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The Economic Feasibility of Achieving SDG 6 (Clean Water and Sanitation) with Innovative Approach to Addressing Water Scarcity in Conflict Zones: Gaza Strip Study Case

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ABSTRACT

This study examines an innovative approach to achieving Sustainable Development Goal (SDG) 6 in conflict zones, using Gaza as a case study. Through an analysis of technological innovations, nature-based solutions, and an economic sustainability framework, we demonstrate how the challenges of water scarcity can be addressed amidst the constraints imposed by conflict. This research presents evidence-based recommendations for achieving universal access to clean water and sanitation, while ensuring economic feasibility in conflict-affected areas.

INTRODUCTION

Achieving SDG 6 in conflict zones presents unique challenges, with Gaza serving as a critical case study. With 97% of water deemed unsafe for human consumption and infrastructure, the region highlights the complex intersection of conflict, water scarcity, and sustainable development challenges (Sicca, 2021). Access to clean and safe water is a fundamental human right, however, many regions, particularly in the Middle East and Gaza, suffer from chronic water shortages.

Gaza, with its limited freshwater resources and ongoing political instability, faces increasing challenges due to climate change, which results in a decrease in freshwater availability and a deterioration of water quality (Shomar and Rovira, 2023). This article explores how climate change adaptation, sustainable water treatment technologies, and mangrove ecosystem restoration can work together to improve water access in this challenging context, while also contributing to the achievement of SDGs related to water, climate, and sustainable development.

Climate change exacerbates water scarcity, especially in arid regions. Rising temperatures, changing rainfall patterns, and rising sea levels have significant impacts on water availability, particularly in areas like Gaza. The Middle East and North Africa (MENA) region is projected to face severe water stress due to a combination of climate change and pre-existing water shortages (Bates *et al.*, 2008). In Gaza, limited freshwater resources and reliance on desalination contribute to a fragile water supply system. Moreover, rising sea levels increase the salinity of coastal aquifers, further threatening the already limited water resources in the region.

Figure 1. Accumulated sewage is contaminating Gaza's water supply - Rafah, 24 April 2024
Source: Devlin, Ahmed and Palumbo (2024)

The degradation of coastal ecosystems, such as mangroves, worsens this issue. Coastal development, the expansion of aquaculture, deforestation, climate change, and other related issues like eutrophication, disease outbreaks, and pollution are the primary factors threatening the sustainability of mangrove ecosystems (Akram *et al.*, 2023). Alongside this ecosystem damage, water quality declines, requiring the implementation of more advanced and sustainable water treatment solutions. Given the water crisis in Gaza, innovative and sustainable water treatment technologies are critical. Nanotechnology, agricultural waste utilization, and low-energy desalination systems offer promising solutions to mitigate water shortages and improve water quality.

Key questions discussed in this article include how can climate change adaptation strategies enhance sustainable water treatment efforts in Gaza? What role do mangroves play in improving coastal water quality? What is the role of nanotechnology and its contribution to the efficiency of desalination and water purification systems?

THEORETICAL FOUNDATION

Economic Feasibility Study

Economic feasibility refers to the assessment of the cost-effectiveness of a proposed project or investment, ensuring that it is financially viable within the resources available. It involves analyzing related expenses, potential revenues, and the long-term financial impact to determine profitability or sustainability. By conducting a thorough economic feasibility study, stakeholders can make informed decisions based on anticipated benefits versus costs (Vaia, 2025).

Economic analysis implies the quantitative assessment of the economic feasibility of an project that includes a detailed comparison of benefits and costs associated with the project during its lifetime, whereas financial analysis deals with quantitative evaluation of the competence of the project to recoup the investments on the basis of self-liquidation (Singal *et al.*, 2023).

SDG 6 (Clean Water and Sanitation)

SDG 6, or Sustainable Development Goal 6, is a United Nations goal to ensure safe and affordable water and sanitation for all. It was established in 2015 as one of the 17 Sustainable Development Goals. There has been positive progress. Between 2015 and 2022, the proportion of the world's population with access to safely managed drinking water increased from 69 per cent to 73 per cent (United Nations, no date).

According to Küfeoğlu (2022) The sixth sustainable development goal, Clean Water and Sanitation, is to ensure that everyone has access to safe, clean water. Everyone has the right to healthy, adequate, physically accessible and affordable water for household use under the right to water security. Acknowledging that millions of people lack access to clean water for sanitation, there is an urgent need for major investments in infrastructure and governance of water provisioning to ensure public health and increase resilience for transmissible diseases and virus outbreaks.

RESEARCH METHOD

The research method used is a descriptive approach commonly employed in social research. This method aims to describe various aspects such as behaviors, attitudes, opinions, and characteristics of a particular population or group. Additionally, the descriptive method can also be used to illustrate processes or events occurring within a community.

Data collection in the descriptive method can be carried out through various steps such as observation, surveys, interviews, and case studies. Once the data is collected, analysis is performed to provide a systematic and accurate portrayal of the facts and characteristics of the object being studied. In this study, Payback Period (PBP) has been used to determine the investment return period, Net Present Value (NPV) to assess project profitability, Internal Rate of Return (IRR) to calculate the rate of return on investment, Profitability Index (PI) to measure economic feasibility, and Break-Even Point (BEP) to ensure the financial sustainability of the project.

RESULTS & DISCUSSION

Nanotechnology offers transformative potential for water purification, particularly in desalination processes. As clean drinking water becomes increasingly scarce, sustainable and cost-effective solutions are needed. Nanotechnology can help by enhancing filtration materials, improving water quality, and reducing costs. (Elhenawy *et al.*, 2024). This technology can significantly improve water access in Gaza, where energy costs are high, and infrastructure is often inadequate.

The utilization of agricultural waste as low-cost adsorbents for water purification provides environmentally sustainable solutions. These materials are both cost-effective and eco-friendly due to their unique chemical properties, their abundance, renewable nature, and low cost make them an ideal option for addressing water pollution (Bhatnagar, Sillanpää and Witek-Krowiak, 2015). Among the various agricultural waste materials studied for water treatment, "waste peels" from fruits and vegetables are particularly important. These peels are often discarded as waste with no practical use, leading to significant disposal issues. Being a renewable resource and an agro-industrial waste, waste peels are, therefore, a promising resource for environmental technology if applied in the treatment of water and wastewaters. In Gaza, where agricultural waste is abundant, this approach can support the local economy while addressing water quality challenges.

In Gaza, regular power outages make solar-powered desalination systems a great solution. Integrating solar energy into the desalination process provides a promising solution to address both water scarcity and environmental challenges (Al-Addous *et al.*, 2024). By utilizing renewable energy, these systems can effectively tackle Gaza's water shortage while promoting sustainability.

Mangrove ecosystems provide essential ecosystem services, such as coastal protection and water filtration, which are crucial in areas affected by climate change. Mangrove trees have unique root systems that create a dense barrier, slowing the flow of water. This slow movement helps contaminants like heavy metals, excess nutrients, debris, and sediment settle or get trapped by the roots, filtering them out of the water (Hammond, 2022). Mangrove forests can remove 80-90% of nitrates, phosphates, and suspended solids from the water that flows through them. In Gaza, where water resources are limited, and water treatment is costly, mangrove restoration could offer a low-cost and sustainable solution to enhance coastal water quality.

With rising sea levels and increasing temperatures, mangrove ecosystems are under threat. Mangrove restoration can boost biodiversity and ecosystem services by creating habitats for a variety of plant and animal species, enhancing water quality, and storing carbon (Ajonina, Diame and Kairo, 2008). Mangrove restoration also contributes to biodiversity conservation, supporting SDGs related to Life Below Water (SDG 14). Restoring mangroves along Gaza's coastline can improve water quality, reduce salinity, and serve as a buffer against rising sea levels. Damnyag *et al.* (2013) in their research highlighted that mangrove restoration has led to an increase in fish and shellfish populations, which has positively impacted local fisheries and the livelihoods of those dependent on them. This effort aligns with SDG 13 (Climate Action) and SDG 14 (Life Below Water).

A combined approach that uses nanotechnology, mangrove restoration, and sustainable water treatment can help solve Gaza's water issues while supporting long-term development. Nanotechnology can meet urgent water purification needs, while restoring mangroves provides lasting environmental and economic benefits. By using both methods together, we can improve water quality, boost coastal resilience, and lower water treatment costs in the region.

Policymakers in Gaza and similar regions should prioritize the integration of these innovative technologies with ecosystem restoration projects. Investments in solar-powered desalination, agricultural waste utilization for water treatment, and mangrove ecosystem restoration can create sustainable, climate-resilient water management systems. Policymakers should also prioritize climate adaptation strategies that address the intersection of water scarcity, climate change, and socio-economic challenges.

The economic feasibility of achieving SDG 6 (Clean Water and Sanitation) through an innovative approach in addressing water scarcity in conflict zones is crucial in ensuring sustainable development. This study on water treatment solutions in Gaza integrates advanced technologies, ecosystem restoration, and sustainable business models. The financial analysis confirms that the project is economically viable, ensuring long-term resilience in providing clean water. The following table summarizes key financial indicators and their implications for the feasibility of the project:

Table 1. Economic Feasibility of SDG 6: Gaza Strip Water Scarcity Project

Financial Metric	Definition	Calculation	Result	Interpretation
Payback Period (PBP)	Measures the time required to recover the initial investment.	Initial Investment ÷ Annual Cash Inflows	2 years	The project achieves financial recovery by the second year, ensuring sustainable revenue for long-term operations.
Net Present Value (NPV)	Evaluates potential profits or losses by considering the time value of money.	Total Expected Cash Inflows - Total Initial Costs	IDR 73.890.530	A positive NPV (>0) confirms financial feasibility, making the project a worthwhile investment for sustainable water access.
Internal Rate of Return (IRR)	Determines the discount rate that makes NPV zero.	The rate where Present Value of Cash Inflows = Present Value of Investment Costs	20%	A strong IRR indicates high financial returns, making the project attractive for investment in water sustainability.
Profitability Index (PI)	Assesses project feasibility by comparing cash inflows to investment costs.	Present Value of Cash Inflows ÷ Initial Investment Cost	4 (>1)	A PI greater than 1 confirms that the project generates more value than its cost, proving its economic viability.
Break-Even Point (BEP)	Indicates when total revenues cover total costs.	BEP > 1	>1	The project surpasses the break-even point, ensuring profitability and long-term financial sustainability.

Source: Data Processed (2025)

This study demonstrates that integrating nanotechnology, ecosystem-based restoration, and sustainable water treatment is not only an effective strategy to address water scarcity in Gaza but also a financially feasible solution for achieving SDG 6 and SDG 13 (Climate Action). The economic analysis, including NPV, IRR, PI, and BEP, confirms its viability. By leveraging innovative approaches, this project ensures long-term water resilience, enhances quality, and promotes economic sustainability. The findings highlight that investing in sustainable water solutions benefits both communities and the environment, making it a replicable model for other regions facing similar climate and conflict-related water challenges.

CONCLUSION

Addressing water shortages in conflict-affected regions vulnerable to climate change, such as Gaza, requires a holistic approach that integrates advanced technologies and ecosystem-based strategies. By utilizing nanotechnology, restoring mangrove ecosystems, and integrating sustainable water treatment solutions, we can improve water access, enhance water quality, and promote long-term water resilience. These integrated solutions directly contribute to the achievement of the United Nations Sustainable Development Goals, particularly SDG 6 (Clean Water and Sanitation) and SDG 13 (Climate Action), while providing a model for other regions facing similar challenges.

Economic feasibility analysis and business viability aspects to support the sustainability of water treatment in Gaza show that the project is feasible, with the Break-Even Point (BEP) recorded as >1. The Payback Period (PBP) indicates that by the second year, the cash inflows have generated a net profit. The Net Present Value (NPV) over one period shows a profit of IDR 73,890,530. The Internal Rate of Return (IRR) is 20%. The Profitability Index (PI) is 4, where this value is >1. These results indicate that the project is economically viable and worthwhile to pursue.

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