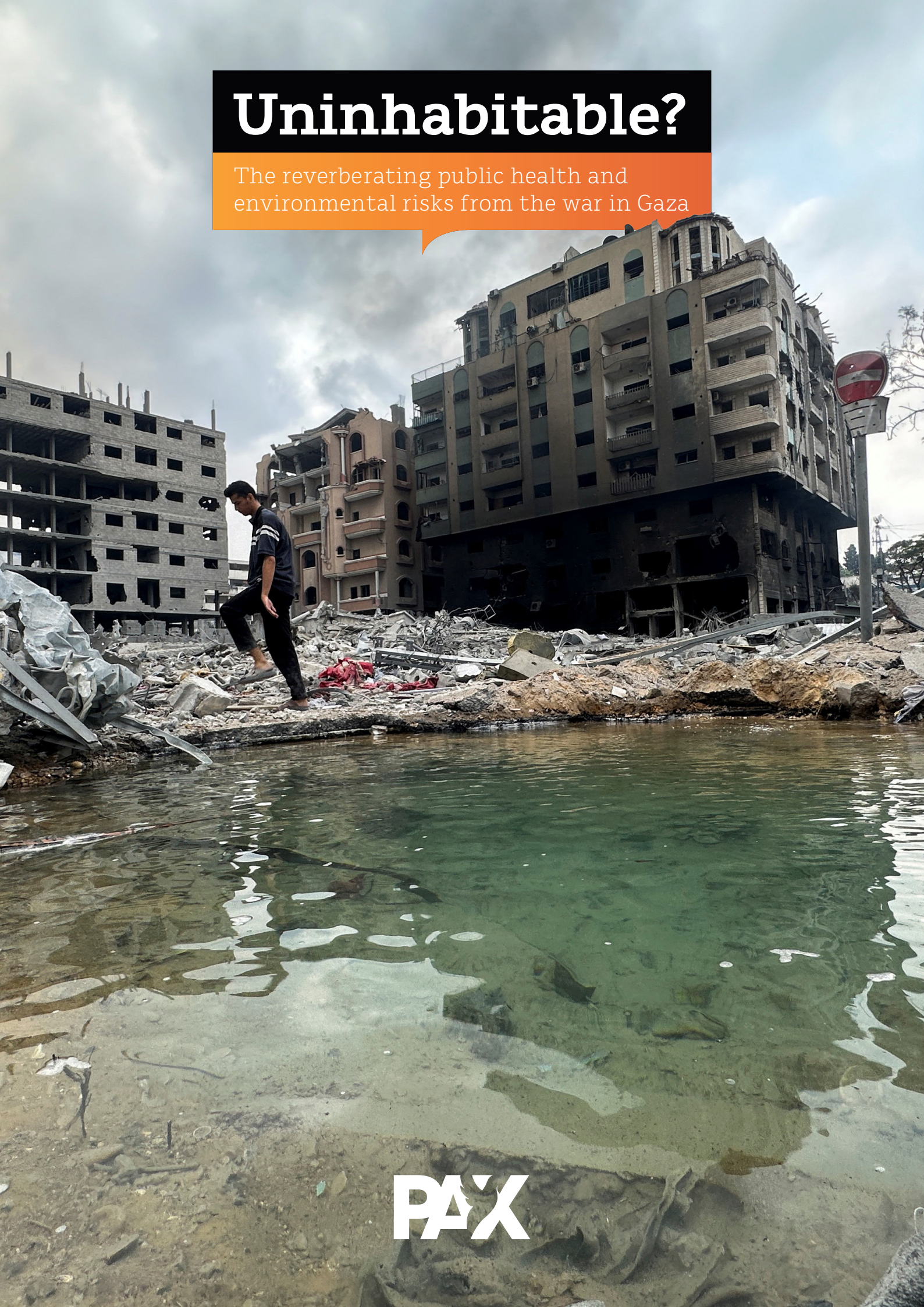
Uninhabitable?

The reverberating public health and environmental risks from the war in Gaza



PAX

Colophon
December 2023
PAX means peace. Together with people in conflict areas and concerned citizens around the world, PAX works to build just and peaceful societies across the globe. PAX brings together people who have the courage to stand for peace. Everyone who believes in peace can contribute. We believe that all the steps we take, whether small or large, inevitably lead to the greater sum of peace.

See also www.paxforpeace.nl.

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Cover photo: A Palestinian walks through the rubble while smoke rises from a damaged residential building nearby, in the aftermath of Israeli strikes, in Gaza City, October 10, 2023. REUTERS/ Mohammed Salem

Introduction

The Israeli army's ongoing campaign in the Gaza Strip has wreaked havoc in the small and overpopulated stretch of land. Since Hamas' October 7 attack that killed 1,200 Israelis, Israel's subsequent offensive has killed over 15,000 Palestinians, per December 1 UN data. Many more dead civilians are still buried underneath the rubble of thousands of pulverized buildings and not accounted for. Beyond these grave humanitarian impacts, the fighting has also resulted in massive destruction of urban areas, environmental infrastructure and agricultural land. Large parts of the Gaza Strip, or more commonly known as Gaza, have become uninhabitable due to severe damage from bombings to built-up areas, the collapse of the healthcare system and the destruction of people's livelihoods, compounded by preexisting existential major challenges from degrading natural resources that Palestinians in Gaza depend on.

The devastating impact on water security for Gaza's residents has been a critical aspect of the current conflict, and damages to water infrastructure, including water, sanitation and hygiene (WASH) facilities, are already posing acute and chronic public health risks. As the increased violence came on top of Gaza's inherent water insecurity prior to the recent escalation, water production has quickly dropped to 5 percent after October 7. Recent estimates by the United Nations indicate that most Gazans are living on one to three liters of water per day — well below the international emergency threshold of 15 liters per day — and even drinking untreated water in desperation. By October 28, humanitarian organizations were reporting widespread instances of chronic diarrhea, dehydration, extreme fatigue, and concentrated urine, while warning that outbreaks of cholera, typhoid, or other waterborne diseases are imminent. Israel's control over Gaza's borders has inhibited aid agencies' ability to fill the gaps and reach people where they are. By the end of October, UNICEF had only distributed bottled water for around 55,000 people (2.5 percent of the population) for two or three days. In sum, water is key for life in Gaza, yet has been under fire since the escalation of the fighting, vastly degrading the humanitarian situation, while widespread destruction is further leading to a deteriorating public health and environmental infrastructure with severe and long-spread consequences for Palestinians in Gaza.

This report seeks to take stock of the conflict's effects on public health and environment by mapping and monitoring damages to critical infrastructure for water security, hazardous facilities, buildings and agricultural land. This analysis will determine the risks of near-, medium- and long-term health and environmental consequences of the ongoing conflict. To visualize these impacts, PAX collected data through remote sensing, open-source information on public health and environmental risks linked with the hostilities, and interviews with water specialists and humanitarians working in Gaza. The conclusions of this assessment aim to support policymakers, donors, aid agencies, and citizens in Gaza as they confront the conflict's acute and long-term effects on public health, livelihoods, ecosystems and climate resilience.

The assessment of the current escalation of conflict and previous rounds of hostilities suggests that disjointed water and energy infrastructure supply chains, lack of sovereignty over water-related infrastructure, and protracted conflicts are unsustainable and fragile by nature. Due to the 16-year blockade of Gaza and repeated cycles of violence there, donors have invested in decentralized wastewater and desalination plants, solar panels, and other smaller and dispersed nodes of critical

infrastructure, deemed less vulnerable to violence and the need for external supplies. While this conflict demonstrates the benefits of these solutions, it also exposes their limitations. With a focus in particular on water security, the mapping also shows how damage to, and restrictions on, elements seemingly unrelated to water can negatively affect water supplies, while providing recommendations for how to address this issue in the long term.

Smoke rises over the Gaza Industrial Estate, with a visibly damaged water tower. December 6, 2023.

© REUTERS/Athit Perawongmetha

Water İnfrastructure Damage

Gaza Strip, Occupied Palestinian Territories

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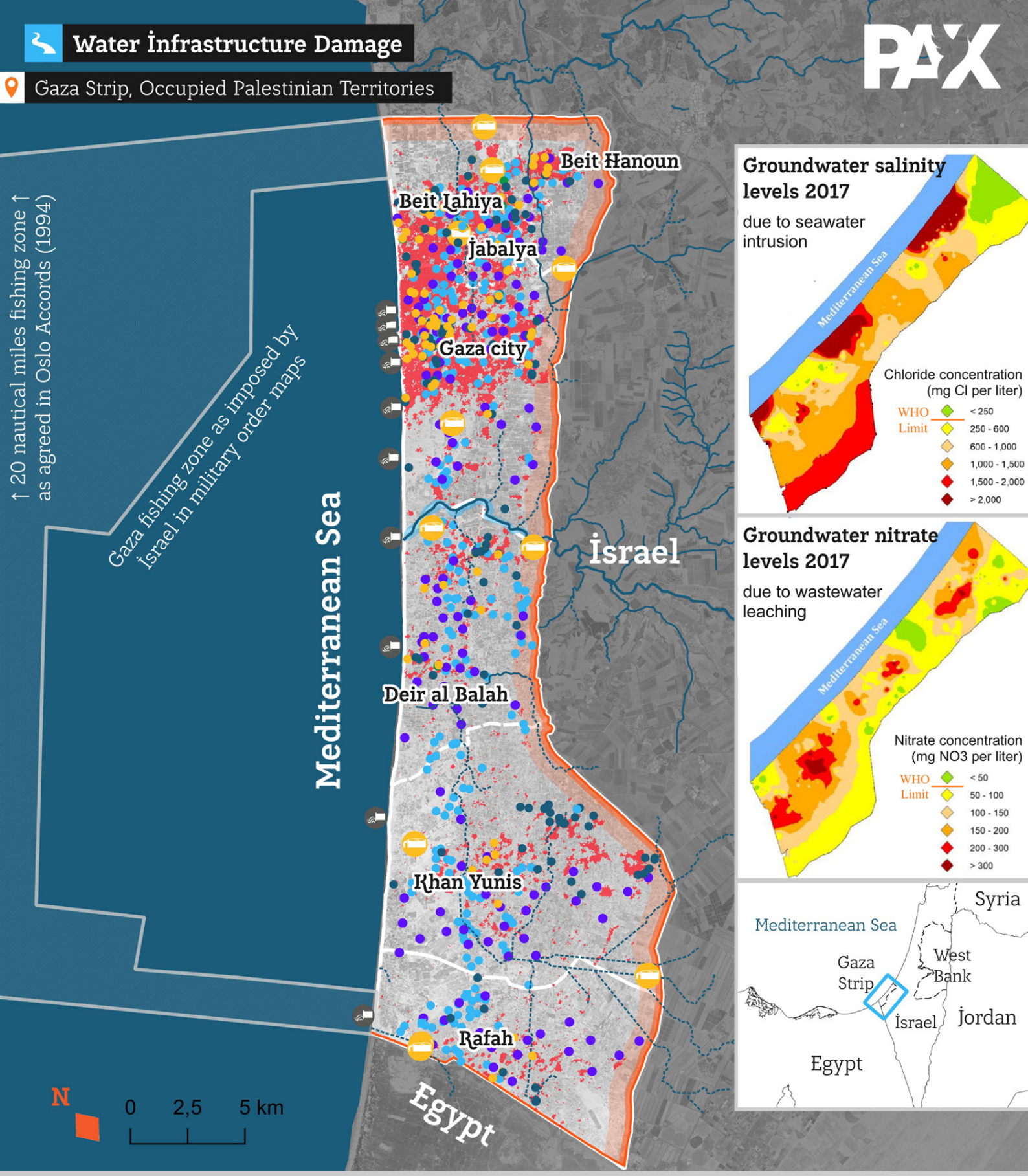

Groundwater salinity levels 2017

due to seawater intrusion

Groundwater nitrate levels 2017

due to wastewater leaching

Sources

Water infrastructure: Palistinian Water Authorities (2018) Municipal Wells 2017, Gaza Water Authority (2021) through OCHA oPt, Open Street Map (2023), UNICEF and WASH CLuster (2021), PAX original research of online literature and satellite imagery (2023),
Desalination plants: Abuzerr et al. (2020)
Fishing zone: OCHA oPt (2019), as imposed by Israel in military order maps
Likely building damage: C. Scher and J. Van Den Hoek (2023) CUNY Graduate Center and Oregon State University
Waterways: Open Street Map (2023)
Wadi Gaza protected area: UNEP-WCMC and IUCN (2023) Protected Planet
Gaza borders and restricted access zones: OCHA oPt (2023)
Chloride and Nitrate maps: Palestinian Water Authority (2018) Gaza Water Resources Status Report 2017
Background image: Google Satellite and Flanders Marine Institute (2019) Global Oceans and Seas

Legend

Water infrastructure

- Drinking water well
- Water network (pumps, towers)
- Wastewater treatment plant
- Sewer network
- Desalination plant
- Storm water infrastructure (dams, weirs, locks, etc.)
- Marine sewage outlet
- River/stream
- Natural and artificial drainage
- Likely building damage 5 Oct - 29 Nov 2023

Boundaries

- District boundary
- Wadi Gaza protected area
- Enforced fishing limitation

Closed and restricted border area

- No-go zone (0-100m)
- Access permitted on foot and for farmers only (100-300m)
- Risk zone (1km)

An Insecure System Predating the Current Escalation

The Gaza Strip's 2.3 million people were facing a multitude of challenges linked with natural resource degradation even prior to October 7 and the subsequent wide-ranging impacts on public health and livelihoods. Among these, water insecurity has been the single most urgent issue for a long time, posing multifaceted threats to sectors ranging from maternal health and livelihoods to transboundary issues. Most Gazans rely on the brackish and contaminated coastal aquifer for water. Rising sea levels have increased the salinity of these underground reservoirs, while has climate change diminished the aquifer's water level. As a result, around 97 percent of Gaza's water requires desalination and treatment to make it drinkable. Inadequate treatment of wastewater puts Gazans at risk for cholera and other waterborne diseases.

Gaza's water security is heavily dependent on outside inputs. Gaza relies on fuel imports, mostly from Israel and Egypt, to extract, treat, and distribute water and wastewater. Gaza also received around 9 percent of its water directly from Israel via three pipelines before the war. Israel cut this supply entirely for 17 days after Hamas' October 7 attack, and then reopened two pipelines with reduced flow. The pipeline to Khan Younis, for example, was restricted to a small network serving 70,000 people due to damage. Israel, wary of pipeline parts being used to make weapons, has also restricted the supply of equipment needed to enhance Gaza's water system. These restrictions, combined with frequent bouts of conflict and the repeated destruction of critical infrastructure, have subsequently made donors wary of investing in infrastructure in Gaza, further weakening water and sanitation systems.

Displaced Palestinian children wait inside Nasser Hospital in Khan Yunis to fill containers with water, in the southern Gaza Strip, 14 November 2023.

© EPA/HAITHAM IMAD

As a result of these preexisting issues, clean water was scarce in Gaza even before the recent conflict. Most Palestinians in Gaza lived on 82.7 liters of water per day before October 7, below the World Health Organization's recommended amount of 100 liters per day. Donors and aid agencies attempted to work around these political externalities, but the current conflict shows the limitations of their efforts.

Water insecurity is exacerbated by the impact of climate change. The warming of the sea has impacted fishing communities as the marine environment, including fish stocks, is affected by the decline in water quality, leading to smaller catches. The agricultural sector has been hit hard by climate change, with 95% of Gazan farmers reporting that higher temperatures and changing precipitation are negatively affecting harvests, leading to a 65% reduction in the olive harvest alone. With population growth and rapid urbanization, Gaza's built-up environment has also become a massive heat trap, worsening living conditions for local Palestinians.

The ongoing escalation of hostilities has severely exacerbated these challenges. The following sections take stock of the damage inflicted upon environmental infrastructure, urban areas and agricultural lands since October 7, with the aim to analyze related risks and consequences for Gaza's environmental security and public health.

A Palestinian man an his wife walk amid the rubble of buildings destroyed during Israeli bombardment in Khan Yunis, October 2023.

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Conflict-linked public and environmental health risks

The scale and severity of the impacts of the bombings and fighting in Gaza has brought a range of acute and chronic health risks to civilians, worsening humanitarian conditions and contributing severe damage to the natural resources their livelihoods depend on. The decades of occupation, blockades and military activities already took its toll on Gaza's natural resources and environmental health, as documented by UNEP in its 2020 State of the Environment and Outlook report that "found substantial evidence of environmental change and degradation in the occupied Palestinian territory. Surface and groundwater courses and marine ecosystems are being degraded by the discharge of untreated wastewater and by leaching from solid waste and unregulated industries. Rapid population growth, the growth of Palestinian urban areas, the expansion of Israeli settlements, land-use changes and the unsustainable use of natural resources have put severe pressure on ecosystem goods and services (…) failure to address any aspect of environmental management and protection covered in this report would have serious implications for the future."

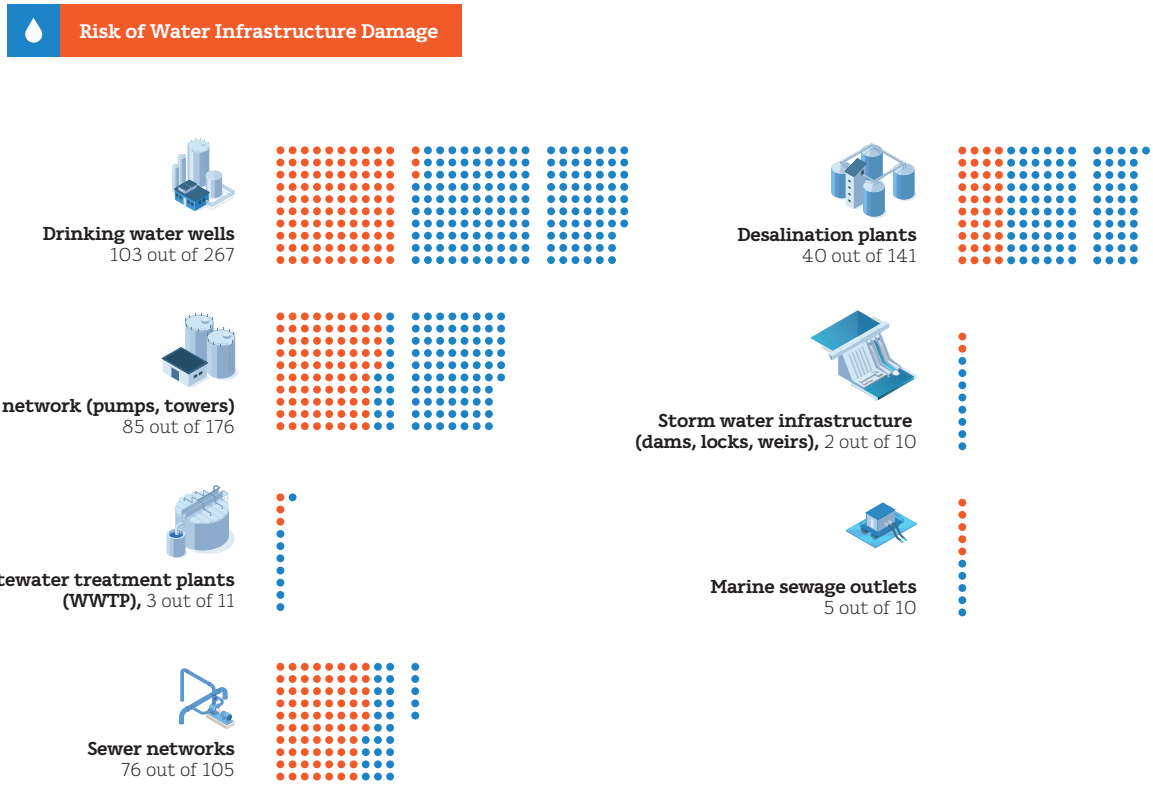
To understand how the current escalation will further impact the living conditions in Gaza, a range of pressing conflict-linked environmental and public health issues have been documented through open-source and remote sensing monitoring work, providing a first glimpse into the devastation that is ongoing. The data and evidence collected could also be instrumental to deal with the challenges for recovery and restoration efforts in a post-conflict scenario.

Damage to Water and Sanitation Infrastructure

Intense aerial and artillery bombardment has damaged much of Gaza's water infrastructure. The UN Office for the Coordination of Humanitarian Affairs (OCHA) has reported that 55 percent of Gaza's water infrastructure requires repair or rehabilitation. Social media reports indicate damage to water towers in the towns of Maghazi and Rafah, while satellite imagery and press photos show both a fully collapsed small and a larger damaged water tower at the Gaza Industrial Estate, an industrial area in the east of the Gaza Strip. Per early December reports by UNOCHA, 20 WASH facilities have been damaged, with no additional information on the type of facilities. The Gaza Municipality documented damages to the sewage pumping station in the east of Gaza City.

Using publicly available data on water infrastructure from UNOCHA, the Palestinian Water Authority, Open Street Maps and academic literature, combined with remote sensing-based damaged building estimates, PAX has produced the following preliminary damage analysis on WASH facilities and infrastructure located in areas affected by the bombing. Ground verification of all the locations is needed, and the numbers are open to change as more information becomes available, but the below figures provide an early rough estimate on the level of damage.

Without energy, all five of Gaza's wastewater treatment plants and most of its 65 sewage pumping stations were forced to shut down by mid-November. By the end of the pause in fighting on November 30, UNRWA and UNICEF had been able to deliver fuel to operate 18 sewage pumping stations and one wastewater treatment plant but with the offensive restarting, fuel supplies immediately dropped again. With many sewage systems and wastewater treatment plants non-operational due to a lack of fuel or damage, over 130,000 cubic meters of wastewater have been discharged into the Mediterranean Sea daily, and raw sewage has started to flow into the streets in some areas



At least three clear examples of large-scale damage to water facilities have been documented by PAX, corroborated with very –high-resolution imagery and social media footage.

The first clearly impacted facility became known on November 4 from social media footage showing a massive water leak that was geo-located on the street near the Indonesian Hospital in Gaza City, in the Tel Zaatar neighborhood. Social media by local authorities indicate that a reservoir providing water to 70,000 people was hit. Satellite imagery obtained from the Airbus Pleiades satellite on November 6 shows a munition impact on the roof of a building north of the main water tower, while a nearby street is visibly covered with mud, indicating the direction of the waterflow seen on the video footage. Considering the building's location on top of the hill and the nearby water tower, it is likely that the building functions as a water facility.

The second visually confirmed damaged water facility has been identified by PAX in the central Gaza Strip. A large smoke plume and fire was seen on Sentinel-2 and Planet imagery on November 16 at the Abdul Salam Yasseen Water Company. The facility is a known provider of water treatment and desalination equipment to international aid organizations. Imagery also shows the words "WATER FACILITY" on the roof of the building. A follow-up investigation by the New York Times with additional satellite imagery demonstrated the location in use by water trucks until mid-October, while also showing the severity of the damage after the fire.

A Palestinian man pushes his bicycle past a crater that hit a water pipeline following an Israeli airstrike on the main road between Rafah and Khan Yunis on the southern Gaza Strip on December 2.

Thirdly, the coastal short-term low volume (STLV) seawater desalinization plant in northern Gaza has been put out of operation and has sustained damage from the fighting, as did the beach well water intake. The STLV plant, built in 2019 with funds from Kuwait, produces 10,000m^3 water per day. The area witnessed intense bombing and fighting as Israeli forces took control over the northern Gaza strip in early November. Satellite imagery from Airbus dated November 11, 2023 shows nearby bomb craters and buildings destroyed next to the facility. As a result of this blast damage, the facility was taken offline. Even if fuel was allowed to enter to these treatment plants, the treated water may need to be trucked rather than piped to communities in the interim. The STLV plant is part of the larger seawater desalinization project for northern Gaza funded by UNICEF and the European Union.

Environmental Reverberating Effects of Explosive Weapons in Populated Areas

The Gaza Strip is one of the most densely populated areas in the world, with more than 77% of the population living in urban areas. The majority of people live thousands of tightly clustered apartment towers, often built from poor materials via unregulated construction. Heavy ongoing intense shelling and airstrikes by Israel, as well as failed and intercepted rocket launches from Hamas and Palestinian Islamic Jihad, continues to cause widespread and severe damage in these urban concrete jungles. The extensive use of explosive weapons, in combination with the high population density of the Gaza strip, is putting civilians at grave risk, both directly and indirectly. The direct impact is immediately visible, in the high number of civilian casualties. The indirect impact might be less visible, but has a profound and often long-lasting impact on civilians and public health nonetheless. Collapsed and damaged buildings, hit by thousands of shells, mortars and rockets, are resulting in millions of tons of debris. Current estimates by both UN-agencies and figures released by the local authorities in Gaza indicate that over 52,000 housing units have been destroyed and 253,000 damaged, a figure which constitutes roughly 60% of all housing units there. The latest satellite analysis conducted on November 13 by UNOSAT shows severe destruction of densely populated areas in Gaza, with 25,000 structures either damaged or destroyed. The majority of these are in Gaza City, including many high-rise buildings with dozens to hundreds of housing units per building.

A novel approach by the Decentralized Damage Monitoring Group, consisting of geospatial analysts from academic and civil society backgrounds, is using open-access radar satellite (SAR) imagery to map the damage to structures in Gaza. According to their latest analysis per December 4, 2023, they estimate that between 82.500 buildings (28,74%) and 105.300 buildings (36.6%) have been damaged or destroyed, though ground verification and high-resolution imagery are needed to validate the results. These new methods can be an important tool to rapidly visualize the impacts of conflict in order to inform the humanitarian response.

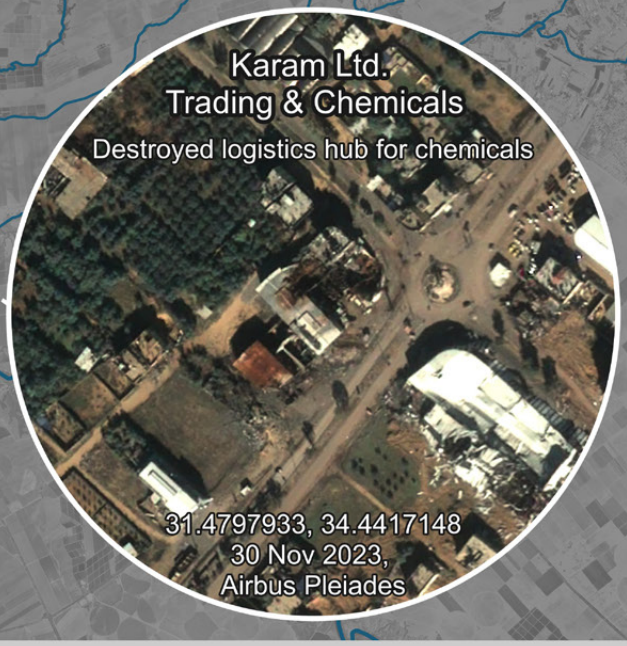
Health and Environmental Risks from Conflict Debris

First responders and civilians remaining in these areas are at risk from exposure to toxic dust from pulverized building materials and hazardous materials inside damaged buildings, including polynuclear aromatic hydrocarbons (PAHs), chlorinated compounds and dioxins. This has been repeatedly demonstrated by past catastrophes and conflicts.

Damage to Hazardous Facilities

Gaza Strip, Occupied Palestinian Territories

PAX



Beit Hanoun
Beit Lahiya
Jabalya Camp
Jabal'a
Ash Shati' Camp
Gaza city
An Nuseirat Camp
Al Bureij Camp
Al Maghazi Camp
Deir al Balah Camp
Deir al Balah
Khan Yunis Camp
Khan Yunis
Rafah
Rafah Camp
Israel
Egypt
Mediterranean Sea
N
0 2,5 5 km

Legend

Hazardous infrastructure

- Industrial facility
- Power plant
- Formal landfill
- Informal waste disposal site

Population exposure

per 100m by 100m

- 600 persons
- 0 persons
- Refugee camp

- Likely building damage 5 Oct - 29 Nov 2023

Boundaries

- District boundaries

Closed and restricted border areas

- No-go zone (0-100m)
- Access permitted on foot and for farmers only (100-300m)
- Risk zone (1km)
- River/stream
- Natural and artificial drainage network
- Main road

Sources

Industrial hazardous facilities, waste disposal sites, and power plants: PAX research of literature, social media and satellite imagery (2023), OCHA oPt (2014)
Wharfs and refugee camps: OCHA oPt (2014)
Population: EC (2023) Global Human Settlement population grid 2020
Building damage: C. Scher and J. Van Den Hoek (2023) CUNY Graduate Center and Oregon State University
Waterways: Open Street Map (2023)
Roads: Palestinian Ministry of Planning, JRC, OCHA (2021)
Gaza borders and restricted access zones: OCHA oPt (2023)
Background image: Google Satellite and Flanders Marine Institute (2019) Global Oceans and Seas

Israeli airstrikes and misfired rockets from militant groups in the 2021 Gaza conflict left more than 12,000 housing units and hundreds of other buildings damaged or destroyed, including 76 WASH facilities, according to the UNDP. These generated roughly 500,000 tons of rubble and debris from residential and public buildings and another 500,000 tons from partially damaged buildings and other sectors. A rapid damage assessment undertaken by the World Bank of the 2021 military campaign found that rubble was contaminated with 30,000 tons of hazardous waste, including asbestos, medical waste, pesticides, fertilizers, hazardous elements from damaged electricity equipment including PCB oils, cells and batteries, and asbestos-cement pipes. This research is indicative for the types of contamination that will need to be dealt with after the current fighting ends.

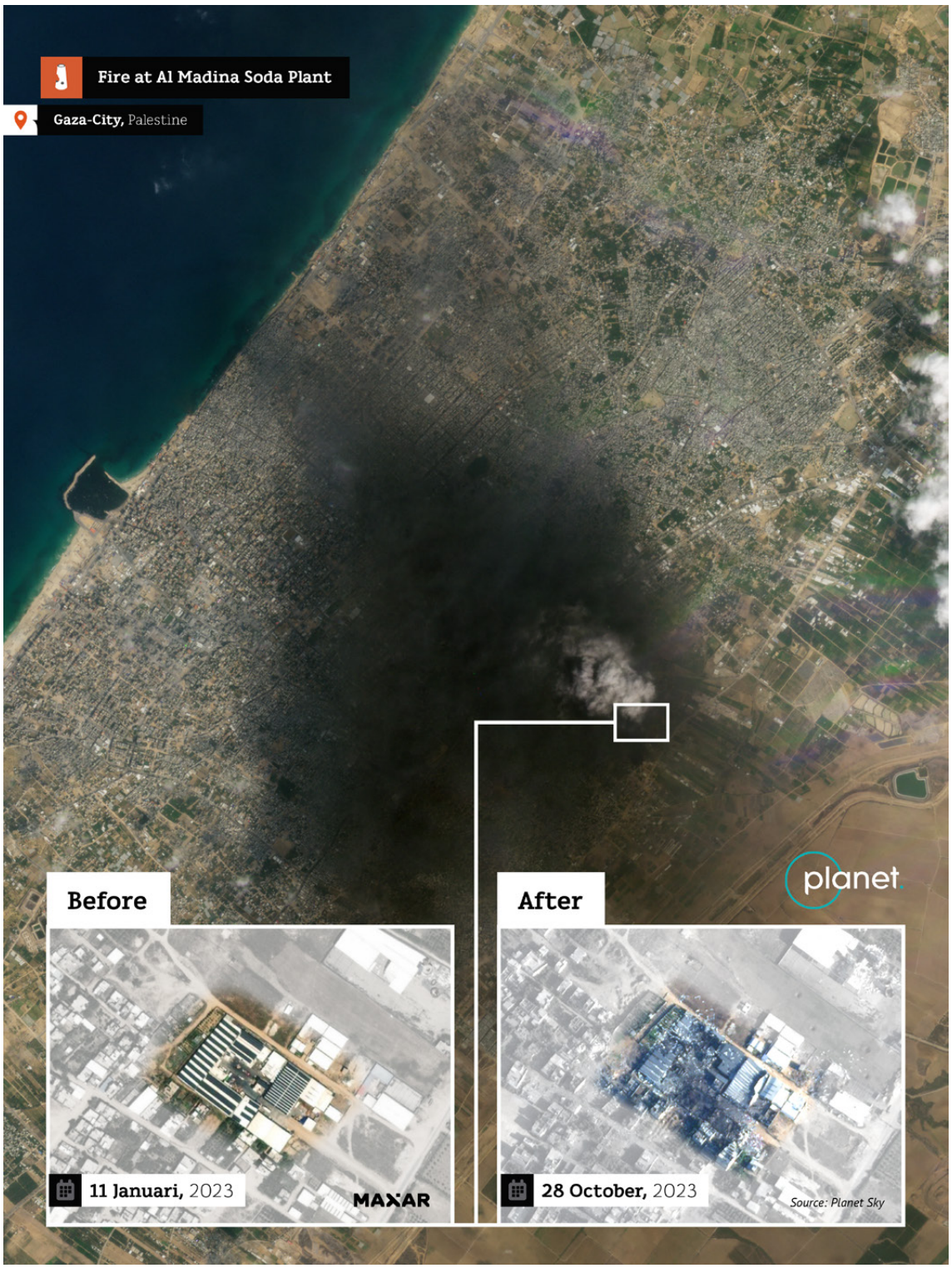
Challenges around the management of the 2.5 million tons of debris from past conflicts in Gaza has led UN agencies and academics to explore options to recycle conflict debris. The costs for reconstruction of the 2021 damages were estimated to be nearly $500 million; the current costs are likely to be more than ten times that.

The present level of urban destruction in Gaza will pose serious long-term public health environmental problems in terms of debris management, unexploded ordnance, human remains and hazardous materials. Dealing with the millions of tons of rubble also involves specific machinery, large amounts of personal protective equipment against dust exposure, the constructions of safe landfills, and recycling options.

Damaged Hazardous Facilities

Gaza's economy is dependent on a range of industrial enterprises that provide food items, household goods, agricultural products and construction materials. Many of these facilities are storing large volumes of hazardous substances that are used in the production process or are an end product, including solvents, chemicals, fuels, pesticides, and herbicides. If previous risk-assessments of these hazardous facilities are indicative of risks from conflict pollution, the current conflict is likely to result in hotspots of environmental dangers from bombed factories and warehouses.

Ongoing monitoring for this research has found already a number of larger industrial sites that have been hit. On October 23, satellite imagery showed a large black smoke cloud forming over the Al Madina Soda factory, likely from burning plastics and other packing materials stored there. S recently installed on the factory's roof were also largely destroyed in the strike. Another environmental risk location is the Gaza Industrial Estate, near the former Qarni border crossing, that hosts more than 54 factories and is funded by the EU and the US. According to local authorities, the complex hosts pharmaceutical and cosmetic industries, plastic industries, textiles and clothing, printing and packaging and other facilities, and is likely to have stored large volumes of hazardous substances. Satellite imagery indicates heavy damage to a number of facilities and the destruction of one of the water towers. The same area was hit heavily in 2021, resulting in large fires from burning plastics. Further pollution risks could arise from damaged petrol stations in urban areas, while satellite imagery has also shown major fires at other large industrial sites in the Ribat district and large commercial districts hosting large and small enterprises in central Gaza City. In the Damage Map of Gaza in this report, there are two examples, including the FOAMCO factory that produces foam and mattresses, and storing a range of industrial hazardous substances, that was also hit in 2021. The other example is the Karam Lt. Trading and Chemical company south of Gaza City, a facility that uses chemicals in the production of pharmaceuticals.



Attacks on industrial facilities, including factories, energy infrastructure such as substations with PCBS, but also smaller warehouses storing hazardous materials, gas stations with petrol, and agricultural buildings storing fertilizers and pesticides, could result in the release of toxic substances and civilian exposure, as was the case in 2021. A full assessment of all potential hazardous facilities, combined with the Flash Environmental Assessment Tool (FEAT) 2.0 is required to identify and map conflict pollution and implement cleanup and remedial measures to protect civilians from exposure and ecosystems from damage.

Collapsing Waste Management

Prior to October 7th, the limitations to deal with the rapidly growing solid waste problems in Gaza already a major issue, resulting in polluted soil and groundwater from waste leachate, while waste burning caused local air pollution. New initiatives were funded by the World Bank to address these issues and alleviate local and cross-boundary pollution risks. The current war-related damages and impediments to wastewater and solid waste services will also impact water and air quality, and subsequently public health. Overflowing sewage and waste as a result of the ongoing conflict will contribute to further land and groundwater contamination. In the coastal areas, the release of untreated sewage into the sea will affect the marine environment and livelihoods depending on it.

As the continued fighting inhibits official waste collection and disposal, people are resorting to informal dumpsites that will worsen soil and groundwater quality in Gaza. Tens –of thousands of tons of household waste are piling up in the streets. The absence of proper waste management is also attracting animals that can spread diseases, especially with people sheltering in close quarters. With the use of satellite imagery, PAX has identified over two dozen locations with informal waste dumps since the start of the conflict, with many more locations expected to be identified. Prior to October 7, UN agencies and international organizations were working to improve solid waste management, as this caused problems for Palestinian communities and transboundary water resources in Israeli territory. The ongoing conflict jeopardizes the implementation of these projects.

Recent studies and commentaries from Palestinian medical experts have raised concerns over the linkages between the degradation and damage of water and wastewater treatment services and the outbreak of antimicrobial resistance (AMR) that hampers the recovery of patients in war zones and can easily spread across borders and continents. New research on AMR in conflict-affected areas indicates a potential link between heavy metals, including those of military origin, and AMR, while other studies suggest linkages between conflict-related injuries and AMR. Doctors working in Gaza hospitals have sounded the alarm on the consequences of the current war in relation to AMR in a recent medical journal article.

A lack of clean water and sanitation, as well as inadequate infection prevention and control promotes the spread of microbes, some of which can be resistant to antimicrobial treatment. Overcrowding in hospitals, makeshift camps and shelters, in addition to the breakdown of the water and sewage system due to bombardment, has already led to a surge in infection rates, which will promote treatment-resistant AMR. The World Health Organization has warned that more people could die from communicable diseases linked with water insecurity than from military activity itself.

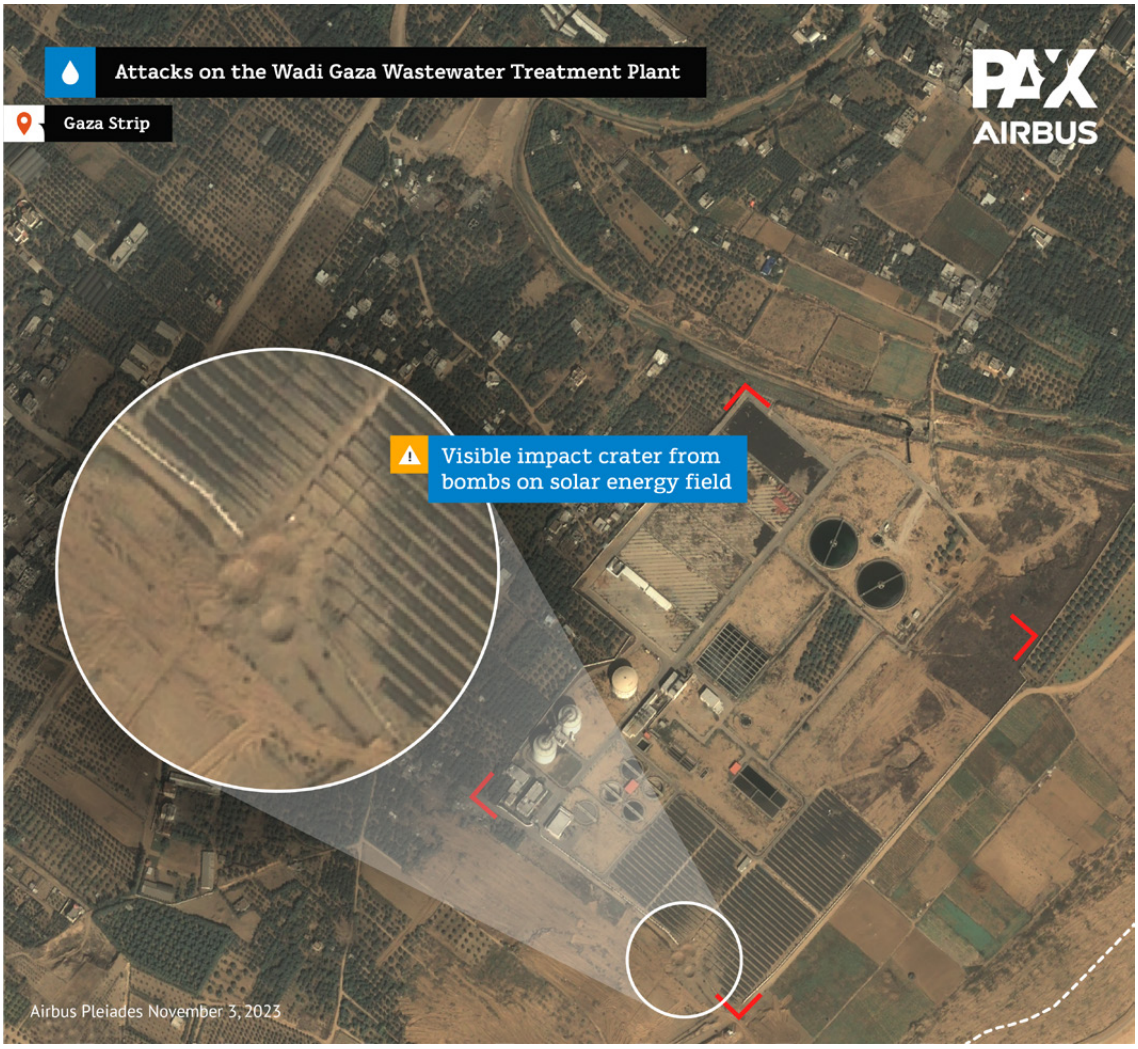
Solar Energy Infrastructure

With limited power supplies, energy blockades and rising fuel needs, Gaza witnessed a boost in solar energy use, and international organizations advocated for investment in solar energy for use in the health care system. Municipalities and enterprises in Gaza invested heavily in solar energy, as evidenced by remote sensing analysis showing an increase from 12 solar panel locations in 2012 to 8,760 solar panels in 2022. This seems to concern largely private household use, with 20% of households in Gaza using solar energy and a lesser extent for industrial and agricultural use. The overall solar energy production is not part of a Gaza-wide sustainable energy grid, though it does provide civilians with access to clean energy.

The current escalation of the conflict is already having a severe impact on these investments, with numerous social media reports indicating deliberate strikes on solar panels throughout Gaza, including on hospitals and bakeries. Satellite imagery of northern Gaza also indicates that many farms and livestock facilities with solar energy panels have been badly hit. An analysis conducted by CSIS on Gaza City identified 544 rooftop solar panels in a one mile (1.6km) radius, including 29 large rooftop solar systems; since the start of the fighting in October, 17 of those 29 large systems have been damaged or destroyed. The full extent of the damage still needs to be assessed, but satellite imagery of two large solar power projects already displays clear damage from munition impacts. The first such project is located in the Qarni industrial area, while the second is in the Gaza Industrial Estate. The World Bank funded a large project in 2018 to cover the Gaza Industrial Estate with a 7.3 Megawatt Peak (MWp) solar park, which was destroyed in the 2021 Israeli air campaign, only to be rebuilt after. Airstrikes in October and November 2023 again destroyed much of the project, including the rooftop panels

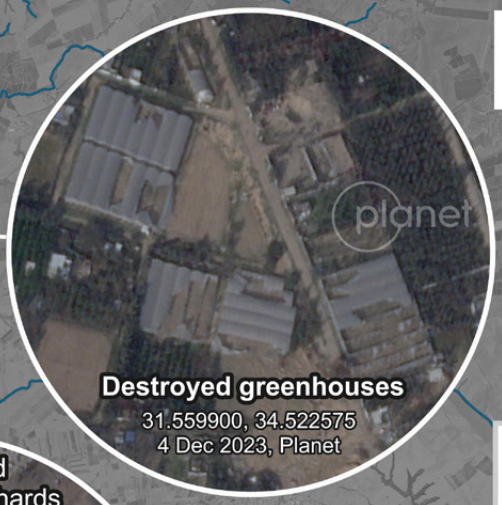
Further south, the Gaza Central Wastewater Plant was opened in April 2021, with an additional solar panel field that provides electricity for the plant's operation, providing treatment of wastewater to over 1 million people. Satellite imagery by Planet shows at least three massive craters on October 16, at the solar field, while later images from November 23 indicate that most of the solar panels have been destroyed, though ground verification is needed.

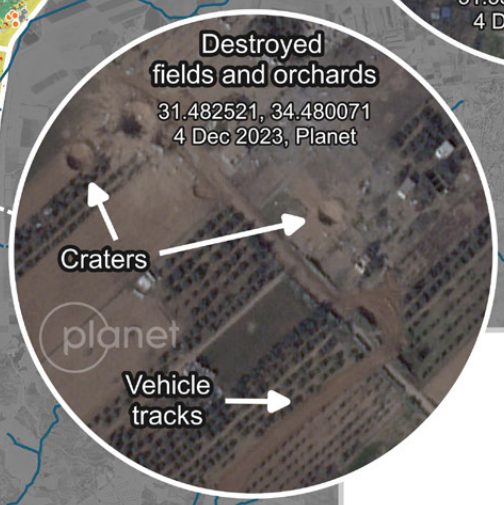
Other industrial sites, such as the Al Medina soda factory solar roof panels, have also been affected. The factory got a recent upgrade of solar panels on the roof with a capacity of 557KWh, which were largely destroyed in recent airstrikes.



Damage to Agricultural Lands

Gaza Strip, Occupied Palestinian Territories





Mediterranean Sea

Beit Hanoun

Beit Lahiya

Jabalya

Gaza city

Deir al Balah

Khan Yunis

Rafah

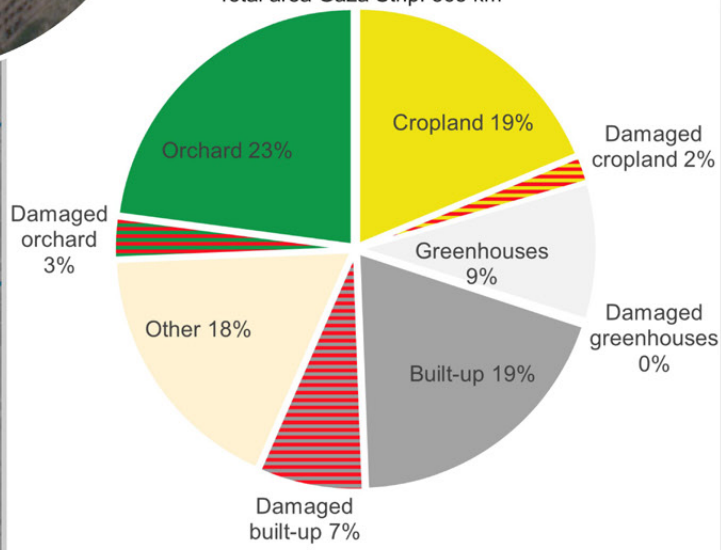
Egypt

N

0 2,5 5 km

Likely landcover damage

7 Oct - 16 Nov 2023
Total area Gaza Strip: 365 km²



Legend

Land use

- Cropland
- Orchard
- Greenhouse
- Woody vegetation
- Built-up: low intensity
- Built-up: high intensity
- Roads
- Barren
- Water

Likely agricultural damage 7 Oct - 16 Nov 2023

- Damaged orchard or damaged field
- Damaged greenhouse

Boundaries and background

- River/stream
- Natural and artficial drainage network
- District boundaries

Sources

Likely land cover and likely agricultural damage: He Yin (2023) Kent State University, based on Sentinel-1, Sentinel-2, and PlanetScope imagery between 7 October and 16 November 2023
Likely built-up damage (diagram): Jamon Van Den Hoek and Corey Scher (2023) Oregon State University, based on Sentinel-1 radar, OpenStreetMap and Microsoft building footprint data between 5 October and 22 November 2023
Waterways: Open Street Map (2023)
Gaza borders: OCHA oPt (2023)
Gaza municipality names: Gaza Housing Council (2019)
Satellite imagery inset: Planet (2023) 4 December 2023
Background image: Google Satellite and Flanders Marine Institute (2019) Global Oceans and Seas

Agricultural Impacts and Protected Areas

Outside the densely populated areas of Gaza City and Khan Younis, thousands of acres of agricultural lands provide Palestinians in Gaza with food and income. Yet weakly regulated agricultural practices have caused severe pollution linked with overuse of pesticides and herbicides, while fertilizer and runoff wastewater has spiked nitrate, nitrite and chlorine concentrations. Climate change has exacerbated the problems for farmers, leading to lower yields and lost harvests. Armed groups have also used many of these fields as cover to place launching installations for missiles, which were subsequently targeted by Israel. Since the start of the bombing campaign on October 7, suspected locations in orchards and fields have been heavily targeted, with visible crater impacts seen on satellite imagery. The subsequent invasion by the Israeli army and its movements through agricultural areas further destroyed greenhouses, fields and irrigation infrastructure.

According to UNOSAT satellite imagery analysis on October 28, 2023, at least 52 greenhouses were damaged, while nearly 600 large craters were observed in agricultural areas, a number that is likely to be higher considering the ongoing fighting since. The movement of tanks and vehicles and fighting between the Israel Defense Forces and Palestinian armed groups have further impacted croplands and orchards. At least 22.7% of arable land has been affected by the war, as indicated by analysis per late November 2023 on land use by remote sensing expert He Yin from Kent State University. Yin used a normalized difference vegetation index (NDVI) to monitor healthy vegetation in Gaza, reaching conclusions which are in line with UNOSAT data.[1] The loss of agricultural lands and infrastructure will put serious constraints on food security and livelihoods of Palestinians in Gaza, worsening economic recovery efforts.

The Gaza Strip also has one main protected nature reserve, the Wadi Gaza, a 9km long strip leading from the Israeli border westwards towards the sea. The coastal wetlands are habitats for migratory birds and local water birds, making it an important biodiversity-rich ecosystem in the Gaza strip. The UN started supporting local authorities with restoration and rehabilitation of this nature reserve and coastal wetland in 2018, under a project that is planned to end in 2025 The water quality in the Wadi and wider basin was already under pressure from pollution sources linked with leaking wastewater pipelines, runoff and solid waste dumps, and will likely worsen as result of the current hostilities.

1 *Yin et al., (in preparation). The impacts of the 2023 Israel-Hamas War on agricultural land. Communication with authors.*

Conclusion and Recommendations

The current war, characterized by the extensive use of explosive weapons in the Gaza Strip, has left a trail of destruction that is exacerbating the deplorable humanitarian conditions, worsening public health risks and medium and long-term chances for recovery and restoration. Widespread damages to built-up areas from the use of explosive weapons has resulted in direct impacts on water services and in millions of tons of debris, toxic waste and destroyed agricultural lands. The outbreak of communicable diseases from poor water, health and sanitation conditions, combined with the risk of exposure to a range of additional hazardous materials and collapse of environmental governance, will expand the toll of the war on civilians even further. In particular, damage to water infrastructure and wide scale urban destruction in combination with a severely degraded healthcare system are a key point of concern for both public health and livelihoods. As a British-Palestinian surgeon warned, this is turning Gaza into a "uninhabitable death war zone". The future that awaits Palestinians once the hostilities end looks bleak, with most of its civil infrastructure in rubble and a collapsed civilian governance with limit means and expertise left to address recovery efforts.

The intense level of bombing and fighting has destroyed much of the sustainable construction and climate-resilience efforts funded by international agencies and donor states, often not for the first time. While donors are likely to prioritize Gaza in their funding work, reconstruction efforts will be slow if previous conflicts serve as a guide, with severe consequences for the population. Prior to current phase of the conflict, a series of escalations between the Israeli military and Hamas from 2008 to 2021 forced the civilian administration in Gaza into a reactive cycle of rebuilding damaged water infrastructure, which was supported by the UN and humanitarian organisations. However, this came along with abandoning more forward-looking plans for resilient systems, such as artificial aquifer recharge and major reverse-osmosis plants to desalinate seawater. The findings of the 2020 UNEP on the environment in the Occupied Palestinian Territories further underscored the dire situation Gaza is in. All water sources cross into Israel, the West Bank, and Gaza. For example, sewage spilling into the sea in Gaza flows up the coast to the intake of desalination plants in Israel. Therefore, it should be in the interest of all parties to the conflict to urgently revert the collapse of environmental infrastructure and prevent further damage.

With a seriously degraded environment affected by millions of tons of conflict rubble, damaged agricultural lands and local hotspots from hazardous facilities that have been bombed, Palestinians will face a huge challenge in returning, dealing with clean-up, remediation and restoration of the areas affected by the bombardments. As the climate pressure on natural resources grows, particularly with water sources, and with urbanization on the rise, rebuilding cities and towns need to anticipate these challenges by focusing on green reconstruction.

The ongoing military campaign will also bring about larger legal questions over accountability in targeting civilian infrastructure, in particular those indispensable for the survival of the civilian population, as laid out under international humanitarian law (IHL)and expanded upon in the recent UN Security Council Resolution 2573. In 2022, 83 states signed the Political Declaration

on the Protection of Civilians from the Use of Explosive Weapons in Populated Areas, to prevent the exact humanitarian harm we see unfolding in Gaza today. The ongoing use of heavy explosive weapons in Gaza provides a crucial opportunity for states to promote their strong commitments to protect civilians against the impact of explosive weapons in populated areas, and to give meaning to this political declaration through the condemnation of such usage.

With Israel likely to occupy parts of the Gaza Strip for the near future, this will also bring forth responsibilities in providing access to clean water and essential public services for the population in the wake of the conflict.

Recommendations

Near-term

An immediate and permanent ceasefire is urgently needed to protect the civilian population in Gaza. In the absence thereof, the following actions should be undertaken by the parties to conflict to curb a full-blown health and environmental crisis in the near term in Gaza, and potentially in Israel and the wider region:

- Adhere to the Geneva List of Principles on the Protection of Water Infrastructure calling for the safe passage of humanitarian relief personnel for water-related and other activities and Article 54(1) of Additional Protocol I to the 1949 Geneva Conventions on starvation of civilians. Protection of "indispensable objects" for human survival such as "drinking water installations and supplies and irrigation works" are also protected under Article 14 of Protocol II of the Geneva Conventions.
- Allow supplies of fuel to desalinization and wastewater treatment plants, with the help of international humanitarian actors.
- Allow for consistent and safe passage of water and water trucks to reach civilians throughout the Gaza Strip.
- Emergency preparedness should incorporate antimicrobial resistance prevention packages for rapid deployment. Without prompt action, this war threatens to redefine antimicrobial resistance epidemiology in Gaza and beyond.
- Stop the use of heavy explosive weapons in populated areas in the Gaza Strip.

Long-term

Over the long-term, Palestinians in Gaza must have access to the basic infrastructure and operational materials (such as fuel) to be able to treat water and wastewater and deal with the broader impacts of conflict-linked environmental damages. This should go beyond reliance on decentralized water treatment plants and solar installations alone, as despite their potential to improve the resilience of communities after bouts of violence, they have their limitations. A more strategic approach is therefore needed to ensure the sustainable recovery and future resilience of environmental infrastructure in Gaza, including the following measures:

- International and regional donors have a larger role to play in overcoming some of the drivers of conflict that lead to inevitable cycles of violence, destruction, and reconstruction. If Israel provided Palestinians in the West Bank and Gaza with the right means to build their own water infrastructure, maintain it, and integrate it, it could be one step toward improved living conditions. Israel has expressed concern that certain materials could be repurposed for use in weapons. While military experts have noted that this round

of fighting has shown that Hamas is using fairly sophisticated guidance systems and rockets that are not homemade but brought in from outside, such concerns can be addressed in a way that does not inhibit water security for the civilian population. Those with the trust of Israel and influence in the country may be able to start this process with a mixture of aid and careful diplomacy.

- Understanding the breadth and depth scale of damages is needed to work on remediation, clean-up and restoration efforts. A coordinated effort with the help of the World Bank, UNDP and UNEP is needed to conduct a full-scale post-conflict environmental assessment, including the mapping of hazardous facilities, water infrastructure damages, impact on groundwater sources and the marine environment, affected agricultural land, biodiversity and other relevant topics, in line with UNEA Resolution 3.1 on conflict pollution.
- The future outlook of Gaza's ability to cope with the multitude of challenges from rising sea levels, pressure on natural resources, including water, and the catastrophic level of destruction of the current conflict will create an existential challenge for Palestinians. Addressing this requires long-term investments and political stability to implement the necessary measures and policies. These include climate-mitigation and resilience policies as part of sustainable reconstruction efforts that would also need inclusion of local communities in both the research and implementation phase.