimal service level. With improvements to service levels, the water tariff as well as the collection rate will be increased under the newly established Water Sector Regulatory Council (WSRC) to ensure sustainability and phasing out current subsidies.

The consumers have, however, demonstrated their ability and willingness to pay provided the water services are of good quality. A public awareness campaign has thus been initiated to inform the beneficiary households about the high water quality standards they will benefit from thanks to the STLV to boost their willingness to pay and to improve the cost recovery. This project envisages the provision of safe water for drinking and domestic purposes through the distribution network, at less than 10% of the cost paid to unregulated vendors. It's envisaged, however, that upon delivery of adequate service level, consumers will be encouraged to pay the reasonable tariffs charged by the local water utility to generate the revenues that will ensure the desalination plant is operated and maintained sustainably.

Geo-political constraints

The change of the political environment in the Gaza Strip in 2006 culminated in the current blockade of Gaza with severe goods and movement restrictions imposed by both Israel and Egypt. The crossing points into Gaza have been restricted to one for goods and one for passenger crossing point with Israel. The only crossing point with Egypt has been closed since early 2015.

Against this backdrop, the management, monitoring and reporting of construction materials imported into Gaza is a tedious and onerous task that must be adhered to under the entry restrictions imposed by the Israeli Authorities operating under the purview of the Israeli Ministry of Defence. The material coordination process depends much on building confidence with the Israeli Authorities. Success in this area resulted in the project being permitted to import some of the hitherto prohibited materials such as sulphate resisting cement and epoxy paint.

Access restriction together with security and safety concerns have also limited the number internationally reputed consultants and contractors specialised in desalination technology participating in the competitive bidding processes. Restriction on the importation of advanced, appropriate and sustainable materials have forced substandard alternatives to be considered while encouraging innovative processes, non-traditional materials and arrangements to be considered in the design and construction processes.

Conclusions

The desalination project is a major first step towards addressing the acute water crisis in Gaza. The key objective of the project has been to mitigate the health and socio-economic impact on the population within the Gaza strip, over 50% of which are young people, children and infants. It is aimed at giving the vulnerable people of Gaza access to their most fundamental of human rights; safe drinking water at affordable prices considering their meagre disposable incomes.

A critical objective underpinning this seawater desalination plant project is to curb the rapid deterioration and total collapse of the Coastal Aquifer that serves not only the Gaza strip but also the adjacent areas and to mitigate a potential environmental and social catastrophe.

Where there are no easy solutions such as in the case of the Gaza strip, transformative technologies such as seawater desalination remains the only option available for even the most impoverished nations. Such technologies once considered as inappropriate or uneconomical, are being increasingly employed to address this life’s most basic need.

The plant will ensure that the water provided to the target communities meets minimum WHO drinking water quality guidelines and have access to at least 90 l/c/d of safe water for drinking and domestic purposes. This together with the extensive public awareness campaigns will advocate and promote the rational use of safe drinking water, and a gradual change in the mind-set to embrace the health and economic benefits of using water supplied through the municipal system, and promoting the payment of water bills.

The successful implementation of this project has become a catalyst for future projects of this nature, with significant donor interest in funding similar projects. The project has also facilitated the capacity building of the local partners to implement, operate and maintain water sector facilities of this complexity and magnitude in the future.

Recommendations and lessons learned

The most variable and potentially largest operational cost of the SG-SDP is energy related. The operator must thus continue to strive to minimize the plant’s energy cost by maximizing its energy efficiency and increase the share of renewable energy, along with parallel efforts to secure reliable energy supply from the grid. Rapidly advancing technologies in renewable energy should be utilised to its maximum potential to further transform this energy intensive process.

Efforts to reduce energy related costs must be further complemented by a significant improvements in cost recovery throughout Gaza’s water sector. The household level campaign initiated in mid-2016 is thus key to raise awareness about the rational use of the high quality water produced by the SG-SDP and the importance to pay water bills as the only way to sustain the plant’s operations and improve the quality of water services in Gaza. Transformative technologies in smart water metering and revenue collection processes will ensure the sustainability of desalination processes.

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