

CASE STUDIES

The Effect of Implementing the Integrated Management System in Desalination Plants in Conflict Zones: Case Study on the Gaza Strip

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Water scarcity is a global issue that has extreme effects on conflict zones in particular. Therefore, seawater desalination provided a practical solution to reduce the problem. The Gaza Strip suffers from potable water scarcity due to groundwater contamination and the deterioration of the coastal aquifers. Thereby, the Palestinian Water Authority (PWA) had constructed three seawater desalination plants (SDP's) in addition to purchasing potable water from the Israeli company (Mekorot). Due to the importance of the SDP's, a flexible and comprehensive management system is required to ensure the sustainability of the performance. Thereby, this study aims to assess the potentiality of applying the Integrated Management System (IMS) in seawater desalination plants. This study used data collected from reports, questionnaires, and interviews, which is then analysed statistically, in order to identify the effects and barriers of applying the IMS in seawater desalination plants. The data also was used in SWOT analysis to formulate strategies for applying the IMS. The reports showed that the physicochemical water quality of samples from seawater desalination plants is compatible with PWA and WHO standards. The results from the questionnaire showed that there are positive impacts of applying the IMS on the performance of the desalination plants in terms of the financial, administrative, technical, environmental, and socio-economic aspects. However, the study identified 12 barriers which were analysed through SWOT analysis to formulate strategies to facilitate the implementation of the IMS. The highest priority and most applicable strategy is the formation of a partnership with the UN institutions to obtain international protection and facilitate the entry of the required materials.

Keywords: Desalination; Seawater; Integrated Management System; Water quality; SWOT analysis

Introduction

The issue of water scarcity that results from the increasing global water demand accompanied by the decreasing clean water sources is one of the most pressing problems that requires increasing attention (Richter et al., 2013). The World Health Organization (WHO) warned that by the year 2025 half of the world will be living in water-stressed areas (WHO, 2017). A lot of people around the world are still suffering to gain access to clean water sources. In which the World Vision Organization (WVO) statistics from 1990 to 2015 showed that 2.6 billion people in developing countries have access to safe water, while around 844 million still suffer from water scarcity and two billion use water sources contaminated with faeces (WVO, 2018). The water scarcity issue is pushing people to use the available sources even though its contaminated, the WHO estimated the deaths from the lack of access to Water, Sanitation, and Hygiene (WASH) services to reach 829000 death/year (WHO, 2019). The world in general and water scarce com-

munities in particular focus their efforts on the conservation of the available water sources, maintaining a sufficient infrastructure, and developing their distribution systems.

Countries that are designated as conflict areas suffer from extreme water scarcity due to damage in the infrastructure and distribution systems along with the contaminated water sources (UNICEF, 2019). Palestine among many conflict areas suffer from long-term water scarcity due to the Israeli control over 90% of the water sources and inaccessibility to these sources (PWA, 2012). The Gaza Strip in particular is the most affected area due to many factors including the imposed siege and the continuous military attacks on the infrastructure. The citizens in the Gaza Strip depend on the coastal aquifers as the main source of water used for domestic, agricultural and industrial purposes.

The rainfall is the only feed source for these aquifers and the sustainable charging rate is estimated by the Palestinian Water Authority to reach 55 MCM/year (PWA, 2018). However, the excessive withdrawal caused the disruption of the aquifers as the domestic consumption exceeds the ability of the aquifers with a withdrawal of 90 MCM/year and it is estimated to exceed 200 MCM/year by the year 2030 (PWA, 2018).

The problem of water scarcity in the Gaza Strip is exacerbated by the wastewater leakage into the aquifers. And this leakage is the result of the direct disposal of untreated wastewater to the sea due to the inability of the wastewater treatment plants to operate sufficiently with the continuous electricity blackouts (CMWU, 2018). Almezan centre for human rights stated that 40% of the wastewater is pumped directly to the sea, and the detected pollution rate in the shore of the Gaza Strip reached around 75%, consequently 97% of the groundwater is considered unsuitable for human consumption (Almezan, 2018). The WHO related quarter of the diseases to water contamination and stated that it is responsible for many cases of child morbidity in the Gaza Strip (Efron et al, 2018).

Among the solutions to solve water scarcity issues in the Gaza Strip, three seawater desalination plants and many small-scale brackish water desalination plants had been constructed. In addition to a central seawater desalination plant that is planned to be constructed to provide 55 MCM/year in the first phase and to be extended to produce a total of 110 MCM/year after finishing the construction of the second phase (PWA, 2013).

The difficult situation in the Gaza Strip requires a flexible management system to ensure the sustainability of the projects. The Integrated Management System (IMS) had proven its efficiency and effectiveness in many desalination companies around the world. The IMS is defined by (Grow EQ) "An integrated management system (IMS) combines all related components of a business into one system for easier management and operations. Quality (QMS), Environmental (EMS), and Safety (OHSMS) management systems are the ones most often combined and managed as an IMS but you can integrate any of the ISO management system standards".

This study aims to evaluate the potentiality of applying the IMS in seawater desalination plants in the Gaza Strip, determine the possible barriers of its application and formulate different strategies to facilitate applying the IMS. Therefore, the research objective is to assess the potentials of applying the Integrated Management System (IMS) in seawater desalination plants in the Gaza Strip through assessing the sustainability of seawater desalination projects, assessing the potential benefits of applying the IMS in seawater desalination projects, and formulate strategies to integrate IMS in seawater desalination projects.

Study Area

The Gaza Strip is located on the eastern coast of the Mediterranean Sea with an approximate length of 42 km and width between 8-12 km to give a total area of 365 km² (Figure 1). The Palestinian Central Bureau of Statistics (PCBS) estimated the population in 2019 around two million (PCBS, 2019). The estimated population with the area of the Gaza Strip shows an overcrowded area, which is described among the most crowded areas in the world (Aufleger and Mett 2011).

The location of the Gaza Strip is in the transitional zone between the Sinai Peninsula that have an arid desert climate and the Mediterranean coast of the semi humid climate that affects the average temperature around the year. Whereas it ranges between 12–14 °C in the winter



Figure 1: The map of the Gaza Strip.

and 25–28 °C in the summer, the peak of the rainy season is in December and January (CMWU, 2012). The average rainfall ranges between 200–400 mm/year and the sustainable recharging rate of the coastal groundwater aquifer is 55 mcm/year. While the domestic use reaches around 90 mcm/year and the total use exceeds 170 mcm/year, the water withdraw massively exceeds the aquifers ability to sustainably recharge (PWA, 2018a).

Methodology

We used a case study approach to describe the case of water desalination projects in the Gaza Strip. The researcher used the analytical descriptive approach to describe the case, analyse the data, and distinguish the relationship between the components of the study.

Data related to the impact and barriers of applying the IMS in seawater desalination plants in the Gaza Strip were collected from over 30 professionals and consultants working in desalination projects in PWA, CMWU, and EPQ through an online questionnaire, as well as through desk evaluations. Also reports related to the physicochemical and, microbiological quality of the water desalinated by private and public plants were collected from the PWA and Ministry of Health (MOH). Furthermore, in-depth interviews had been conducted with two managers in CMWU, MOH, and a consultant to interpret and clarify some results of the questionnaire.

The data collected from the questionnaire and interviews were analysed to determine the sustainability of the established seawater desalination plants and what impact the IMS would cause to these plants. Then, a SWOT analysis technique had been used to analyse and compare the current situations and future possible scenarios of applying the IMS in seawater desalination plants in the Gaza Strip. In which, the SWOT analysis was used to determine the internal/external factors related to applying the IMS in seawater desalination plants in the Gaza Strip using the evaluation

of the interviewed managers. The analysis was followed by designing an Internal Factors Evaluation Matrix (IFEM) and External Factors Evaluation Matrix (EFEM) to formulate the strategies, which are evaluated and prioritized through the quantitative strategic programming matrix (QSPM).

Case Study Description

Water Status in the Gaza Strip

The Gaza Strip depends on the coastal groundwater aquifer system which is fed primarily by the rainfall, and the continuous excessive withdrawal of the groundwater led to massive damage of the aquifers along with seawater intrusion into the coastal aquifer that result in an increase in the salinity, nitrates and chloride concentrations (Efron et al., 2018). The concentration of nitrates in the coastal aquifer ranges between 100-800 mg/L, and chloride concentrations range between 800–4000 mg/L depending on the depth of the well (PWA, 2018a). The WHO released a warning that the nitrate and chloride concentrations in the Gaza Strip violates the safe standards as they exceed the maximum safe levels which are 50 mg/L for nitrates and 250 mg/L for chloride (WHO, 2017; WHO, 2014). Therefore, citizens in the Gaza Strip depend on many primary sources of drinking water, with most of their dependence is on the purchased water from water vendors, along with other sources like humanitarian aids from local and international institutions and private wells (Ismail, 2003).

Waterborne Health Crisis in the Gaza Strip

The groundwater contamination along with the disposal of the untreated wastewater to the sea is causing many adverse effects on people health in the Gaza Strip in which 26% of the diseases are caused by water contamination (Efron et al., 2018). The reported diseases result from chemical and biological contaminants, whereas the chemical contaminants come from the seeping of the wastewater and the agricultural run-offs into the groundwater, which increase the chloride and nitrate concentrations (Efron et al., 2018). The high concentrations of chloride can cause corrosion of the pipelines and react with the metals to release soluble salts that is considered toxic in high levels. While the high concentrations of nitrate can cause methemoglobinemia, known as the blue baby syndrome, to infants of age under six months (Eran et. al., 2014). The problem of low water quality and quantity was partially solved by constructing several small-scale brackish water desalination plants, three seawater desalination plants, and purchasing potable water from the Israeli water company (Mekorot).

Water Desalination Plants in the Gaza Strip

According to the PWA report released in 2016, the total number of brackish water desalination plants in the Gaza Strip is 286 with different capacities, technologies and locations as shown in **Figure 2** (PWA, GVC, and UNICEF, 2017).

The increasing number of desalination plants reflects the increasing needs for clean water. However, the report showed that 79% of the plants are unlicensed, 68% are pH outrange, 38% were detected violating the Standards of water quality and are not disinfected, all these problems are due to the political differences that hinder the ability to monitor all the plants.

The MOH makes regular tests on samples taken from different desalination plants to keep monitoring their performance, and the results showed that many desalination plants do not meet the standards set by the PWA and MOH. **Table 1** shows the results of bacteriological analysis of desalinated water samples taken from different brackish water desalination plants in the five governorates.

Many of the tested water samples contain Total Coliform (TC) and Faecal Coliform (FC), which pose serious health problems. Also, the physicochemical characteristics of desalinated water in different private desalination plants had been tested regularly, and the results showed many violations of the WHO and PWA water quality standards in which the pH in many samples was below or higher than the accepted levels. Additionally, the Electrical Conductivity (EC) and nitrates levels exceeded the recommended levels stated by both the PWA and WHO. **Table 2** shows the physicochemical water quality in samples collected by the Ministry of Health from 164 desalination

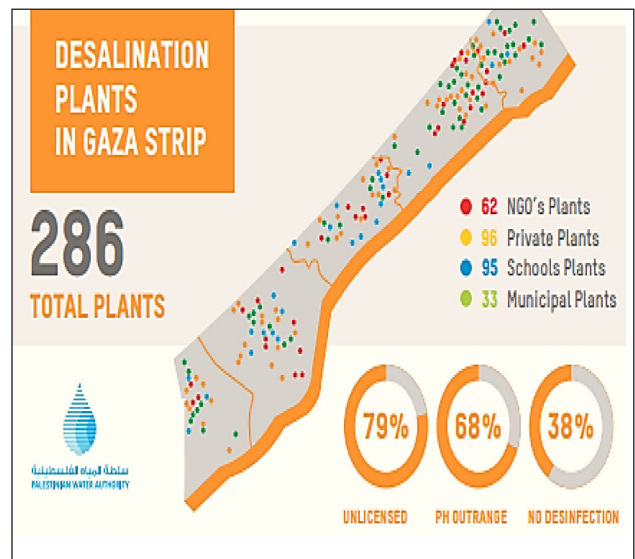


Figure 2: Desalination plants in the Gaza Strip (source: PWA, GVC, and UNICEF, 2017).

Table 1: Results of bacteriological analysis of desalinated water (MOH, 2020).

Governorate	No. of samples	No. of samples contaminated with		% of contamination	
		T-Coli.	F-Coli	T-Coli	F-Coli
North Gaza	127	9	0	7	0
Gaza City	97	13	0	13	0
The Middle area	91	10	5	11	5
Khanyonus	120	14	2	12	2
Rafah	44	10	0	23	0
Total	479	56	7	12	1

Water is considered contaminated if it contains T-Coliform > 4 microbes/100ml.

Water is considered contaminated if it contains F-Coliform > 4 microbes/100m.

Table 2: Physicochemical water quality of desalination plants (RO) and the standard levels by WHO & PWA.

Parameters	Mini- mum	Maxi- mum	Average	WHO	PWA
pH	4.95	9.62	6.61	6.5–8.5	6.5–8.5
TDS (mg/l)	9	436	88.46	1000	1500
EC	17	704	158.29	400	400
Cl ⁻ (mg/l)	3	169	31.25	250	600
No ₃ ⁻ (mg/l)	1	62	84.45	50	70

plants (RO) in the five governorates and the standard levels stated by WHO and PWA.

The increasing number of private desalination plants increases the stress on groundwater along with the low water quality produced by many private desalination plants, thereby the PWA had constructed three Seawater Desalination Plants (SDP's) in three different governorates with a total capacity of the three plants 35,000 m³/day (UNICEF, 2018). The southern Gaza SDP was constructed with a capacity of 6,000 m³/d in the first phase, and is planned to reach a total capacity of 20,000 m³/d in the second phase of construction. The Northern Gaza SDP was constructed to produce 10,000 m³/d, while the middle Gaza SDP produces 6,000 m³/d (UNICEF, 2018). The three SDP's have common characteristics including the use of the Reverse Osmosis (RO) technology, 40–45% recovery rate, the overall energy consumption is around 4 Kwh/m³, the feed water is withdrawn from beach wells through using pressure pumps, and it has a Total Dissolved Solids (TDS) value about 40,000 ppm (CMWU, 2019).

A strategic plan set by the PWA and many other international institutions had been approved to construct Gaza Central Seawater Desalination plant (GCDP) with a total capacity of 110 MCM/year which is expected to cover the needs of two million citizens while enable the coastal aquifers to sustainably recharge and recover, and improve the economic development (PWA, 2014). The first phase of the project will produce 55 MCM/year, and reach the total capacity when finish constructing the second phase (UfM, 2011). The plan also includes the use of solar and wind energy to provide the plant with 15.1% of energy requirements (PWA, n.d.). The GCDP plan implementation is accompanied by Associated Works (AWs) which include constructing a north-south conveyance system with storage tanks, and lines to blend the desalinated water with groundwater, in addition to a Non-Revenue Water (NRW) reduction strategy to increase the efficiency of revenue collection to 80% (PWA, 2014; PWA, n.d.).

The Cost of Seawater Desalination per Cubic Meter

The costs of the desalination depend on many factors including the plant's capacity, the quality of the feed water, the desalination technology used, the costs of energy consumption, capital cost, and the location of the plant (Ismail, 2003). The desalination process consumes high energy, which is responsible for 60% of the total desalination costs (Zotalis et. al, 2014). The cost of seawater desalination/m³ in the Gaza Strip is around 3.3 NIS/m³

equivalent to 0.95 US\$/m³ (CMWU, 2020), while the water tariff/m³ is 1.8 NIS according to the Water Sector Regulatory Council (WSRC). However, the low water tariff is not enough to cover operations and maintenance (O&M), which increases the financial burden on the municipalities (World Bank, 2018).

Brine Management in the Gaza Strip

The desalination process produces two streams, the desalinated water and the concentrate, known as the brine, that contain concentrated levels of inorganic salts and chemicals (Lattemann and Hopner, 2008). The amount of the produced brine exceeds the desalinated water due to the low recovery rate and low feed water quality (Jones et. al, 2018). The physical and chemical composition of the brine causes many environmental problems especially in the site of discharge (Lattemann, 2010). Therefore, the sufficient brine disposal technique is essential for maintaining sustainable desalination processes. In the Gaza Strip, the brine disposal technique applied is the direct disposal to the sea through pipelines with diffusers as it is the most economically, environmentally, and technically feasible option (Mogheir and AlBohissi, 2015). Furthermore, many studies recommend mixing the discharged brine with treated wastewater to dilute it before discharging to the sea (Katal et. al, 2020).

Results and Discussion

The Impact of Applying the Integrated Management System on the Performance of Seawater Desalination Projects

The results of the questionnaire showed that applying the IMS in seawater desalination plants in the Gaza Strip would have positive impact on the financial, administrative, technical, environmental, and socio-economic performance. In which, the respondents unanimously agreed on the ability of the IMS in reducing the operational costs, improving the efficient use of funds, and increasing the profits. As well as, the improvement of the efficient use of resources, enhancing the requirements performance index, improving the project's durability and the project's life cycle, reducing and controlling office documents, ensuring the achievements of the desalination's projects vision, mission and strategic objectives, and improving the communications between departments.

Regarding the technical aspects, the respondents also agreed on the ability of the IMS in improving the quality of water physically, chemically, and biologically, increasing the volume of the produced water, using the Best Available Technology (BAT), and the continuous improvements in the operations following the situation in the Gaza Strip. Also, the there was a major agreement on the positive environmental effects represented by reducing the stress on the marine environment by a better brine management, reducing the chemical discharges, reducing the emissions of polluting gases such as GHG to the atmosphere, and reducing the overall energy consumption. Finally, the respondents also agreed on the ability of the IMS in improving the socio-economic conditions in the Gaza Strip through reducing the risks of accidents that result from fuel storage and transport. In addition to increasing the

access to clean water, increasing the satisfaction of the workers in the seawater desalination plants, improving the economic growth, preserving the natural water resources, and improving water usage and reducing its wastage.

However, applying the IMS in the Gaza Strip would face many barriers due to the sensitive situation; these barriers were summarized as follows:

1. The commitment of management
2. The lack of sufficient experience
3. The differences in the needs of workers, investors, and citizens.
4. The lack of knowledge and training among employees and management.
5. The existence of more important priorities.
6. The lack of awareness and concern about the importance of applying the system.
7. The existence of complexities and differences in the management systems between The Gaza Strip and the West Bank.
8. The blockade imposed on the Gaza Strip affects the entrance of the required materials.
9. The electricity blackout that results from the shortage of fuel.
10. The lack of funding and resources.
11. The political instability in the Gaza Strip.
12. The continuous Israeli attacks that cause the destruction of the infrastructure.

Analysing the SWOT Matrix

SWOT analysis is one of the simplest tools to evaluate the current situation of the organization represented by the strengths and weaknesses, and the future scenarios represented by the opportunities and threats. The analysis provides an insight to develop a business plan and formulate strategies to overcome the weaknesses and threats. In this study, the data obtained from the questionnaire and interviews were used as inputs to determine the strengths, weaknesses, opportunities, and threats of applying the

IMS in seawater desalination plants, and the SWOT analysis matrix is shown in **Table 3**.

Designing an External and Internal Factors Matrix (IFEM and EFEM)

After analysing the internal factors and the external environment, the internal and external factors that affect applying the IMS in seawater desalination projects in the Gaza Strip. Based on the managers' opinions, each factor was evaluated by giving a weight and a rank to calculate the score of each factor and ultimately the total score for both internal and external factors.

External factor evaluation (EFE) matrix is a management tool used to evaluate and prioritize the opportunities and threats that hinder the business achievements. Riston (2008) summarized the benefits of the EFE matrix by:

1. Increase the attention to the environment surrounding the business.
2. Enhance decision making related to resources allocation.
3. Improve risk management processes.

Internal factor evaluation (IFE) is a management tool that focus on the evaluation of the internal environment. IFE and EFE were used in integration to evaluate the internal and the external conditions and determine the highest influencer on the potentiality of applying the IMS in seawater desalination projects. From the results shown in **Table 4**, the IFE and EFE equals 2.79 and 2.55, respectively.

Formulating TOWS Strategic Alternative Matrix

SWOT analysis is the basic step toward the formulation of strategies. The TOWS strategic alternatives matrix relates the Strengths and weaknesses with opportunities and threats to formulate four strategies that focus on the following:

1. SO strategies: focus on using the Strengths of the IMS by utilizing the opportunities.

Table 3: SWOT analysis matrix.

Strengths	Weaknesses
<ol style="list-style-type: none"> 1. IMS contributes in many economic benefits in terms of reducing costs, increasing profits, sufficient use of funds, and enhanced project's durability and achievements. 2. Enhances the technical aspects of the project. 3. Provides a socio-economic viable project. 4. Increases the environmental considerations of the project. 5. Provides an effective communication between the departments. 6. Emphasizes more considerations for the public and employees' health and safety. 	<ol style="list-style-type: none"> 1. Lack of experience and knowledge among the management and employees. 2. Requires operational capacity building and training. 3. The public outreach and education usually start after the operation starts. 4. The lack of commitment of the management. 5. Internal political influence on the project's management.
Opportunities	Threats
<ol style="list-style-type: none"> 1. The increases of the market share. 2. Multiple stakeholders are motivated to participate. 3. Builds people's trust in the project. 4. Technological advancements and processes innovation. 5. International grants that aim to develop the water sector in the Gaza Strip. 	<ol style="list-style-type: none"> 1. The differences in the needs of workers, investors, and citizens. 2. The blockade imposed and the subsequent effects from limited entrance of materials and fuels. 3. The political instability in the Gaza Strip. 4. The differences between the managements in the Gaza Strip and the West Bank. 5. The continuous Israeli attacks that cause the destruction of the infrastructure.

- 2. WO strategies: focus on reducing the weaknesses that face the application of the IMS by utilizing the opportunities.
 - 3. ST strategies: focus on using the strengths to overcome the threats.
 - 4. WT strategies: focus on addressing the weaknesses that will make the threats possible to occur and minimize their impacts.
- The four categories of strategies are summarized in **Table 5**.

Table 4: IFE & EFE Matrix.

Internal factors		Ave. weight	Normalized Ave. Weight	Ave. rating	weighted score
Strengths	IMS contribute to many economic benefits in terms of reducing costs, increasing profits, sufficient use of funds, and enhanced project's durability and achievements.	0.157	0.149	3.67	0.55
	Enhance the technical aspects of the project.	0.067	0.063	3	0.19
	Provide a socio-economic viable project.	0.087	0.082	3.67	0.301
	Increase the environmental considerations of the project.	0.047	0.044	3.33	0.148
	Provide an effective communication between the departments.	0.12	0.114	4	0.46
	Emphasize more considerations for the public and employees' health and safety.	0.083	0.079	4	0.32
Total		0.56	0.53		1.95
Weaknesses	Lack of experience and knowledge among the management and employees	0.1	0.095	2	0.19
	Require operational capacity building and training	0.16	0.152	2	0.304
	The public outreach and education usually start after the operation starts.	0.033	0.032	1	0.032
	The lack of commitment of the management.	0.097	0.092	1.67	0.153
	Internal political influence on the project's management	0.103	0.098	1.67	0.164
	Total		0.49	0.47	–
Total weighted score		1.053	1	–	2.79
External factors		Ave. weight	Normalized Ave. Weight	Ave. rating	Weighted score
Opportunities	Increase the market share of the project	0.133	0.107	3.33	0.36
	Multiple stakeholders are motivated to participate	0.117	0.094	3.67	0.34
	Build people's trust in the project	0.043	0.035	3	0.105
	International grants that aim to develop the water sector in the Gaza Strip	0.15	0.121	4	0.48
	Technological advancements and processes innovation	0.08	0.064	3	0.193
	Total		0.52	0.42	
Threats	The differences in the needs of workers, investors, and citizens.	0.077	0.062	1.33	0.082
	The blockade imposed and the subsequent effects from limited entrance of materials and fuels	0.167	0.134	2	0.27
	The political instability in the Gaza Strip	0.15	0.121	2	0.24
	The differences between the managements in the Gaza Strip and the West Bank	0.177	0.142	1.67	0.24
	The continuous Israeli attacks that cause the destruction of the infrastructure	0.15	0.121	2	0.24
	Total		0.72	0.58	–
Total weighted score		1.243	1	–	2.55

Table 5: TOWS strategic alternative Matrix.

Strengths		Weaknesses
Opportunities (SO)	<ul style="list-style-type: none"> Follow a cost leadership strategy* to expand market share and obtain grants from donor institutions to implement projects Promote effective communication to establish partnerships with the public and private sector, increase stakeholder participation and improve public confidence in projects. Increasing interest in technical considerations to encourage innovation 	<ul style="list-style-type: none"> Establish a capacity development program. Enhancing internal communication to enhance the generation, transfer and sharing of knowledge and experience among employees Improve the technical aspects and the effective communication to enhance the commitment of senior management and to reduce the negative internal political influence on project management.
Threats (ST)	<ul style="list-style-type: none"> Gradual shift from electricity to renewable energy. Promote effective communication to analyze and meet the needs of employees, investors and citizens Using part of the profits in the process of purchasing materials and fuel needed for projects in advance to avoid cases of closing the crossings Establish effective communication with the relevant authorities in Gaza and Ramallah to avoid conflicts between the authorities that might confuse the project. 	<ul style="list-style-type: none"> Building effective partnership and communication with UN institutions to obtain UN protection for projects against targeting the occupation and facilitate the process of bringing the necessary materials into the Gaza Strip Enhancing the interest and capabilities of senior management by applying risk management methodology.

***Cost leadership strategy:** A strategy in which the project's costs be at a minimum and it is the lowest among the projects that are implemented in the market by advanced technology and methods, which contribute to increasing the profits and a greater margin for competition and winning bids (Swamidass, 2002).

Designing a Quantitative Strategic Planning Matrix (QSPM)

The Quantitative Strategic Planning Matrix (QSPM) is a management tools that is used to prioritize the strategies in order to choose the best applicable strategies. Each key factor is given an Attractiveness Score which is multiplied by its weight in order to obtain the Total Attractiveness Score (TAS) for each factor and the sum of all TAS (STAS) is used to determine the priority of the strategy. Based on the results, the highest priority strategies were:

- WT1: Building effective partnership and communication with UN institutions to obtain UN protection for projects against targeting the occupation and facilitate the process of bringing the necessary materials into the Gaza Strip.
- ST3: Using part of the profits in the process of purchasing materials and fuel needed for projects in advance to avoid cases of closing the crossings.
- WT2: Enhancing the interest and capabilities of senior management by applying risk management methodology.
- ST4: Establish effective communication with the relevant authorities in the Gaza Strip and Ramallah to avoid conflicts between the authorities that might confuse the project.
- SO1: Follow a cost leadership strategy to expand market share and obtain grants from donor institutions to implement projects.

Conclusion

The desalination of seawater is becoming a worldwide adopted technique to cover the fresh water needs around

the world especially in the Gaza Strip and other conflict areas that suffer massively from fresh water shortfall. The excessive withdrawal of the groundwater caused massive deterioration of the aquifer's quality and the ability to sustainably discharge. Thereby, the seawater desalination plants are providing a solution for regenerating the coastal groundwater aquifers. The management of the seawater desalination plants is critical for the success and continuity of the projects', in which the IMS is able to provide a sustainable method to improve the performance of the SDP's in the Gaza Strip. However, the implementation process would face many barriers, which can overcome by the following strategies based on the study results:

- Building effective partnership and communication with UN institutions to obtain UN protection for projects against targeting the occupation and facilitate the process of bringing the necessary materials into the Gaza Strip.
- Using part of the profits in the process of purchasing materials and fuel needed for projects in advance to avoid cases of closing the crossings.
- Enhancing the interest and capabilities of senior management by applying risk management methodology.
- Establish effective communication with the relevant authorities in Gaza and Ramallah to avoid conflicts between the authorities that might confuse the project.
- Follow a cost leadership strategy to expand market share and obtain grants from donor institutions to implement projects.

Abbreviations

CMWU	Coastal Municipalities Water Authority
EFEM	External Factors Evaluation Matrix
EMS	Environmental Management System
EQA	Environmental Quality Agency
GCDP	Gaza Central Desalination plant
IFEM	Internal Factors Evaluation Matrix
IMS	Integrated Management System
MCM	Million Cubic Meter
MoH	Ministry of Health
OHSMS	Occupational Health and Safety Management System
PCBS	Palestinian Central Bureau of Statistics
PWA	Palestinian Water Authority
QMS	Quality Management System
QSPM	Quantitative Strategic Planning Matrix
SDP	Seawater Desalination Plants
TDS	Total Dissolved Solids
UN	United Nations
UNICEF	United Nations International Children's Emergency Fund
WASH	Water, Sanitation, and Hygiene
WHO	World Health Organization
WVO	World Vision Organization

Additional Files

The additional files for this article can be found as follows:

- **Appendix 1.1.** The results of the Impact of the Integrated Management System in desalination projects. DOI: <https://doi.org/10.5334/fce.119.s1>
- **Appendix 1.2.** The barriers of applying the integrated management system in seawater desalination projects. DOI: <https://doi.org/10.5334/fce.119.s2>

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Further Research

This study had come out with many strategies for applying IMS in seawater desalination plants in the Gaza Strip, and further studies to evaluate the most applicable strategies and the methods of their application is required.

Competing Interests

The authors have no competing interests to declare.

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