



REPORT

THE ENVIRONMENTAL-HUMANITARIAN IMPACTS OF THE ISRAEL-HAMAS WAR IN GAZA

PUBLICATION NOTES

Author: Dr. Mariam Abd El Hay

Contributors: Elaine Donderer and Dr. David Lehrer

Editors: Hannah Kadish and Eliza Mayo

Graphic Design: Liana Berlin-Fischler

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EXECUTIVE SUMMARY

This report provides an analysis of the environmental impact of the current Israel-Hamas war, focusing on the effects in Gaza and broader implications for the region in six key areas - water, health, food, emissions, energy, and nature.

The current Israel-Hamas war has severely compromised the region's essential services and natural resources, leading to a significant humanitarian crisis in the Gaza Strip, as well as transboundary ecological threats. This report provides an analysis of the environmental impact of the current Israel-Hamas war, focusing on the effects in Gaza and broader implications for the region in six key areas - water, health, food, emissions, energy, and nature. Documenting the environmental dimensions

Access to clean, potable water has been critically restricted, exacerbated by damaged infrastructure, fuel shortages, and unsustainable extraction practices. The region's primary water source, the Coastal Aquifer, is heavily polluted and increasing in salinity, with 97% of the water deemed unsafe for consumption. The war has also devastated wastewater treatment systems, resulting in untreated sewage discharge that contaminates the environment and threatens public health. The displacement of large populations puts additional pressure on the already strained water and sanitation systems.

Additional health risks have surged due to toxic pollution from damaged buildings and military activities, with long-term consequences for public health. The energy sector has been crippled and is characterized by persistent electricity shortages despite previous investments in solar power. Agricultural land and infrastructure have faced extensive damage, intensifying food insecurity

and economic instability.

of the war is particularly important, considering the transboundary nature of the region's resources. By connecting the holistic impacts of all areas discussed, this report intends to form pathways to re-imagine a sustainable future for Gaza, and cultivate hope.

Solid waste management systems have collapsed, leading to widespread environmental pollution. Furthermore, the degradation of nature reserves threatens local biodiversity, compounding the



Photo: Palestinians in Gaza face the risk of epidemics due to uncollected garbage and accumulated sewage water in Rafah, southern Gaza Strip, April 26, 2024.



Photo: Jabaliya refugee camp, northern Gaza Strip, Wednesday, Nov. 1, 2023.

ecological damage. The impacts of this war will reach far into the future, with greenhouse gas emissions far surpassing those of previous wars.

Gaza's interconnectedness with the broader region highlights the urgent need for comprehensive interventions to address these challenges. The enduring impacts of the war on health, water, food security, and the environment emphasize the critical need for sustainable solutions and robust support to mitigate the humanitarian crisis, and foster long-term recovery.

Looking to the future, the Arava Institute and its partners remain committed to fostering transboundary environmental cooperation and safeguarding life. In doing so, these impacts must be addressed as a joint effort with the international community for the rehabilitation of Gaza. However, even with funding and large-scale deployments of

resources underway, the scope of such a large-scale rebuilding undertaking requires months of planning and years of implementation. The population in Gaza may endure years without adequate access to water, energy, sanitation, food, and, ultimately, a sense of hope. Deploying decentralized water, sanitation, hygiene (WASH) and energy technologies can assist in addressing short- and medium-term humanitarian and natural resource needs, and become an integral part of community development in Gaza. The Jumpstarting Hope in Gaza initiative, a coalition of NGOs and private sector entities led by Damour for Community Development, and supported by the Arava Institute for Environmental Studies, offers such a perspective.

INTRODUCTION

This report provides an analysis of the environmental impact of the current Israel-Hamas war, focusing on the effects in Gaza and broader implications for the region. In scope, the aim of this report is broad, assessing short-, medium-, and long-term environmental consequences in six key areas: water, health, food, emissions, energy, and nature. Not one of these aspects exists in isolation; only by carefully considering each element's role in relation to the others can we understand the true

extent of the damage. This report briefly highlights a snapshot of pre-war conditions before assessing current environmental and infrastructure damage. Documenting the environmental dimensions of the war is particularly important, considering the transboundary nature of the region's resources. By connecting the holistic impacts of all areas discussed, this report intends to form pathways to re-imagine a sustainable future for Gaza, and cultivate hope.

THE GAZA STRIP BEFORE OCTOBER 7TH

With a considerable young demographic, high unemployment rates, and a staggering population density of 6,507 people/km², about 80% of the population within the Gaza Strip has long relied on humanitarian aid to meet their basic needs.¹ A general lack or limited access to healthcare services and facilities has further exacerbated public health vulnerabilities. Children between five and nine years old are the largest population group in the Gaza Strip. Simultaneously, children and the elderly are amongst the most vulnerable population groups, and exposure to contaminated soil, water, and air would affect

their development and health disproportionately due to higher exposure.²

Before the onset of the war, Gaza faced chronic electricity shortages, with only 38% of its electricity needs being met.³ The inadequate electricity supply has persisted for decades, with power being available for occupants of the Gaza Strip for an average of eleven hours per day in 2021. Disputes between authorities in Gaza and the West Bank led to even more severe shortages, with electricity available for only seven hours per day in 2017 and 2018.⁴ The Gaza Strip

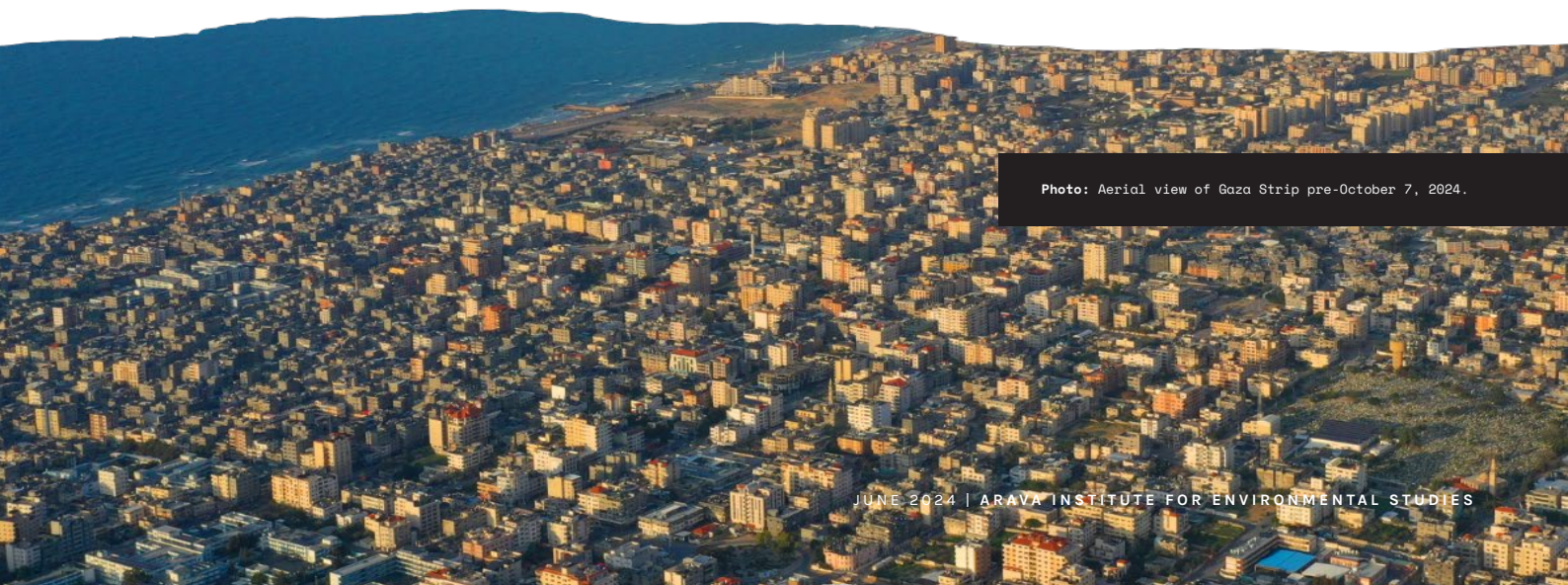


Photo: Aerial view of Gaza Strip pre-October 7, 2024.

primarily relies on Israel as its energy provider. Qatar purchases the fossil fuels needed to power Gaza's sole electricity power plant, which provides between 60 and 80 MW of electricity.⁵ Israel facilitates the energy production, and supplies an additional 120 MW via interconnected electricity grids, including ten power lines, while Egypt previously provided around 20 MW before ceasing supply in February 2018.⁶ Despite this, Gaza still faces a shortage of around 250–270 MW, with energy demand estimated at 450 MW.⁷

While the relatively large tracts of agricultural land, especially in central and southern Gaza, contributed only a minor percentage of the population's food supply and nutritional requirements, these lands were essential to the local economy, providing income to many Palestinians before October 7th.⁸ In addition, Gaza's agriculture has been poorly regulated, resulting in serious environmental problems such as the overuse of pesticides and herbicides, and elevated levels of nitrates, nitrites, and chlorine in runoff irrigation water. In addition to this pollution, the effects of climate change have led to shifting patterns of drought, resulting in reduced agricultural production. Farmers have seen poorer yields and missed harvests.⁹ This underscores the significant reliance of the population in Gaza on imported foods.

To further illustrate the pre-existing need for infrastructure and social services, the following section investigates the water sector in the Gaza Strip before October 7th. Gaza's water supply is extremely fragile. Since 2007, restrictions on the entry of potentially dual-use materials into Gaza have considerably increased the difficulty of importing the materials and fuel required to power and maintain wastewater treatment facilities and desalination plants, further aggravating conditions of worsened

water scarcity. Untreated wastewater is thus discharged directly into the environment, risking permeation into the Coastal Aquifer, and leading to a further decline in water quality. Additionally, import restrictions, frequent wars, governance dysfunction, and political instability have delayed the construction and operation of these essential facilities. This delay has long impacted water quality and quantity. Before the current war, many individuals in Gaza had access to 80 liters of water per day, which falls below the 100 liters per person per day set by the World Health Organization as a quantity that ensures basic needs are being met.¹⁰



Photo: Pool of sewage in Wadi Gaza at central of the Gaza Strip, 24th June, 2019.

Moreover, the population of Gaza heavily relies on extractions from the Coastal Aquifer, an underground water source spanning Egypt's Sinai Peninsula and Israel's eastern Mediterranean coast. The Coastal Aquifer is permeable, shallow, and unconfined, with a productive zone along the coast where groundwater flows from the hinterland in the east towards the Mediterranean Sea.¹¹ This body of water has been severely depleted and contaminated over time. The aquifer saw increased salinity levels due to unsustainable extraction practices such as excessive pumping, causing the water tables to drop below sea level, and seawater intrusion that heightened the salinity of the underground reservoirs.¹² In addition,

Gaza's capacity for water treatment remains insufficient to meet the demands of the rapidly growing population; about 97% of Gaza's water is deemed unsafe for human consumption.¹⁴

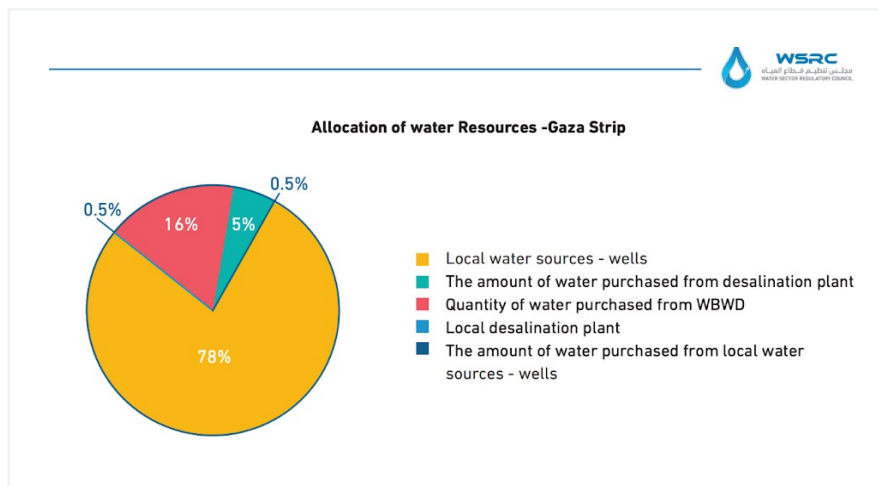
the gradual decrease in rainfall following the effects of climate change has further reduced the water level of the aquifer.¹³ Gaza's capacity for water treatment remains insufficient to meet the demands of the rapidly growing population; about 97% of Gaza's water is deemed unsafe for human consumption.¹⁴

The water situation in Gaza before the current conflict was described as a complex network of water sources and consumption patterns. Approximately 90% of Gaza's population had access to water utilities in their homes.¹⁵ In 2022, the total water supply for household use was approximately 111,305,127 cubic meters (m³).¹⁶ Most of this supply, about 78%, came from municipal water wells, totaling 87,053,341 cubic meters (m³), while 16% (18,172,034 m³) was acquired by the West Bank Water Department (WBWD) from Mekorot, Israel's national water company, through three pipelines.¹⁷ Therefore, any damage to this infrastructure would have a significant impact on the population. Desalination plants contributed 5% to the total supply, producing 5,576,385 m³ from seven public facilities and various small-scale private plants.¹⁸

Equally crucial is examining and understanding the reasons behind water consumption from various sources. In Gaza, water consumption predominantly relies on deep well water, which, as

previously mentioned, is considered unsafe for human consumption. Consequently, it is primarily utilized for non-potable purposes

such as irrigation for agriculture, personal hygiene, laundry, and sanitation.¹⁹ Thus, residents heavily relied on purchasing water from tankers and bottled sources for drinking purposes. Desalinated water from tankers served as the primary potable water source for households, with approximately 83% of the population relying on tanker water, while the remainder purchased bottled water, much of which was imported from neighboring countries.²⁰ Residents must pay up to 30 ILS/m³ for freshwater purchased from desalination plants in order to meet their drinking water needs.²¹ However, this figure varies significantly across different municipalities



within the Gaza Strip. Some areas, such as Khan Younis and Buraij, exhibit a consumption rate as low as 74 l/c/d, while that of Mughraga and Dair Al Balah stand at an even lower 64 l/c/d and 63 l/c/d, respectively.²² These numbers highlight the geographical disparity and accessibility of water sources in the Gaza Strip. Coastal municipalities, particularly those with access to desalination plants,

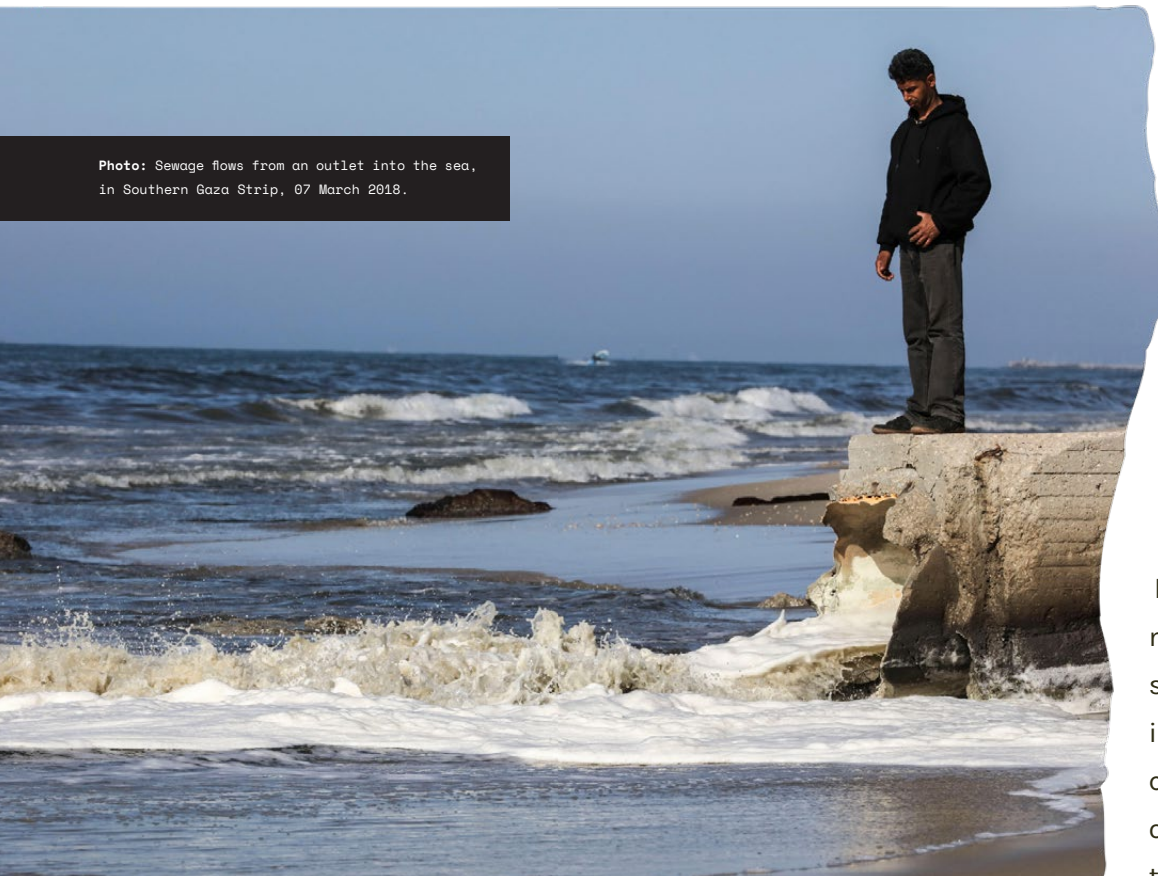
Mekorot, and underground reservoirs, tend to have more diverse water sources.

Gaza also continues to grapple with significant losses in its water distribution system. Disparities in distribution efficiency are apparent across governorates, with Khan Yunis governorate leading

Gaza's broader water crisis cannot be isolated from its wastewater treatment issues. Before the current war, Gaza faced an annual production of approximately 80 MCM of domestic wastewater. Around 83.5% of this volume was managed through a sewage network, while the remaining portion was discharged via septic tank cesspits and open

drains.²⁵ Before October 7th, Gaza's solid waste management was hampered by lack of capacity and resources, which resulted in local air pollution from uncontrolled burning waste in landfills, contaminated soil, and groundwater from waste leakage.²⁶ Various routes may lead to contamination, such as bioaccumulation in cultivated plants, direct contact with soil (skin, oral, or inhalation), or through infiltration into

Photo: Sewage flows from an outlet into the sea, in Southern Gaza Strip, 07 March 2018.



with an efficiency rate of 71%.²³ Despite the limited availability of water resources, a considerable portion is lost due to various factors such as leakage, illegal pumping, uncontrolled irrigation, and unauthorized consumption. Efforts to address this are evident in the decrease of non-revenue water from 44.08% in 2021 to 41% in 2022.²⁴ However, challenges persist, highlighting the urgent need for collaboration and innovation in sustainable water management practices.

the underlying coastal aquifer.²⁷ The air pollution from the burning landfills spilled over into Israel. Over 1,300 tons of solid waste are generated every day in Gaza, with 0.35 to 1.0 kg of waste generated per person.²⁸ Although recent literature and peer-reviewed studies on the environmental impacts of the war are scarce, the aforementioned hazards and vulnerabilities offer an evidence-based framework to examine the environmental implications of war in Gaza.

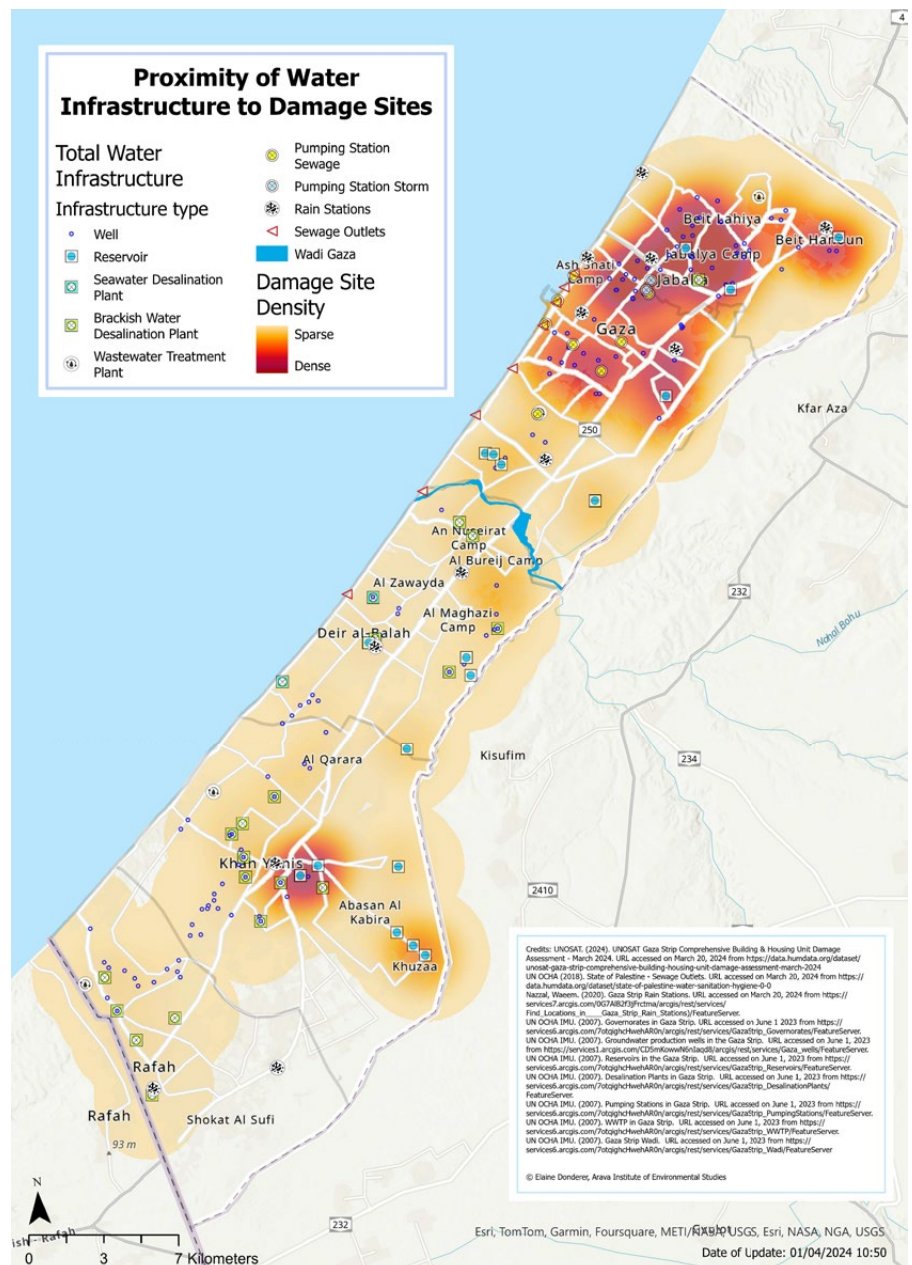
ENVIRONMENTAL-HUMANITARIAN IMPACTS OF THE WAR

WATER

Water is one of the major areas significantly affected by the war that will remain impacted for many decades. In Gaza, water infrastructure has been severely damaged due to aerial bombing and ground operations, amounting to approximately 65,000 tons of bombs dropped in the first 89 days of the war.²⁹ The affected infrastructure includes drinking water, wells, water networks, such as pumps, and towers, sanitation and hygiene facilities, sewage networks, desalination plants, stormwater infrastructure, marine sewage outlets, as well as wastewater treatment plants. As of October 23rd, the UN Office for the Coordination of Humanitarian Affairs (OCHA) estimated that 55% of Gaza's water infrastructure needs reconstruction or repair.³⁰ Since the bombardment has continued long past that point, it is likely that this number is even higher today.

Due to airstrikes and Israeli evacuation directives, a significant portion of Gaza's population has been forced to leave their homes in search of safety. Nearly 83% of Gaza's population, totaling around 1.7 million individuals, have been

displaced following Israel's invasion. This large influx of internally displaced people (IDPs) exacerbates water scarcity in southern Gaza, where existing water systems are inadequately equipped to cope with the escalating demand.



One significant example of damage to water facilities is the water reservoir in the Tel Zaatar neighborhood of Jabalia. This reservoir served as a crucial water source for approximately 70,000 people.³¹ Additionally, another vital water structure, the Abdul Salam Yasseen Water Company in the central Gaza Strip, known for supplying water treatment and desalination equipment to international aid organizations, has also confirmed sustained damage.³² Similarly, the Coastal Short-Term Low Volume (STLV) seawater desalination plant in northern Gaza, which produced 10,000 cubic meters (m3) of water per day, has been adversely affected.³³

Following the October 7th attack, Israel ceased supply of the 10 million cubic meters (MCM) of water provided through Mekorot for 17 days before resuming operation to two pipelines with reduced capacities.³⁴ Israel’s concerns about the potential diversion of pipeline components for weapon production have led to restrictions on equipment supply for Gaza’s water infrastructure improvement. Only two pipelines originating from Israel, located

southern “safe” zone, remain operational at the time of this report’s publication. However, the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) reports significant leakage issues in these pipelines, with one losing up to 70% of transported water.³⁵ Moreover, water production in Gaza has rapidly decreased to approximately 5% of production before the war, or a few liters per person per day.³⁶ This is significantly less than the fifteen

Type of need	Quantity	Comments
Survival (drinking and food)	2.5 to 3 lpd	Depends on climate and individual physiology
Basic hygiene practices	2 to 6 lpd	Depends on social and cultural norms
Basic cooking needs	3 to 6 lpd	Depends on food type, social and cultural norms
Total	7.5 to 15 lpd	lpd: Litres per day

Source: Adapted from Sphere. Also see WHO, 2011. *Guidelines for drinking-water quality, 4th edition*. World Health Organization, Geneva. http://www.who.int/water_sanitation_health/publications/2011/dwq_chapters/en/index.html

liters per day needed for very minimal human needs, as per international emergency standards. To grasp the severity of this shortage, understanding the water requirements for basic daily activities is foundational. Approximately six liters of water are used to flush an efficient toilet once, around four liters for appropriate handwashing, about forty liters for a five-minute shower, and at least two liters for cooking each day.³⁷ These basic tasks become near impossible with such limited access to clean water.

Photo: Pool of sewage in Wadi Gaza at central of the Gaza Strip, 24th June, 2019.



Furthermore, by mid-November the lack of energy made it inevitable for all five of Gaza’s wastewater treatment plants (and most of its 65 sewage pumping stations) to close, as reports by Oxfam indicate.³⁸ Moreover, a considerable portion of Gaza’s wastewater networks, including three out of five treatment plants and five out of six waste management sites, have been damaged or completely destroyed.³⁹ This

resulted in the discharge of untreated sewage into the Mediterranean Sea.⁴⁰

UNEP estimates that in Gaza, approximately 100,000 cubic meters/day of sewage and wastewater are released onto the land and into the Mediterranean Sea every day due to the shutdown of treatment facilities.⁴⁰ This quantity starkly contrasts with the 13,000 cubic meters/day of untreated black and gray water released daily before the war.⁴² Additionally,

The escalating conflict in Gaza has deeply affected the water situation, worsening the existing humanitarian crisis and deteriorating non-renewable water resources for generations to come.

untreated sewage dumped into the ocean harms the marine ecosystem and poses a severe public health hazard across borders. In the past, Israel's Ministry of Health has taken measures in response to the severity of Gaza's sewage crisis by, for instance, closing down Ashkelon's Zikim Beach in 2017 because of fecal contamination coming from Gaza.⁴³ The current overflow of sewage could present potential health and environmental hazards, for instance, by negatively impacting the desalination plant in Ashkelon, which provides around 13% of Israel's domestic consumer demand.⁴⁴

The escalating conflict in Gaza has deeply affected the water situation, worsening the existing humanitarian crisis and deteriorating non-renewable water resources for generations to come. The widespread destruction is causing a significant decline in public health and environmental infrastructure, thereby exacerbating poverty traps and systemic vulnerabilities. People in Gaza are now largely forced to resort to consuming brackish water, while the remaining water sources are increasingly polluted

with sewage due to the collapse of the wastewater network. This collapse means that illnesses related to water contamination, which already accounted for 26% of diseases observed in Gaza before October 7th,⁴⁵ will likely increase.

Among other reasons for the collapse is the shortage of fuel needed to operate machinery to transport waste and to operate the wastewater facilities themselves.⁴⁶ Tens of thousands of tons of residential rubbish have been accumulating in the streets due to the breakdown of waste management.⁴⁷ This has resulted in informal dumpsites, which increase soil and groundwater

pollution, as well as contribute to excessive algae blooms along the coast, negatively affecting marine life and bathers.⁴⁸ Inadequate waste management is also attracting animals that can transmit diseases, particularly when people are taking refuge in close quarters.⁴⁹ Rat and cockroach infestations have been reported in displacement camps, along with the accumulation of solid waste and wastewater.⁵⁰

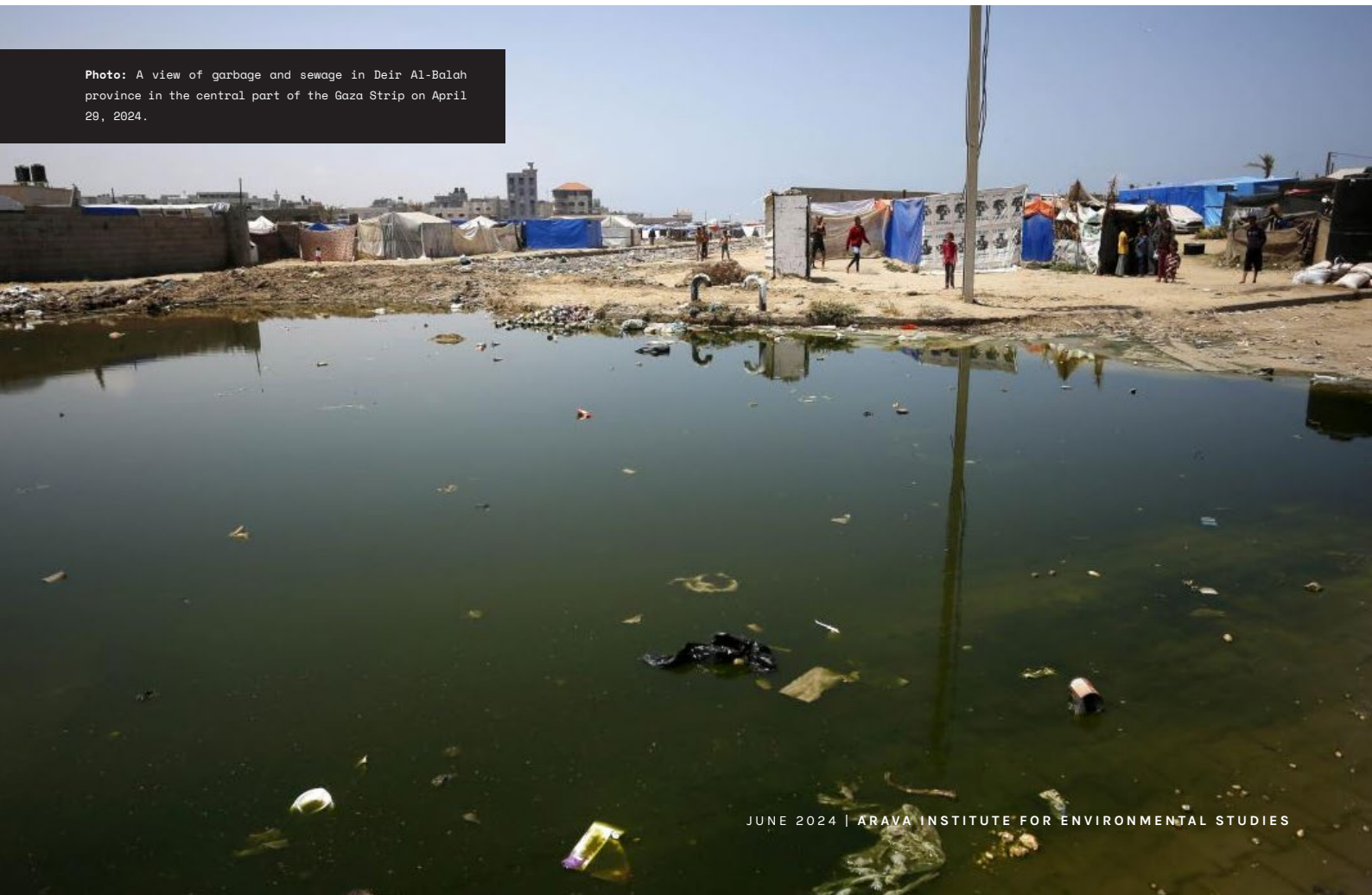
The health consequences of drinking contaminated water are disastrous, significantly increasing the risk of disease, with individuals frequently experiencing diarrhea, fever, nausea, vomiting, and stomach discomfort. Children are especially vulnerable to these illnesses brought on by drinking contaminated water. Already by October 28th, humanitarian agencies reported extensive spread of chronic diarrhea, dehydration, severe exhaustion, and concentrated urine, further warning of impending epidemics of cholera, typhoid, and other water-related diseases.⁵¹ These illnesses are spread by consuming water or food that is contaminated by an infected person's feces. The bacteria causing these illnesses can live

in brackish water streams and coastal waters.⁵² Sewage permeates roadways and water streams and is seeping into the soil, contaminating food, and crossing the border between Israel and Gaza through Wadi Gaza, the Mediterranean Sea, and the coastal aquifer. Researchers and medical professionals⁵³ have recently raised concerns regarding the link between the degradation of water and wastewater treatment infrastructure and the emergence of antimicrobial resistance (AMR), which can quickly spread across continents and borders, and generally impede patient recovery in conflict areas.⁵⁴ The result of the spread of AMR is that bacteria become resistant to antibiotic treatment, so antibiotics can no longer be used to treat infectious diseases, which portends an uncertain future for medical treatment. While some studies propose connections between AMR and injuries related to conflict,⁵⁵ new research on AMR in conflict-affected areas points to a possible relationship between heavy metals, including those

with military origin, and AMR.⁵⁶ Serious diseases, extended hospital stays, increased healthcare expenses, higher second-line medication prices, and increased treatment failures are all secondary consequences of AMR infection.⁵⁷

The proliferation of bacteria resistant to treatment is facilitated by inadequate sanitation, water quality, and infection prevention. As a result of hospital overcrowding and damage to water and sewage systems, infection rates have increased, exacerbating the AMR epidemic. The World Health Organization has issued a warning, stating that infectious diseases associated with water scarcity may kill more people in Gaza than military violence.⁵⁸ These consequences echo across diverse domains, encompassing health, livelihoods, and cross-border matters, underscoring the imperative for comprehensive intervention strategies.

Photo: A view of garbage and sewage in Deir Al-Balah province in the central part of the Gaza Strip on April 29, 2024.



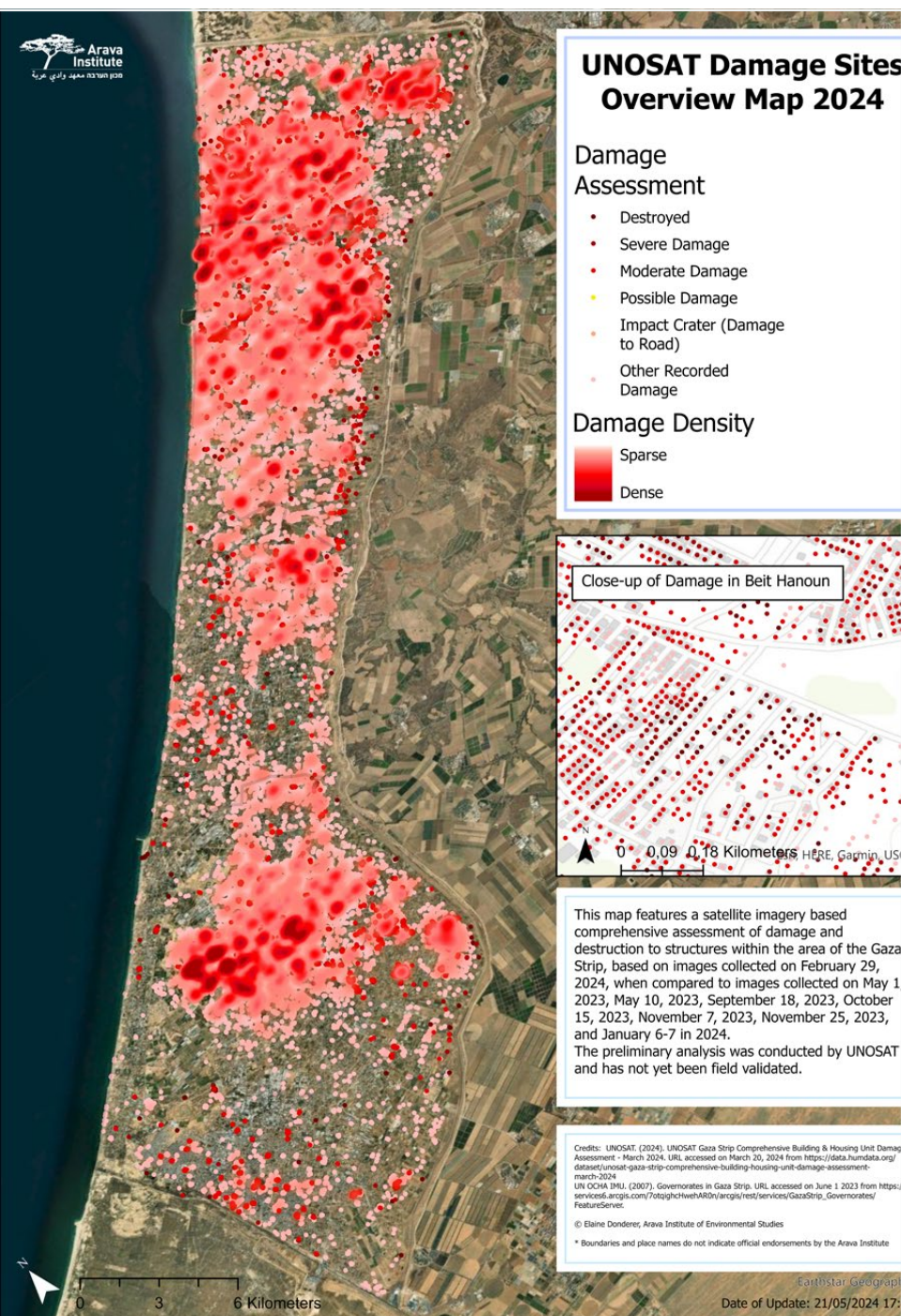
THE TOXINS OF WAR

The Gaza Strip, with over 77% of its population residing in urban areas, ranks among the world's most densely populated territories.⁵⁹ It accommodates 2.2 million citizens in densely populated apartment blocks constructed with substandard materials and minimal oversight. The destruction of buildings and the contents of building rubble are, thus, crucial

components in evaluating the impacts of the war on soils, air, water, and living organisms.

High-resolution satellite imagery obtained from the United Nations Satellite Centre (UNOSAT) on February 29th reveals that 35% of all buildings in the Gaza Strip, totaling 88,868 structures, had incurred

damage or destruction. Specifically, 40,762 structures were moderately damaged, 16,908 were severely damaged, and 31,198 were destroyed entirely.⁶⁰ Notably, UNOSAT reported 2,010 severely damaged structures in Gaza City, while Khan Yunis suffered the most, with 12,279 out of the total 16,908 severely damaged structures.⁶¹ It should be noted that this analysis is preliminary and has not yet undergone field validation. Nevertheless, with 70% of buildings in north Gaza damaged, military analysts are drawing comparisons between the destruction in northern Gaza in the first seven weeks to the year-long carpet bombing of German cities during the Second World War.⁶² As of April 2nd, 2024, the World Health Organization (WHO) reports that 1.7 million people, constituting 75% of the population, have been displaced,⁶³ and 500,000 are left without homes to return to,⁶⁴ a significant portion of the population faces prolonged displacement due to the extensive destruction of Gaza's vital public infrastructure. Among the affected



buildings are high-rise structures, hospitals, schools, factories, warehouses, electricity grids, solar panels, and industrial facilities producing pharmaceuticals, cosmetics, plastics, and various chemical goods. These sites also house hazardous substances such as solvents, fuels, pesticides, and herbicides, posing significant environmental and health risks. Moreover, the bodies buried beneath the rubble present a disastrous environment for the residents, who suffer the absence of loved ones, and face the unsettling prospect that animals, such as rats, may be attracted to the bodies. This poses a severe risk of disease transmission and the potential outbreak of epidemics.

Beyond that, civilians suffer from the immense impacts of explosive weapons used extensively in the densely populated areas of Gaza. According to the Palestinian Ministry of Health in Gaza, as of April 2024, approximately 34,000 Palestinians have been killed since the start of the war, predominantly from aerial bombings.⁶⁵ Human waste and the lack of burials for dead bodies have already caused the spread of intestinal and skin disease among hundreds of thousands, according to the WHO.⁶⁶ In addition, civilians in Gaza now face the indirect health effects of the bombardment. The collapse and damage to buildings may contribute to long-term repercussions on public health and civilian livelihoods, generating millions of tons of debris and releasing clouds of noxious smoke, toxic dust, and fumes into the environment. The exact composition of this debris is directly unverifiable. However, researchers can estimate the possible chemicals released into Gaza's environment during and after these occurrences using knowledge of building materials, historical data from conflict areas, and past incidents such as 9/11.

In an undamaged state, building materials usually do not pose a direct health threat. Explosions, however, crush building materials into tiny pieces, which makes it possible for toxic particles to be released into the environment and then absorbed by humans. Even though the highest exposure to these



Photo: Smoke and flames billow after Israeli forces struck a high-rise tower in Gaza City, October 7, 2023.



Photo: A view of destruction after Israeli forces' withdrawal from parts of Khan Yunis, April 7, 2024.

toxins occurs at the time of the explosion, the micro-particles of dust and toxic ash can be dispersed by wind or picked up by footsteps or moving vehicles. As a result, Gazans and anyone else in the area surrounding Gaza may be at risk for years to come. Looking at 9/11 as an indicator of health risks, we see that those exposed in the attack on the World Trade Center commonly experienced a variety of health consequences, including aerodigestive diseases, mental health conditions, and cancers.⁶⁵ Debris also

includes hazardous waste, including unexploded ordnance, depleted uranium containing shrapnel, cluster bomb munitions, fl  chette shells, fuel-air bombs (which explode twice, including after impact), white phosphorous, and Dense Inert Metal Explosives (DIME bombs).⁶⁸ All have either been shown to damage the environment or studies have not been done on their impact.^{69,70,71} These pollutants persist in the environment, posing a threat to all forms of life, including vegetation. They contaminate soil, air, and water sources, endangering ecosystems.

Following October 7th, an estimated 15 million tons of debris cluttered the Gaza Strip by January, as stated by Thorsten Kallnischkies, a former disaster waste manager with experience in clean-ups across twenty countries.⁷² As of April, the latest estimate suggests that the debris has increased to 37 million tons, with projections indicating it will take at least 14 years to clear.⁷³ The toxic dust generated from the pulverized concrete, insulation, and personal

belongings of this immense volume of debris fills the air in Gaza. The precise quantity up to this point can only be estimated. However, based on the analysis of the 2021 Hamas-Israel conflict, which resulted in 500,000 tons of rubble, including 30,000 tons of toxic waste,⁷⁴ it is evident that the current war has already produced a significantly larger amount of debris. With an estimated 15 million tons of rubble from the destruction of over 88,868 buildings, it is projected that this could yield a minimum of 900,000 tons of toxic waste. This amount is 30 times greater than the waste produced during the previous conflict in 2021.

The war in Gaza has worsened existing health risks and humanitarian conditions, damaging vital resources.

The severity of bombings and fighting has amplified these challenges, posing acute and chronic health risks to civilians. Toxic pollution, a consequence of prolonged conflict, presents significant long-term public health and environmental problems. Therefore, the consequences of the conflict on health extend beyond immediate casualties, casting a long shadow over the environment and public well-being in the area for generations to come. Only time will reveal the actual repercussions of these released substances, as seen in the aftermath of events like 9/11 and other wars, with people still grappling with health issues decades later.⁷⁵

Once the current war subsides, addressing the toxic remnants left behind will be imperative. For instance, in the Jabalia refugee camp, asbestos is

The war in Gaza has worsened existing health risks and humanitarian conditions, damaging vital resources. The severity of bombings and fighting has amplified these challenges, posing acute and chronic health risks to civilians.

present in apartment towers, posing a significant health risk due to its carcinogenic properties when damaged. Asbestos, commonly used in construction in Gaza, was found in the toxic waste following the 2021 conflict, further elevating the risk of cancer through inhalation. Exposure to these toxins can result in respiratory issues, skin irritation, and long-term health complications. In addition to the toxins released from destroyed buildings and their contents, the use of weapons themselves and the detonation of explosives release significant amounts of greenhouse gases, such as carbon dioxide, carbon monoxide, nitrogen oxides, and particulate matter. This report's section on emissions will delve further into this issue.

FOOD SECURITY

Electricity shortages and environmental pollution from the war further degrade pre-existing vulnerabilities in Gaza's food systems in terms of farmland and crop destruction, strains on food imports, aid theft, and the spread of disease contaminants and other toxins. Missile launch locations by Hamas were often suspected in fields and orchards, resulting in heavy targeting and crater impacts. Additionally, soils, fields, irrigation systems, and greenhouses were severely devastated by the Israeli army's ground invasion. Croplands and orchards have been harmed significantly by the movement of tanks, vehicles, and fighting between Palestinian armed groups and the Israel Defense Forces.⁷⁶

According to He Yin from Kent State University, satellite data indicates that the war damaged between 15 and 29 percent of Gaza's agricultural land.⁷⁷ The latest update from UNOSAT, which analyzed satellite imagery collected by the Sentinel-2 satellite from April 2017 to 2024, indicates that around 45% of the permanent crop fields and arable land in the Gaza Strip experienced a notable decrease in health and density in April 2024, compared to the average of the previous seven years.⁷⁸ This decline constrains the region's capacity to produce food and sustain its population during times of war.

As of February 15th, 2024, there is clear evidence of major damage, with the most severely damaged being residential barns (307), chicken farms (235), and sheep farms (203). There were 626 agricultural wells damaged, with central Gaza (208) and northern Gaza (213) suffering the most damage. The most severely damaged greenhouses are in northern and central Gaza, accounting for about 26.6 percent

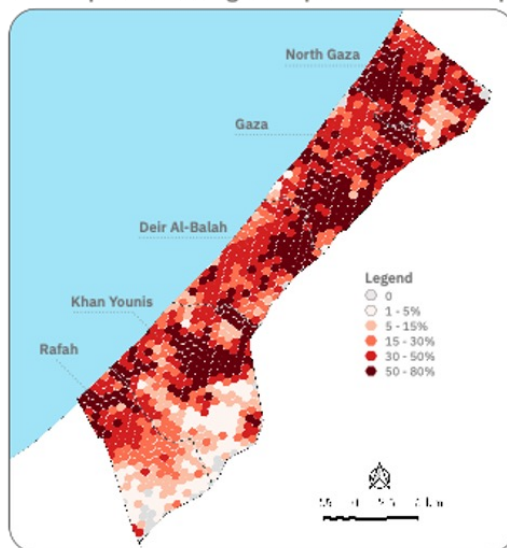


Food and Agriculture
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United Nations

Overview of the damage to agricultural land and infrastructure due to the conflict in the Gaza Strip as of 15 February 2024



Proportional damage to cropland in the Gaza Strip



Damaged cropland area (ha) by governorate

Governorate	Original Area (ha)	Damaged Area (ha)	Percent
North Gaza	3 099	1 402	45.2%
Gaza	3 545	1 941	54.8%
Deir Al-Balah	2 783	1 408	50.6%
Khan Younis	4 474	1 492	33.3%
Rafah	1 797	451	25.1%
Total	15 697	6 694	42.6%



Damaged cropland area (ha) by categories

Category	Original Area (ha)	Damaged Area (ha)	Percent
Irrigated land	2 155	887	41.2%
Orchards	11 670	5 027	43.1%
Rainfed land	1 872	780	41.7%
Total	15 697	6 694	42.6%



Agri-infrastructure damage (number of infrastructures damaged)

Wells: 626	Ponds: 47	Ports: 1
Home barns: 307	Agricultural warehouses: 100	Farm storages: 46
Agricultural suppliers: 7	Animal shelters: 119	Rabbit farms: 11
Dairy farms: 26	Broiler farms: 235	Turkey farms: 7
Sheep farms: 203	Cattle farms: 5	Pigeon/other bird farms: 42



Greenhouses

Total land area	1 277 ha
Damaged	339 ha



26.6% of greenhouses damaged

This assessment has been conducted based on available satellite imagery, auxiliary data and remote sensing analysis for the period 7 October - 15 February 2024 without field validation. Land cover data from 2023 was used as baseline data due to limited availability for data collection in the area of interest and time constraints related to the nature of the report. This assessment was conducted by the Geospatial Unit at the Land and Water Division (NSL) of FAO and will be further complemented with additional field assessment and use of very high-resolution imagery. The boundaries and names shown, and the designations used on these maps do not express any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries. Dashed lines on maps represent approximate border lines for which there may not yet be full agreement.



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(339 ha) of the total. The damage to farmland in Gaza is estimated to be 42,6% (6,694 ha), with the Gaza governorate suffering the most (1,941 ha). This information is represented visually in the map below from the Food and Agriculture Organization of the United Nations.

Prior to the war, Gaza had already depended on food imports and humanitarian aid for food security. The population of Gaza is now facing a severe food crisis, exacerbated by limited and poorly facilitated aid deliveries, as well as the diversion of aid from beneficiaries. As of March 2024, 95% of Gaza’s population, or 2.13 million people, are experiencing high acute food insecurity, classified Integrated Food Security Phase Classification (IPC) Phase 3 or above. Projections suggest that without intervention, half of Gaza’s population, around 1.11 million individuals,

could reach IPC Phase 5 (Catastrophe), indicating catastrophic conditions, by mid-July.⁷⁹

The extensive damage and a significant reduction in humanitarian aid have led to acute malnutrition in Gaza. Consequently, the recovery of the agriculture sector is essential for Gaza’s overall rehabilitation. The issues discussed are interwoven with transboundary implications, reflecting an aspect of a shared existence for people in the region. This report underscores Gaza’s interconnectedness with its immediate and neighboring environments, emphasizing the urgent need to address these challenges as a critical step toward environmental protection and the well-being of all residents in the region.



Gaza Strip: Acute Food Insecurity Situation for 15 February - 15 March 2024 and Projection for 16 March - 15 July 2024. IPC. (2024, March). <https://www.ipcinfo.org/ipc-country-analysis/details-map/en/c/1156872/>

GREENHOUSE GAS EMISSIONS

The weapons used by Israeli and Hamas forces since October 7th have produced extremely high levels of emissions. Understanding the full scope of the impact of emissions requires examining not just the “what” but the “when” of emissions; both elements will be highlighted below.

Increasing attention is brought by the international and scientific community to study war-related

greenhouse gas emissions.⁸⁰ For instance, an article in The Guardian reports that estimates of greenhouse gas emissions produced during the initial two months of the current conflict in Gaza exceeded the annual carbon footprint of over 20 of the world’s most climate-vulnerable nations.⁸¹ In the first sixty days of battle, approximately 281,000 metric tons of carbon dioxide were emitted, primarily from Israel’s aerial bombardment and ground invasion of Gaza.⁸²

This emission volume equates to burning around 150,000 tons of coal.⁸³ Additionally, emissions from the October 7th attack by Hamas on Israel amounted to about 646 metric tons of CO₂, which is equivalent to approximately 300 tons of coal.⁸⁴ Sources of these emissions include the manufacturing and detonation of explosives, artillery, and rockets, as well as activities such as aircraft operations, tank maneuvers, and vehicle fuel consumption. For instance, while the Gaza war in 2014 lasted for some 51 days, and Israel claimed to have used 20,000 tons of explosives, from October 7th to December 31st, 2023 alone, Israeli forces dropped over 89,000 tons of explosives on the Gaza Strip.⁸⁵ Notably, methane and other significant greenhouse gases are not accounted for in these figures.

Delegates and civil society organizations at the recent COP28 meetings in Dubai closely monitored the Israel-Hamas war and its climate implications. In 2023, the conference agenda included discussions on the connections between conflict and climate change for the first time. Continuing the COP discussion is particularly vital to address gaps in military emissions reporting and to advocate for immediate reductions in military emissions.⁸⁶ As indicated by the UN Environmental Program’s Emission Gap report, the environmental impact of the global military is considerable, with the combined global militaries producing an estimated 5.5% of the world’s greenhouse gas emissions.⁸⁷ However, most governments are unwilling to share specific details of their military emissions with the United Nations Framework Convention on Climate

Change, including the Israeli government and the Palestinian Authority.⁸⁸ Despite this lack of self-reported data, military emissions can be estimated by external means. During the current war in Gaza, the weapons technology used by combatants would appear to contribute significantly to greenhouse gas emissions.⁸⁹



Guardian graphic. Source: A multitemporal snapshot of greenhouse gas emissions from the Israel-Gaza conflict. Note: emissions calculated by usage not manufacture, Benjamin Neimark, Partick Bigger et al.

The anticipated post-war construction needed in Gaza runs the risk of becoming yet another source of damaging emissions, as an estimated 30 million metric tons of greenhouse gases may be produced during construction to restore 100,000 damaged buildings.⁹⁰ The construction industry worldwide is responsible for about 11% of global CO₂ emissions and encompasses activities such as producing concrete, and steel, material transportation, machinery operation, and building demolition.⁹¹ Thus, any rebuilding effort must concern itself with an efficient and localized provision of sustainable energy and materials to minimize additional externalities.

ENERGY

Prior to the war, Gaza experienced a surge in solar energy adoption by both donors and private citizens, as a means to mitigate energy deficits resulting from limited and unreliable power supplies, fuel blockades, and escalating fuel demands.⁹² Gazan municipalities and companies made significant investments in solar energy infrastructure, as demonstrated by a remote sensing study showing an increase in solar panel sites in Gaza from 12 in 2012 to 8,760 in 2022.⁹³ This prompted international organizations to advocate for increased investment in solar energy, particularly in essential sectors such as healthcare and other critical infrastructure, including wastewater and desalination plants.⁹⁴ Twenty percent of Gazan households use solar energy, whereas solar energy is used less frequently in industrial and agricultural settings.⁹⁵ Although solar energy gives residents of Gaza access to clean and renewable power sources, the region still lacks in sustainable energy infrastructure.

Additionally, renewable energy investments are currently suffering significant damage from the ongoing conflict.⁹⁶ An analysis conducted by CSIS

revealed the presence of 544 rooftop solar panels, 29 of which are major rooftop solar systems within a mile radius of Gaza City. Seventeen of these large rooftop solar systems (58%) have been damaged or destroyed since the war began in October.⁹⁷ While the full extent of the damage is yet to be determined, signs of damage from munition impacts are now visible in satellite imagery of two prominent solar generating plants.⁹⁸

Two additional large solar power projects funded by the World Bank in the Qarni industrial area and the Gaza Industrial Estate have suffered damage from airstrikes. Furthermore, a 2-megawatt peak (MWp) solar field built in the Khan Younis Governorate by one of the Arava Institute's Track II Environmental Forum Partners, Gaza Life Power, which had yet to be connected to the grid, was destroyed by bombing in late November of 2023. The World Bank launched a noteworthy project in 2018 that included a 7.3-MWp solar park spanning the Gaza Industrial Estate.⁹⁹ The project was completed after the estate was destroyed in 2021, but airstrikes caused additional damage in 2023. Furthermore, the Gaza Central Wastewater



Photo: Damaged 2 MWp Gaza Life Power solar field provided by Gaza Life Power

Plant, which was inaugurated in April 2021,¹⁰⁰ and uses solar panels to generate electricity for operation, has been severely damaged, affecting wastewater treatment for more than half of the population.

Evidently, many energy sector investments are experiencing significant harm from the ongoing war.¹⁰¹ Nevertheless, strategic partnerships and projects persist in the region. For instance, the placement of off-grid technologies in hospitals and schools and strong partnerships between NGOs and the private sector have helped safeguard five

out of seven installed Watergen systems, with only minor repairs required for the solar panels. These systems continue to supply potable water amidst crisis and help populations in Gaza to address conditions of chronic scarcity. When considering energy infrastructure, these occurrences highlight the significant environmental consequences of the conflict. As explained in the sections above, critical infrastructures cannot function without electricity, and the effect can go beyond local impacts, resulting in the spread of disease and a humanitarian crisis that affects the entire region.

NATURE

Wadi Gaza, a nature reserve within the Strip, illustrates the transboundary nature of the surrounding environment. As an ecosystem rich in biodiversity, this nine-kilometer-wide stretch of land runs westward from the Israeli border to the sea, and is an extension of Nahal Besor, a stream flowing from Hebron in the West Bank through Beer Sheva in Israel, into the Mediterranean Sea. Both local water birds and migratory birds rely on the coastal wetlands in this area as their habitat.¹⁰² The UN has actively assisted local authorities in Wadi Gaza and the preservation and regeneration of its coastal wetlands since 2018.¹⁰³ The continuation of the war threatens to deteriorate water infrastructure further, thereby increasing contaminant runoff and solid waste dumps. The biological integrity of the reserve and the general health and biodiversity of the surrounding ecosystem are seriously threatened by this condition.¹⁰⁴ With water being a shared resource that crosses international borders,¹⁰⁵ and migratory birds traveling across continents,¹⁰⁶ Wadi Gaza illustrates how intertwined ecosystems are on a global scale, and the urgent need for ongoing conservation efforts in the area.^{107, 108}



Map source: El-Hallaq, M. (2019). Studying the Impact of Pollution from Wadi Gaza on the Mediterranean Sea Using GIS and Remote Sensing Techniques. *Advances in Remote Sensing*, 08, 40-50. 10.4236/ars.2019.81003. accessed 01/05/2024

Photos source: El-Hallaq, M. (2019) Studying the Impact of Pollution from Wadi Gaza on the Mediterranean Sea Using GIS and Remote Sensing Techniques. *Advances in Remote Sensing*, 8, 40-50. doi: 10.4236/ars.2019.81003. accessed 01/05/2024

JUMPSTARTING HOPE IN GAZA

Without adequate drinking and domestic water, sanitation services, and a reliable supply of electricity, millions of people in Gaza will continue to suffer and be prevented from starting a path to recovery. The international community, including the United States, European Union countries, Arab countries from the region, and donor institutions with the Palestinian Authority must lead an ambitious plan to establish security and rebuild Gaza. To garner the international and regional support necessary for this plan to succeed, it must include a political horizon for community development and capacity building.¹⁰⁹

Within this international effort to rebuild and revive hope in Gaza, there is an important role to be played by NGOs like Damour for Community Development and the Arava Institute for Environmental Studies. Damour, a Palestinian organization, and the Arava Institute, an Israeli organization, have years of experience in cross-border cooperation to deploy decentralized WASH and energy technologies to address short- and medium-

term humanitarian and natural resource needs.

These and other water, sanitation, and hygiene (WASH) and energy infrastructure interventions require minimal planning and

The essential supply of WASH and energy services cannot wait and must be deployed simultaneously, meeting immediate needs and offering alternative pathways for rebuilding communities in Gaza in a socially and sustainably oriented effort.

can be rapidly deployed, replicated, and scaled to immediately and significantly benefit civilians while the international community initiates a long-term rehabilitation plan. A major initiative to reconstruct infrastructure and housing in Gaza will take months to plan and years to implement. The essential supply of WASH and energy services cannot wait and must be deployed simultaneously, meeting immediate needs and offering alternative pathways for rebuilding communities in Gaza in a socially and sustainably oriented effort.

Damour and the Arava Institute established a proactive partner consortium of qualified



Atmospheric Water Generators (AWG) in Gaza

[See article](#)



Off-grid wastewater treatment plants (WWTP)*

[See article](#)

*A similar WWTP has been installed in a West Bank Palestinian village of Asira Al Shmaliya, and another system is being installed in Jericho in partnership with the United Nations Development Program (UNDP).

PREVIOUS OFF-GRID TECHNOLOGY PROJECTS

JUMPSTARTING HOPE COALITION



For more information on these initiatives and how to get involved, contact Dr. David Lehrer at david@arava.org.

experts and organizations to rapidly deploy off-grid, small-scale, decentralized WASH infrastructure and energy interventions in Gaza. We have also established a line of communication with the Coordinator of Israeli Government Activities in the Territories (COGAT) office to enable the import of the technologies into Gaza. Additionally, the consortium is exploring establishing a brick factory for recycling and re-purposing rubble from destroyed buildings as raw material. Within the next few months, the consortium plans to introduce various sustainable off-grid technologies into 10 model refugee camps built by Damour for community development along the coast of Gaza to house 10,000 IDPs.

The technologies include:

- Atmospheric water generators
- Mobile wastewater treatment and reuse plants
- Small-scale desalination pumps
- Solar panel arrays with lithium batteries
- Off-grid internet networks

Looking to the future, the Arava Institute and its partners remain committed to fostering transboundary environmental peacebuilding and collaboration to safeguarding life. The Jumpstarting Hope in Gaza initiative, a coalition of NGOs and private sector entities led by Damour for Community Development and supported by the Arava Institute for Environmental Studies, offers such a perspective. We look forward to working with our partners and building sustainable opportunities for communities in Gaza and beyond.

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