Reconstruction of the Gaza Strip: Water and sanitation infrastructures and services, a synthetic scenario

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Abstract

This document presents a structured, three-phase strategic framework developed by Acquedotto Pugliese for the reconstruction of the water, sanitation, and hygiene (WASH) sector in the Gaza Strip. The WASH system—encompassing Water supply, Sanitation (sewage and waste management), and Hygiene promotion—is a foundational pillar of public health and human dignity. Its near-total collapse in Gaza has created a dire humanitarian crisis.

The proposed methodology moves from an Emergency Phase—focused on rapid, temporary solutions like mobile desalination units, water trucking, and emergency sanitation to ensure survival and contain immediate public health risks—through a Stabilization and Rehabilitation Phase aimed at restoring minimum operational capacity, rehabilitating partially damaged networks, and building local technical skills via dedicated Workshop Areas. The final Reconstruction Phase adopts a long-term, systemic perspective, focusing on building a new, resilient, and efficient WASH system through the construction of modern infrastructure (e.g., desalination plants, advanced wastewater treatment), the integration of digital monitoring and smart

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control systems, and the implementation of certified quality management protocols.
The overarching goal of this phased approach is to transition from emergency response to the establishment of an autonomous, sustainable, and resilient water and sanitation system that not only restores services but also improves upon pre-conflict conditions, ensuring public health, environmental protection, and long-term community resilience.

Keywords

Gaza water crisis, Emergency sanitation plan, Infrastructure reconstruction plan

Introduction

The reconstruction of water supply and sanitation infrastructures in the Gaza Strip represents one of the most urgent and complex challenges within the broader framework of international cooperation, humanitarian engineering, and essential services planning.
The prolonged conflict has led to an almost total collapse of the WASH system, with severe repercussions on the availability of safe drinking water, wastewater treatment, public health, and environmental protection. Recent assessments document widespread destruction of water and sanitation infrastructures, a dramatic reduction in access to drinking water and a significant deterioration in environmental conditions.
The contribution developed by Acquedotto Pugliese outlines a synthetic yet operational framework of the current

conditions, proposing a structured approach for the gradual restoration of water and sanitation services. This approach is articulated into three phases - emergency, stabilization, and reconstruction - consistent with the Gaza Phoenix plan.
The recovery path of the WASH system in the Gaza Strip requires a coordinated set of targeted, progressive, and sustainable interventions. These measures include the securing of water resources and existing facilities during the emergency phase, the rehabilitation and optimization of damaged systems, along with reconstruction planning, during the stabilization phase, and the construction of new infrastructures alongside the implementation of advanced monitoring and management systems during the reconstruction phase.
Such interventions aim first to re-establish minimum sanitary safety conditions, and subsequently to build a more resilient, autonomous, and sustainable system than the pre-conflict one, through appropriate technical and technological solutions, local capacity building, and a long-term vision focused on resilience, sustainability, and self-management.

Current status of water and sanitation systems

Over the past year, the water supply and sanitation system in the Gaza Strip has experienced an almost complete collapse, with dramatic implications for public health, environmental quality, and the population's ability to sustain minimum living conditions.
The most recent data indicate that between 60% and 85% of water infrastructures have been damaged or destroyed (OCHA 2024–2025); the majority of the population receives substantially insufficient quantities of water for essential needs, with daily consumption ranging between 2–8 litres

per person, compared to pre-conflict levels of approximately 85 litres per person (UNEP 2024). Additionally, the water available is often of extremely poor quality.
Frequent blackout have further compromised the operation of pumping stations, wells, and treatment plants. Untreated wastewater is being discharged into the sea and infiltrating potentially groundwater-connected land, leading to a progressive risk of aquifer contamination and long-term environmental degradation (Abu Shomar 2024).
The analysis of existing water and sanitation networks reveals highly heterogeneous damage conditions: some areas retain partial operational capacities, while others are entirely deprived of services. Notably, 79% of WASH infrastructures are located in militarized or evacuation zones, while 91% of households have reported a significant deterioration in access to safe drinking water (GPF 2024). This spatial and functional variability necessitates a differentiated strategy that maximizes the functionality of existing assets, supplemented by mobile or temporary solutions where necessary.

Methodological approach and intervention strategy

The reconstruction of the water and sanitation sector does not merely represent a technical necessity but constitutes an essential prerequisite for restoring minimum conditions of safety, public health, and human dignity. Therefore, it is crucial to define a comprehensive strategy that encompasses the physical infrastructure, access to services, water quality, and environmental protection.
The proposed pathway integrates the principles of the Gaza Phoenix framework, adopting a time-layered methodology structured into three sequential yet interconnected phases:
1. Emergency phase (short term)

2. Stabilization and rehabilitation phase (medium term)
3. Reconstruction phase (long term)
These phases are described in detail in the following subsections.

Emergency phase (short term)

The first phase, referred to as the Emergency Phase, focuses on rapid response interventions designed to ensure population survival and immediately contain sanitary and environmental risks. The proposed actions are not intended to be structural; rather, they are conceived to be rapid, temporary, flexible, and easily adaptable to unstable logistical conditions.
In this short-term phase, the priority is to prevent and mitigate immediate risks, while ensuring minimum water supply and maintaining an essential level of service provision. It is therefore characterized by high operational intensity and low technological complexity.
A critical focus during this phase is on interventions in campsites and survival nodes, namely the areas where the population is effectively concentrated, thus ensuring adequate coverage and accessibility of available resources.
Additionally, this phase marks the beginning of a site assessment and preliminary survey of existing conditions, aimed at identifying the real needs of the population and supporting the planning of targeted interventions, transitioning from localized emergency issues to broader strategic challenges addressed in subsequent phases.

Water supply infrastructure
In the Emergency Phase, activities related to water infrastructure are primarily aimed at securing and maximizing the use of residual water sources and

infrastructures that remain operational, in order to ensure a minimum level of water availability.
To compensate for the interruption of distribution networks and the destruction of many facilities, small-scale desalination units and mobile water packaging systems are deployed. These solutions enable the production of drinking water directly on site overcoming the problem of non-functional external connections. In parallel, water trucking (tankers) becomes a fundamental mechanism for rapidly serving isolated areas or those completely lacking distribution infrastructure.
A key action involves localized leakage repair, focusing initially on primary transmission pipelines and, where feasible, on the reactivation of pumping stations powered by still functional electrical lines, so as to re-establish a minimal but vital flow of water.
In sites facing critical energy shortages, portable generators are distributed to guarantee the operation of essential water supply systems and ensure the continuity of basic services under emergency conditions.

Sanitation and wastewater management
In the sanitation sector, the strategy mirrors the approach adopted for water services: securing and utilizing what remains operational, while integrating the system with decentralized and context-appropriate emergency solutions.
In a context where no full wastewater treatment chain can be immediately restored, the partial reuse of existing networks and treatment facilities represents an essential bridging solution to ensure a minimum level of wastewater management.
In parallel, the deployment of mobile sanitations units, e.g. mobile toilets and chemical toilets, is necessary. Moreover, the realization of septic tanks and cesspits in unserved zones provides essential sanitation services to the population.

These facilities help to reduce the risk of uncontrolled discharges and environmental contamination.
Designated areas, primarily located adjacent to cesspits, are identified for the future establishment of natural wastewater treatment systems, e.g. phytoremediation systems. These sites will serve as strategic locations for sustainable, low-maintenance treatment solutions, helping to manage effluent volumes while minimizing environmental and public health risks. This solution represents a pragmatic and sustainable approach that can be rapidly implemented and is suitable for fragmented infrastructural contexts.
A critical component is the regular emptying and management of decentralized sanitation units, which is essential to contain the spread of diseases and to mitigate odours, an often underestimated but crucial element in public health protection and the habitability of emergency settlements.

Water and environmental quality monitoring
Regarding water and environmental monitoring, this phase prioritizes simplified monitoring tools and procedures, which can be effectively implemented even in the absence of full laboratory capabilities. The objective is to safeguard survival and prevent immediate health risks through fast, robust, and mobile monitoring solutions.
The mapping of water sources and preliminary classification of their quality represents the starting point for orienting subsequent interventions.
The installation of basic disinfection stations and regular monitoring of chlorine residual in distributed water are essential to prevent microbiological contamination and serve as the first steps towards fostering a quality control culture.
For wastewater, this preliminary phase includes the identification of suitable areas for future treatment plants,

ensuring an appropriate distance from potential potable water sources.
Simultaneously, systematic data collection on the quantity and quality of raw wastewater begins, providing essential information for properly shaping the technical planning for the next phase.

Stabilization and rehabilitation phase (medium term)

The second phase, referred to as the Stabilization Phase, marks the transition from emergency management to the re-establishment of minimum operational conditions of the WASH system. It represents a critical transitional stage, designed to prevent emergency arrangements from becoming permanent and to lay the technical, operational, and organizational foundations required for long-term reconstruction.
This phase aims to restore the minimum functional capacity of existing infrastructures and to create a stable operational framework. Technology begins to re-emerge as a central component, although applied through a pragmatic and context-sensitive approach.
The temporary solutions introduced during the emergency phase continue to be used, but are progressively optimized, standardized, and systematized through clear guidelines, structured maintenance, and monitoring protocols.
Throughout this medium-term phase, all essential activities initiated during the emergency, particularly within campsites and survival nodes, are preserved to guarantee continuity in the provision of basic water supply and sanitation services. In parallel, interventions are extended to slightly damaged sites, where infrastructure has sustained partial damage but can be restored through targeted and technically feasible repair operations.

A key innovation introduced during this phase is the implementation of Workshop Areas, which are dedicated facilities equipped for training, technical support, and community engagement. These areas represent the cornerstone of local capacity building, offering practical and immediately deployable skills, facilitating infrastructure maintenance, and fostering community autonomy. They also serve as preparatory platforms for the more complex and large-scale interventions planned for the reconstruction phase.

Overall, the stabilization phase combines infrastructural, organizational, and capacity-building components. The training of local personnel becomes a fundamental element: it enhances awareness of public health risks, strengthens operational and management capacities, and ensures that rehabilitated and newly developed infrastructure can be operated safely, efficiently, and sustainably in subsequent phases.

Based on the surveys and assessments conducted during the emergency phase, this stage also involves the planning and design of reconstruction interventions, ensuring that long-term efforts are based on a technically robust, context-appropriate, and operationally coherent foundation aligned with real population needs.

Water supply infrastructure

Interventions focus on the rehabilitation of both transmission and distribution pipelines, wherever damage is partial and restoration is technically feasible. This approach aims to progressively re-establish hydraulic continuity and functional connectivity across the network, enabling at least a minimum level of service provision.

A strategic priority is the recovery and reactivation of existing desalination plants. Their restoration not only increases the availability of drinking water, but also gradually

reduces reliance on mobile solutions and water trucking, shifting from emergency-based provision towards more stable and semi-autonomous production systems.
In parallel, efforts are directed towards the reactivation of pumping stations, frequently inoperative due to energy shortages or structural damage. The restoration of these facilities is critical to ensuring the minimum required pressure and enabling continuous water flow, particularly towards peripheral and structurally disadvantaged areas.
The small-scale desalination units, mobile water packaging systems and water trucking (tankers) continue to be employed.

Sanitation and wastewater management
The rehabilitation of damaged networks and treatment facilities aims to re-establish more controlled wastewater management cycles, thereby reducing sanitary and environmental risks.
Temporary solutions, such as mobile toilets and septic tanks, continue to be employed; however, they are now implemented in a more regulated and integrated manner, supported by periodic maintenance and standardized operational procedures.
The introduction of phytoremediation systems represents a significant step forward in sustainable wastewater management, enabling the treatment of a portion of effluent using low-cost, low-maintenance natural systems.
Finally, the remediation of contaminated areas is a crucial intervention to mitigate the environmental risks accumulated during the emergency phase.

Water and environmental quality monitoring
With regard to water and environmental quality monitoring, this phase represents a transition to a more technical and structured level of management. The establishment of a

network of laboratories, the development of standardized procedures to ensure water quality during the rehabilitation of networks, and the training of specialized personnel constitute the foundational elements of a modern, autonomous water quality control system.
During this phase, a stable organizational framework for water quality monitoring is established, and technical procedures are defined for both potabilization and desalination processes.
Regarding wastewater management, support processes are introduced to enable the operation of treatment plants, the implementation of laboratories to enhance analytical capacity for these facilities, and the definition of technical procedures for monitoring wastewater treatment processes.
The overarching objective of this phase is to facilitate the transition from emergency management to the structural recovery of the system, establishing the technical and operational foundations necessary for longer-term, sustainable reconstruction interventions.

Reconstruction phase (long term)

The third phase, referred to as the Reconstruction Phase, adopts a systemic and forward-looking perspective. The focus is no longer on repair and stabilization, but on the construction of a new WASH system that is more resilient, autonomous, and efficient.
During this phase, damaged water and sanitation infrastructures are rebuilt, new facilities are constructed, and technological innovation, digitalization, energy efficiency, and environmental sustainability are systematically implemented.
The deployment of advanced solutions and digital monitoring systems enables more effective network

management, ensuring continuity, reliability, and service quality.
Thus, this phase embodies a vision oriented towards resilience and sustainability, in which the water and sanitation system not only recovers but becomes stronger, more autonomous, and more stable than before.
While previous phases focused initially on small centres and then on progressively larger areas, interventions during this phase are aimed at the renewal and modernization of the entire regional urban context, establishing the foundation for long-term development and sustainable management of water resources.

Water supply infrastructure
The enhancement or construction of new desalination plants represents a strategic choice, given the fragility, overexploitation, and frequent salinization of the coastal aquifer.
Furthermore, the identification of new autonomous water sources constitutes a step towards the diversification of supply, thereby enhancing autonomy in water supply and reducing the system's vulnerability to future crises or supply interruptions.
The construction of new transmission and distribution infrastructures offers the opportunity to redesign networks that are more resilient and better integrated with the remaining functional portions of the existing system. This phase incorporates principles of redundancy and flexibility, enhancing the system's capacity to adapt to and withstand critical events.
The introduction of advanced monitoring and control systems, based on sensors, telemetry, and smart control platforms, marks the transition towards an evolved management model, enabling continuous monitoring of

water quality, flows, network pressures, and infrastructure condition.

Sanitation and wastewater management

In the wastewater and treatment sector, existing facilities are modernized, integrating more efficient and lower-energy technologies that are compatible with local conditions. At the same time, new treatment plants can be constructed, designed to accommodate anticipated population growth and equipped with advanced treatment systems.

The completion of primary and secondary networks enables the elimination of uncontrolled discharges and restores the continuity of the sewerage cycle.

Within this framework, the agricultural reuse of treated wastewater, managed through risk-based approaches, represents a strategic measure, both for the recovery of non-conventional water resources and for its contribution to food security and community resilience.

Water and environmental quality monitoring

In the monitoring sector, the transition to ISO 17025-certified laboratories consolidates analytical capacity and ensures the reliability of water quality controls. The integration of laboratory analyses with real-time sensor data enhances the ability to anticipate, prevent, and respond to contamination events.

The development of a marine and inland water monitoring programme is essential to assess long-term environmental impacts and to guide evidence-based policies and protection interventions.

During this phase, water quality resilience is strengthened through the implementation of a Water Safety Plan approach, which enables the management of risks throughout the entire water cycle, from source to point of use.

With regard to wastewater, the upgrade of treatment facilities with advanced technologies is supported, alongside the implementation of an integrated environmental quality assessment plan (covering marine, freshwater, and soil), combined with a risk-based approach to the agricultural reuse of treated wastewater, in accordance with international best practices.

Conclusions

The reconstruction of the water and sanitation system in the Gaza Strip constitutes a complex multi-layered process that requires an integrated and phased approach. Overall, the three phases outline a coherent and well-structured pathway that progressively addresses different levels of need: from immediate emergency response, through operational stabilization, to innovative long-term development. This represents a scalable and adaptable model, combining technical pragmatism, environmental sustainability, and the strengthening of local capacities.

The proposed actions - from restoring essential infrastructure, to deploying simple and reliable technologies, and ultimately implementing advanced monitoring and management systems - aim to reduce health risks, improve water quality, protect the environment, and ensure service continuity. Equally important are local workforce training, the dissemination of technical skills, and the adoption of standardized procedures, which are essential for building a system that can operate autonomously and sustainably.

Looking ahead, the reconstruction provides an opportunity to rethink the WASH sector according to the principles of resilience, sustainability, and equity. By strengthening local capacities, introducing appropriate technological innovations, and integrating physical infrastructure with

management systems, it is possible to transition from a survival-based model to one of stable long-term development, ultimately improving living conditions for the population, safeguarding the environment and ensuring autonomy.

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