Thematic Report:

Damage to Gaza's Agriculture Sector and Viability for Rehabilitation

March 2026

Contents

Executive Summary

After more than two years of virtually unbroken war, Gaza's agricultural sector has been reduced to a state of devastation. A combination of years of bombardment, coupled with the protracted imposition of military no-go zones, and the threats of deadly attack have forcibly displaced farmers and growers, destroying much of the land they left behind. **By the time of the ceasefire in October 2025, only 4 percent of Gaza's cropland is both accessible and not damaged, alongside 17 percent of greenhouses, 9 percent of agricultural wells, and 7 percent of agricultural infrastructure.** The majority of all cropland (54 percent) remains damaged and while 33 percent of lands are accessible, they are too damaged to be utilized. In addition to loss of access, the physical condition of farmland has deteriorated severely due to the impact of heavy military machinery, repeated shelling, and environmental contamination from munitions, untreated waste, and damage to groundwater. **These compounded impacts have led to the collapse of the agri-food system, which is one of the drivers in Gaza's catastrophic food insecurity situation, which reached famine levels in the Gaza governorate by August 2025.**

Figure 1: Normalized difference vegetation index (NDVI) analysis showing the destruction of vegetation across Gaza, circa. 2024

The following report contributes to the understanding of the scale of destruction inflicted upon Gaza's agricultural sector. **It examines the present and projected impacts of the crisis, highlighting how the current damage is likely to reverberate across future recovery efforts.** It analyzes the ongoing efforts by Palestinian communities to sustain limited cultivation activities in pursuit of short-term food security amid widespread disruption. Additionally, it provides an analysis of current patterns of land use to offer additional details on potential for agricultural rehabilitation.

Prior to the outbreak of the war, agriculture constituted a vital component of Gaza's economy and food system, with 42 percent of the territory's total land area devoted to such activities. The sector was characterized by small-scale, family-operated farms producing a range of crops, with perennial tree crops, vegetables, and field crops comprising the majority of cultivated land. Despite longstanding structural challenges including acute water scarcity, soil degradation, and salinization of groundwater resources, Gaza nonetheless achieved self-sufficiency in the production of several crops, particularly fresh vegetables.[1] While an impressive achievement given the obstacles, Gaza was still largely dependent on external sources to meet its food needs, with 56 percent of agricultural products consumed by families imported from outside.

Two years of war have inflicted immense damage on Gaza's agricultural sector. As introduced above, the most essential systems and infrastructure are in a state of complete devastation, while land remains inaccessible or in need of extensive rehabilitation. Explosive residues are estimated to have deposited thousands of tons of heavy metals such as lead, cadmium, copper and aluminum into the soil, with concentrations likely exceeding World Health Organization (WHO) safety thresholds for agriculture. **These contaminants not only render large areas unfit for cultivation but also pose a high risk of entering the food chain through bioaccumulation in crops, particularly vegetables.**[2] In addition, the extreme heat from detonations, in some cases reaching temperatures above 2,000°C, has incinerated organic matter and destroyed vital soil microbiota, impairing nutrient cycling and fertility.

Furthermore, damage to sewage and wastewater infrastructure has led to widespread discharge of untreated sewage into urban and agricultural areas, contaminating soil and water sources with harmful pathogens and pollutants. **Gaza's highly permeable sandy soils facilitate the rapid infiltration of these pollutants into its groundwater, a situation further exacerbated by the overcapacity of existing landfills and the proliferation of unregulated waste disposal sites.** Concurrently, the extensive damage to agricultural wells, compounded by protracted fuel shortages, has drastically reduced irrigation capabilities. Heightened dependence on the remaining operational wells – particularly in densely populated areas such as Al Mawasi – has accelerated groundwater overextraction, inducing severe seawater intrusion and a marked increase in salinity levels.[3]

Amid severely restricted land access and suffocated humanitarian aid channels, **family farming remains one of the few sources of fresh vegetables in Gaza, primarily through limited cultivation on small plots and cooperative greenhouse efforts that provide modest market supplies and limited income.** Urban agriculture has expanded significantly during the conflict, with backyard gardens (often under 150 square meters) growing seasonal vegetables and resilient, salt- and drought-tolerant crops using untreated wastewater. Greenhouse cultivation persists collectively, despite soaring operational costs, focusing on heat- and salinity-tolerant crops during summer and more diverse plantings in winter, though overall productivity is constrained by soil and water quality issues, while soil degradation has driven demand for costly artificial soils, further limiting sustainable production.[4]

[1] Key Informant Interview (KII), June 30, 2025.
[2] KII, June 4, 2025.
[3] KII, June 17, 2025.
[4] KII, June 4, 2025. KII, June 23, 2025. KII, June 30, 2025.

The conflict has inflicted lasting damage on Gaza's agricultural viability and created complex and mutually-reinforcing obstacles to rehabilitation and recovery. **Reconstruction requires both extensive and prolonged physical rehabilitation of farmland, irrigation, and water infrastructure, alongside urgent provision of – many of which face a double burden in their importing due to goods.**[5] The destruction of productive assets, in addition to wells, irrigation networks, and greenhouses, coupled with soaring input costs and disrupted supply chains, threatens the financial stability of farming households attempting to resume cultivation.[6] A critical and immediate barrier remains the widespread contamination of farmland with unexploded ordnance (UXO) and explosive remnants of war (ERW), the clearance of which is a slow, complex process likely to delay safe land access for years. Additionally, soil compaction from heavy military machinery has degraded soil structure and fertility, requiring extensive rehabilitation efforts. Furthermore, the destruction of desalination and wastewater treatment infrastructure has eliminated key sources of agricultural water, with repairs impeded by import limitations on technical components.

The destruction of Gaza's agriculture sector is the result of deliberate choices and policy by Israel in how it has waged its war against the coastal territory. **Any prospects of recovery are similarly dependent on these political factors.** widespread contamination of farmland with unexploded ordnance (UXO) and explosive remnants of war (ERW), the clearance of which is a slow, complex process likely to delay safe land access for years. Additionally, soil compaction from heavy military machinery has degraded soil structure and fertility, requiring extensive rehabilitation efforts.[7] Furthermore, the destruction of desalination and wastewater treatment infrastructure has eliminated key sources of agricultural water, with repairs impeded by import limitations on technical components. The destruction of Gaza's agriculture sector is the result of deliberate choices and policy by Israel in how it has waged its war against the coastal territory. **Any prospects of recovery are similarly dependent on these political factors.**

The report closes with a summary of innovative agricultural activities that can complement conventional reconstruction efforts, centered on strengthening agricultural resilience in Gaza through the integration of smart farming strategies and decentralized water solutions. **These approaches offer pathways to improve productivity, optimize resource use, and reduce dependence on increasingly scarce resources such as water, energy and arable land.** While not substitutes for the urgent rehabilitation of core agricultural infrastructure these interventions serve as complements to further early recovery planning and the resumption of Gaza's food production capacity following the war.

[5] KII, June 30, 2025.
[6] KII, June 30, 2025.
[7] KII, June 30, 2025.

Context, Objectives, and Methodology

Context

Since the outbreak of war in 2023, Gaza's agriculture sector has been comprehensively and systematically devastated. **Land, groves, crops, and key infrastructure and systems have been either badly damaged or destroyed as a result of bombing, invasion, and other military operations, alongside lack of maintenance and blockages on critical inputs and spare parts. Mass displacement, via Israel's sweeping evacuation orders and the recent imposition of the so-called Yellow Line[8] has further left vast swathes of land uncultivated**. Among the most damaging impacts as of October 2025:

- 96 percent of Gaza's cropland was either inaccessible or damaged, including virtually all cropland in the North Gaza, Gaza, and Rafah governorates. Only 601 hectares (ha), out of a total of 15,053 hectares is available for cultivation.
- Only 17 percent of total greenhouse area was accessible and undamaged, almost all of which is located in the Khan Yunis governorate. While 36 percent of greenhouse area in the Deir al Balah governorate was undamaged, it was simultaneously not accessible. In North Gaza, the majority of greenhouse area was accessible, but damaged.
- Only 9 percent of agricultural wells were undamaged and accessible. While 43 percent are accessible, they were also damaged.
- Only 7 percent of agricultural infrastructure was accessible and undamaged, located primarily in the Deir al Balah governorate. The North Gaza, Gaza, and Rafah governorates were assessed to have virtually no functional or accessible infrastructure. In Gaza and Deir al Balah, the majority of infrastructure was accessible, but damaged.

Combined with Israel's onerous restrictions on aid and commercial imports – which reached the level of a near-total blockade in March 2025 – and the destruction of crucial food processing, warehousing, and refrigeration facilities, the annihilation of Gaza's agricultural sector has had devastating food security impacts. **In August, the Integrated Food Security Phase Classification (IPC) confirmed that the Gaza governorate was experiencing famine, attributing the catastrophe to "the collapse of local food production" among other conflict-driven factors.** The same report assessed that 90 percent of children under two years old were consuming no more than two food groups per day, with 41,000 children threatened with death from severe acute malnutrition." The World Health Organization (WHO), reflecting on the harrowing state of hunger and malnutrition, warned that an "entire generation" was at risk of "stunted growth [and] impaired cognitive development."

While the ceasefire reached in October 2025 has led to a marked improvement in circumstances, the overall reality remains precarious. The IPC's analysis, undertaken two months after the agreement was brokered, showed that while famine conditions in the Gaza governorate had been "offset," the majority of the population continued to face high levels of acute food insecurity, including 100,000 people continuing to endure "catastrophic conditions." Between October 2025 and 2026 an estimated

[8] Under the ceasefire agreement reached in October 2025, Gaza has been divided into two zones, separated by a demarcation line drawn in yellow in the original document published by the White House. The population of Gaza is permitted to be present within the line, but is barred from accessing significant swathes of pre-war farmland located beyond the boundary.

101,000 children are expected to experience acute malnutrition, almost one-third of which would suffer from severe acute malnutrition. While restrictions on humanitarian operations had loosened to some extent since the October ceasefire, they still remain heavy to the point that aid actors could "meet only people's basic needs." **Crucially, the ability of agriculture to address prevailing food insecurity is limited, accounting for the immense levels of destruction to land and infrastructure, inability to access land beyond the so-called Yellow Line, and persistent Israeli restrictions of any items not deemed strictly humanitarian.** While prices of staple goods have consistently declined since the advent of the ceasefire, these improvements have not been the result of increased local food production but are exclusively the result of a more permissive import regime.

Study Background, Objectives, and Rationale

The present study is designed to assess the obstacles and prospects for rehabilitation of Gaza's agriculture sector following the massive destruction that has been inflicted on the sector and society writ large. The research is designed to incorporate, build on, and complement many of the existing studies that have been and continue to be conducted on the state of agriculture in Gaza. It also accounts for studies done on rehabilitating agricultural activities in the wake of destructive conflict, both in Palestine and abroad. **While several studies have been conducted on restoring these activities and rehabilitating the wider sector in the aftermath of conflict, key findings and policy prescriptions derived from these analyses are predicated on circumstances that are either sharply distinct, or wholly different, from Gaza's likely post-war reality**. Chief among these:

- Most studies assume that farmers will have access to outside markets, allowing for the export of certain crops. Such linkages are highly improbable in Gaza's post-war reality, with the territory likely to remain under a suffocating Israeli blockade, preventing the export of agricultural produce.
- The level of devastation inflicted on Gaza is incomparable to many other contexts that have been assessed. Gaza's level of human development has regressed to standards not witnessed for 70 years with the entire population impoverished. Even under the more favorable post-war contexts that can reasonably be envisioned, the entire territory will continue to have virtually no assets or purchasing power, limiting the prospects of locally-driven rehabilitation of the sector or production for any purposes other than subsistence.
- Gaza will remain under belligerent occupation by another country, severely limiting its access to crucial imports necessary to rehabilitate the agriculture sector. Occupation also entails the threat of frequent military action, access restrictions, and other dangers that impair economic recovery. By contrast, other contexts studied have not remained under occupation after the conclusion of conflict and, rather than malign policies by their occupier, are more likely to suffer from governmental neglect or poor decision-making.

As such, the following study is designed to assess the agricultural sector and prospects for rehabilitation in a manner rooted in Gaza's distinct circumstances. It was initiated and designed to answer the overarching research question: *To what extent has Gaza's agricultural sector been rendered inoperable and what are the priority needs to be focused on in rehabilitating the sector?*

There are several sub-questions that the research set out to answer, namely:

- Where and how much cropland was lost and remains active since October 7th?
  - What is the vegetation health and soil health condition of remaining active farmland?
  - What is the current land use of lost farmland?
  - Where and how much of formerly built-up areas is currently being used for agriculture, and where might area-based opportunities exist for agriculture investment/recovery?
- To what extent has small-scale agriculture in Gaza mitigated food insecurity?
- How can current access to and quality of water used for agriculture be characterized? How has it shifted in the past years?
- Which crops have become most scarce as a result of agricultural degradation and which are most viable given the current state of the sector and potential/likely future scenarios?
- To what extent are agricultural inputs necessary and available to pursue farming or rehabilitate land currently available in Gaza?
- How much time is necessary to restore Gaza's agricultural land to a viable state?
- What are the primary challenges and opportunities in initiatives to restore Gaza's agricultural sector?

To generate answers to these questions, the research employed a mixed-methods approach, consisting of the following research tools:

- **Remote sensing analysis:** Satellite imagery was used to provide insights into how access to and quality of land had changed since the beginning of the war. The research used imagery from the World Resources Institute's Dynamic World image collection to assess how land was being used and track land cover changes over time. Areas where land cover that was previously identified as agricultural but is now classified as non-agricultural[9] will be the basis for an analysis of agricultural land losses in Gaza, with the viability and level of degradation of cropland assessed through NDVI. Overall, the research assessed the presence of cropland and the health of vegetation across two scenarios, each accounting for a different geopolitical reality: one in which the Palestinian population remains entirely limited to the area within the Yellow Line and the other where they have access to the entirety of Gaza, save the so-called buffer zone expected to be established along the territory's perimeter.
- **Key Informant Interviews (KII):** The research team conducted a total of five KIIs over the course of the project. KIIs were held with experts in agriculture, food security, food systems, and the Gaza context, with many speaking from direct professional experience in wartime Gaza. The cohort of interviewees included those with both technical and programmatic expertise.
- **Secondary Data Review (SDR):** To supplement the analysis generated by the remote sensing analysis and KIIs, the project also incorporated information and analysis from secondary sources. The most prominent included similar studies conducted by organizations specialized in agriculture and food systems, food security, water availability and hydrology, and related topics. Several of these studies and actors are listed in the report's annex. Certain materials reviewed were provided by KIIs who had access to non-public reports and similar resources.

[9] Land was identified as agricultural if more than 60% of the DynamicWorld image collection categorized a pixel as cropland between March 10th and May 1st for each year from 2019 to 2025. Additionally, the median Normalized Difference Vegetation Index (NDVI) of the during April of each year, calculated using the Sentinel-2 satellite, must have been greater than or equal to 0.3 to minimize misclassified pixels by ensuring the vegetation cover is sufficient to represent cropland.

Analysis

The following section provides analysis of Gaza's agricultural collapse and explores potential futures for recovery or further deterioration. It is divided into five sub-sections, organized around distinct topics and themes, namely:

1. An overview of pre-war agricultural practices and structural challenges in the Gaza Strip, presenting many of the vulnerabilities and obstacles that preceded and accelerated the current crisis.
2. The impact of the war on access to land and degradation of land and water resources, through contamination, infrastructure destruction, and ecological disruption, in addition to the lasting damage caused to food systems both immediately and over the long term.
3. The impact of Israeli blockade and restrictions of the import of basic and crucial inputs.
4. Current land use and production patterns under wartime constraints, including urban agriculture and restricted greenhouse cultivation.
5. How access to arable land will change under two potential scenarios in the coming months.

Pre-War Agricultural Practices and Challenges in the Gaza Strip

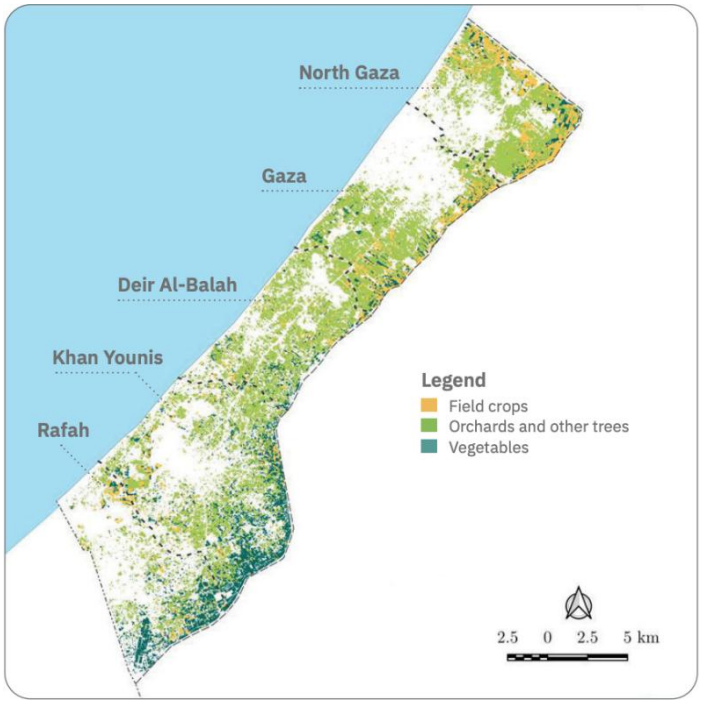

Figure 2: FAO and UNOSAT Map: Cropland classification in the Gaza Strip (February – May 2023).

Before the war, the Gaza Strip comprised 15,123 hectares (ha) of cropland or 42 percent of its total land area. Most land was used for orchards and other perennial tree crops (8,854 ha), followed by vegetable cultivation (3,208 ha) and field crops (2,952 ha). Regionally, North Gaza had the highest extent of field crops (964 ha), followed by the Gaza governorate (681 ha). The Rafah governorate was distinct in that a roughly equal amount of agricultural land in the governorate was used for both vegetable production and fruit trees. Most field crops and vegetables were planted along Gaza's eastern and northern perimeter, which today is destroyed and inaccessible.

The majority of Gaza's farmers have historically been small-scale by international standards, with most operating within a single family. In 2014, the Palestinian Authority's Ministry of Agriculture (MoA) defined small-scale family farming[10] as "the simplest and most obvious model of farm unit, where a farmer controls the production, resources, and assets of the farm, including labor." According to the 2021 Agricultural Census, the size of an average agricultural holding in Gaza was 3.8 dunums (0.38 hectares), with the majority of plots in Gaza less than 20 dunums (2 hectares)

[10] The agricultural census has historically excluded home gardens from inclusion given their miniscule size, despite the contributions of these plots to food security and household income.

and 17 percent less than 3 dunums (0.3 hectares). **Of the smallest plots in Gaza, 25 percent were farmed solely for the consumption of the household, the highest rate among holdings of various sizes.**

Beginning in the late 1990s, Gaza witnessed a shift toward intensive agriculture, characterized by widespread greenhouse cultivation. These greenhouses varied greatly in size, from rooftop installations of a few dozen square meters to expansive ground-level structures of hundreds square meters. **Key greenhouse crops included fruit and leafy vegetables, notably tomatoes, cucumbers, peppers, eggplants, and melons. Secondary crops consisted of bell peppers, jute mallow, beans, and watermelons.** In areas with saline water, tomato monocultures dominated, occasionally rotated with winter crops such as eggplants or peppers. Regions with easier access to fresher water typically grew diverse, year-round greenhouse cycles, including cucumbers, jute mallow, and melons. Greenhouse farming, while more profitable than rainfed or open-field irrigated crops, was also more water-intensive. Tomato monocultures in greenhouses consumed around 8,000 m^3/ha/year, compared to 3,000–7,000 m^3/ha/year for open-field crops, excluding strawberries, which could reach 10,000 m^3/ha/year. While greenhouse-based farming had increased noticeably, the majority of Gaza's land was irrigated by rain in 2020, with significant amounts of land using drip systems. Importantly, despite long-standing Israeli restrictions on access to arable land and inputs, Gaza was able to achieve a notable level of self-sufficiency in the production of fresh vegetables. Prior to the start of the war, the territory not only met its own domestic needs but also produced a surplus, with approximately 30 percent of its fresh vegetable output being exported to external markets, including the West Bank, Israel, and Gulf countries.[11]

Gaza is characterized by a semi-arid climate and severe water scarcity, both of which constrain agricultural production. **Even before the war, Gaza's agriculture sector was struggling and facing long-term threats to its viability and production.** Gaza's coastal aquifer was becoming increasingly depleted and damaged as a result of over-exploitation by farmers using the water to irrigate crops. **In particular, mounting levels of seawater intrusion were turning the water salty, while chemical run-off and pesticides, the latter of which were often used in agriculture, were causing pollution.** To counteract the effects of water salinity, farmers often resort to over-irrigation to leach excess salts and reduce soil salinization, contributing further to the overextraction of already-depleted groundwater resources. High levels of water salinity and pollution adversely impact overall crop yields. **Gaza's grey water footprint (GWF), defined as the volume of freshwater necessary to assimilate pollutants, was evaluated to be "unsustainable" in a 2024 study[12], owing to the high use of fertilizers and low prevalence of nitrogen-absorbing crops.**

Climate change has intensified Gaza's environmental stress by reducing rainfall, particularly between the critical months of October to January, which has reduced groundwater recharge. Simultaneously, rising temperatures have intensified irrigation demands. These climatic shifts have had tangible impacts on agricultural productivity: the 2023 wheat harvest, for instance, recorded a 1,000-ton decrease compared to 2022 due to drier seasons and insufficient rainfall. In addition,

[11] KII, June 30, 2025.
[12] Though published in 2024, the study used agricultural data from 2021.

climate-related stress has led to elevated rates of flower drop and asynchronous flowering among various plant species, significantly diminishing fruit yields.[13]

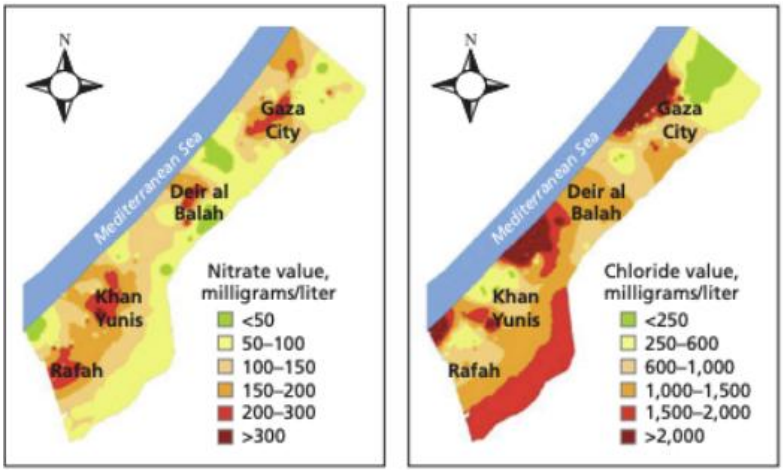

Figure 3: Contour map of nitrate and chloride presence in Gaza's coastal aquifer in 2016.

Before the current war, Israel had incrementally imposed a so-called buffer zone along the eastern and northern perimeters of Gaza. This process began in 2000, during the Second Intifada, when Tel Aviv unilaterally declared the establishment of an undefined "no-go" area inside Gaza, which was soon followed by systematic leveling of land. By mid-2006, Israel was regularly flattening land up to 300–500 meters from the perimeter fence. Between 2006 and 2012, approximately 25 km^2 of cultivated land within what became known as "Access Restricted Areas (ARAs)" was razed by Israeli forces. **By the time of the 2012 ceasefire, the buffer zone encompassed approximately 14 percent of Gaza's total territory, but 30 to 55 percent of Gaza's arable land. Restrictions on this zone resulted in the annual loss of an estimated 75,000 metric tons of agricultural produce, equating to approximately $50 million in foregone value each year.**

The repeated wars waged on Gaza, along with restrictions on rebuilding and rehabilitation, have also been among the most damaging for the agricultural sector. The 2008-2009 war, the first in Gaza's modern history, caused $268 million of damage to the sector and was characterized by the leveling or destroying of a "major portion" of the territory's agricultural assets. Before the present war, the 2014 conflict was the most destructive, causing approximately $449 million of direct and indirect losses to the agriculture sector. **Gaza has also been denied the opportunity to rebuild in the wake of these destructive conflicts as a result of the decades-long blockade, the most oppressive element of which is Tel Aviv's maintenance of a "dual-use" list under which any items assessed to have a military application can be barred from entry.** Fertilizers, chemicals, heavy machinery, and crucial inputs to operate the necessary water and electricity networks have all been prohibited under this policy. **The ultimate result has been the withering of agriculture as a productive economic sector**. In 2006, before the political schism between Gaza and the West Bank and the intensification of Israel's blockade, there were an estimated 100,000 farmers in Gaza. By 2016, two years removed from Gaza's third war in six years the number had shrunk to 18,000.

Conflict-Induced Degradation of Agricultural Land and Water Resources and the Collapse of Gaza's Food System

Since the outbreak of the present war, the combination of bombardment, sweeping evacuation orders, destruction of agricultural roads, and systematic targeting of people who have attempted to return and cultivate fields, have rendered the majority of Gaza's agricultural land inaccessible and unproductive. Within the Yellow Line, the area of Gaza in which Palestinians are permitted to live,

[13] KII, June 30, 2025.

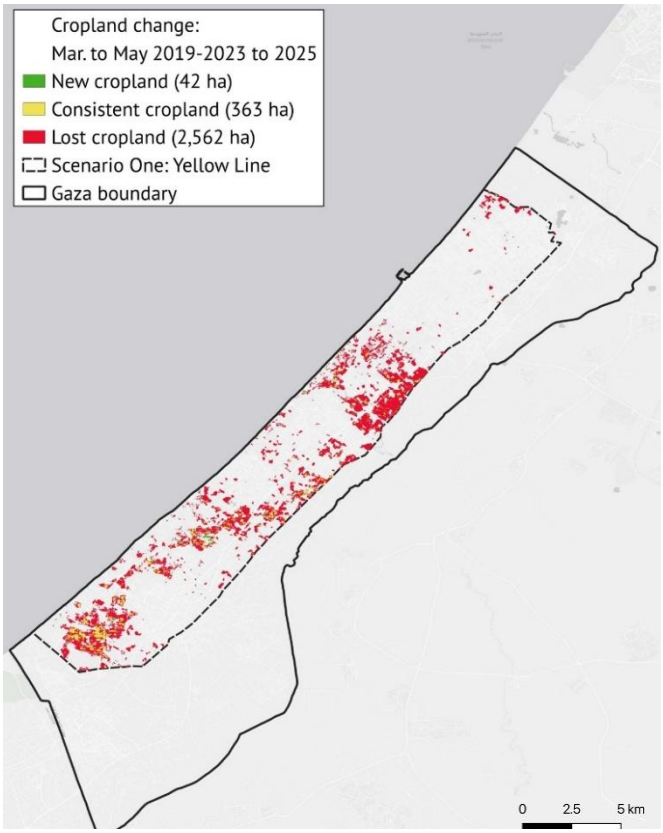

Figure 4: A comparison in changes of cropland character within the Yellow Line, comparing March – May cycles from 2019 – 2023 to the cycle in 2025.

this destruction is especially profound and virtually no agricultural land remains available to the population. Satellite analysis reveals that, as of May 2025, 2,562 ha of agricultural land has been lost, while only 363 ha remains in use.[14] Agricultural land in the Wadi Gaza area between Gaza City and Deir al Balah has been completely lost as a result of Israel's construction of the Netzarim Corridor during the war. As a result, the only remaining cropland is located in the Al Mawasi area of western Khan Yunis, though this former breadbasket of Gaza has also suffered extensive losses.

Approximately half of the cropland that has been lost has reverted to grass or shrubland, a development emblematic of the inability of farmers to properly tend and cultivate lands over the two years of war. Importantly, 877 ha, almost one-third of pre-war cropland, has been transformed into built-up areas, primarily camps and related sites for the displaced. As Gaza's population remains squeezed within the Yellow Line, the ability to rehabilitate this land or return it to agricultural purposes will be limited or outright foreclosed given its purpose in providing living space.

Beyond the loss of access to farmland, the war has seriously degraded and impaired Gaza's agricultural sector and food production by other means. Chief among these is the damage to the soil's fertility and other qualities critical to cultivation of crops. **Vast swathes of cropland have been razed, compacted, and in some cases incinerated due to the movement of heavy military machinery and sustained shelling. This has been compounded by widespread soil contamination from the deposit of heavy metals and toxic residues associated with munitions and the infiltration of pollutants from untreated solid waste and wastewater.** Critical infrastructure essential for production has been either severely damaged or destroyed, including irrigation networks, agricultural wells, greenhouses, solar-powered pumping systems, tractors, water tanks, and seedling nurseries. These cumulative and compounding effects – the repercussions of which are expected to persist for decades – have precipitated the collapse of Gaza's agrifood system, erasing the population's capacity to pursue even rudimentary local food production.

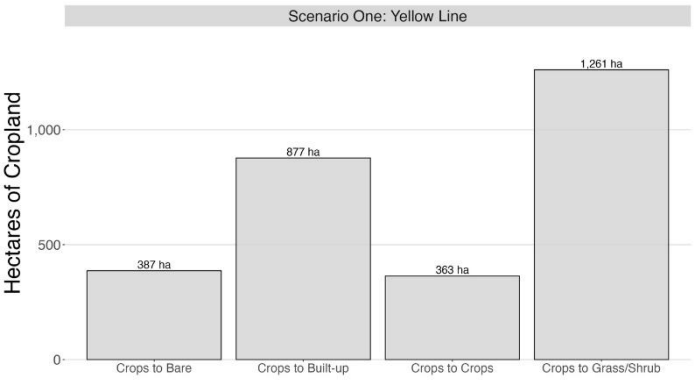

Figure 5: Change in land use of former cropland within the Yellow Line

[14] A negligible amount of land (42 ha) has been brought online.

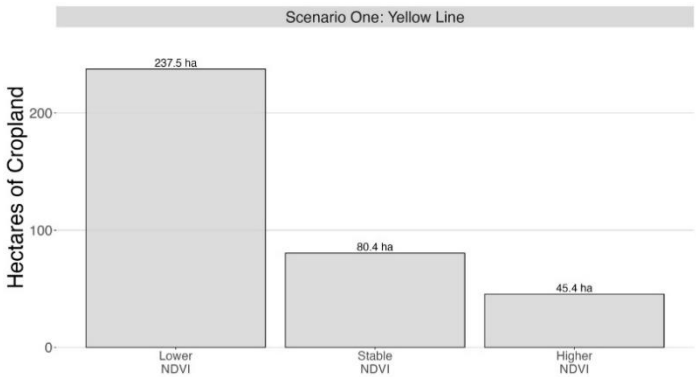

Figure 6: Change in NDVI of cropland within the Yellow Line from 2023 – 2025.

The compounded effect of this devastation is telling in the amount of land that is still suitable for agriculture. Nearly two-thirds (65 percent) of the cropland that remained under cultivation until 2025 exhibits less vegetation according to an NDVI analysis, suggesting diminished productive capacity. This diminution is likely caused by several factors, including damage to the environment, inability to adequately tend the land, and loss of crucial inputs and other resources to promote plant health.

Degradation of Soil from Explosives and Toxic Pollutants

The following section provides an overview of the leading drivers of degradation in soil health as a result of the war. In particular, the immense scale of the Israeli bombardment, as well as the use of heavy machinery by invading forces, are among the leading factors in damage to the soil and its limited ability to be used for cultivation without significant rehabilitation.

Microbial Soil Degradation Driven by Explosive Heat Stress

The intensity and scale of Israel's bombardment and use of explosive weapons across Gaza have been among the most consequential drivers in the destruction of soil health. **Estimates assess that over 85,000 tons of explosives have been deployed via aerial and naval means, as well as artillery, and engineering demolitions – equating to approximately 250 kg of explosives per square meter across the territory.**[15] The intensity of bombardment has caused substantial damage to the soil's chemical and biological properties. Explosive detonations, which can generate temperatures exceeding 2,000°C, have incinerated organic matter and destroyed critical soil microorganisms. This microbiological disruption has severely impaired nutrient cycling and soil fertility, conditions essential for sustainable crop production. The loss of beneficial microbes and organic substrates could render the soil unproductive for at least five years, even under optimal rehabilitation efforts, which are unlikely to materialize in Gaza's post-war reality.[16]

Heavy Metal Contamination of Gaza's Soils from Explosive Residue

The extensive use of explosives during the war has resulted in severe environmental contamination of the soil, particularly with heavy metals, likely to include nickel, chromium, copper, manganese, lead, and phosphorus, as well as cobalt, cadmium, and aluminum. **Based on typical munition composition, it is estimated that these explosives may have deposited around 6,800 tons of heavy metal residues into the soil.** Given that heavy metal content in munitions can range between 4 and 12 percent, and assuming contamination is concentrated over 50 percent of the territory, local soil concentrations are likely to exceed WHO thresholds for safe agricultural use by 1.3 to 2.5 times.[17]

[15] KII, June 4, 2025.
[16] KII, June 17, 2025.
[17] KII, June 4, 2025.

The impact is further exacerbated by the spatial concentration of bombardments in agricultural areas, increasing the risk of crop contamination through accumulation of toxic metals, particularly in vegetables, which are highly sensitive to soil toxicity. Studies from other conflict zones have demonstrated the long-term persistence of such pollutants in soils, noting that contamination can endure for decades. Moreover, this degradation compounds pre-existing environmental vulnerabilities in Gaza, where previous wars had already raised levels of contaminants and the breakdown of wastewater infrastructure had further contributed to soil toxicity. **Even in areas not directly hit by explosives, the indirect spread of contaminants raises the likelihood that surviving produce may still be unfit for consumption**, echoing patterns observed in other regions exposed to Israel's style of warfare, such as southern Lebanon.

White Phosphorus and Environmental Contamination

The use of white phosphorus munitions by Israeli forces in Gaza has also caused damage to the agriculture sector, though the overall impact may have been mitigated by the territory's environmental profile. **As an incendiary substance, white phosphorus not only destroys orchards, groves, and vegetation upon contact, but also leaves behind chemical residues that can persist in the soil and water**. Its presence alters soil chemistry by acidifying the substrate, thereby reducing essential nutrients and harming soil-dwelling microorganisms critical to fertility and nutrient cycling. While white phosphorus typically degrades within days in oxygen-rich environments, around 10 percent may remain in anaerobic conditions such as deep soil or aquatic sediments, where it can persist for decades or even centuries.

In Gaza's predominantly alkaline soils (pH up to 8), phosphorus tends to become chemically immobilized, reducing its direct toxicity to plant roots. However, significant harm still occurs through foliar absorption, particularly among perennial trees, which have shown symptoms of leaf loss and dieback. While the long-term toxicity of white phosphorus is generally considered less severe than that of heavy metals, its immediate environmental effects pose a substantial threat to agricultural productivity and ecological stability in Gaza.

Soil Contamination from Fuel Spills and Solar Panel Debris

In addition to metal residues, fuel-related contamination has been documented in previous wars. In the aftermath of the 2008-2009 war, a United Nations Environment Program (UNEP) investigation found that the destruction of a diesel tank at a Rafah cement factory released approximately 1,000 liters of fuel, severely polluting the surrounding soil with Total Petroleum Hydrocarbons (TPHs) and aliphatic hydrocarbons. Additionally, the destruction of solar panels during bombardment not only eliminates a critical source of energy but also poses environmental risks through the potential leaching of hazardous substances such as cadmium and lead into the soil.

Worsening Quality and Availability of Agricultural Water Resources

Gaza's water resources have also suffered extensive damage to their quality and associated use for agriculture, which, like the degradation of soil, will have far-reaching effects.

Contamination of Aquifers from Damage to Wastewater and Waste Management Systems

Across Gaza, approximately 70 percent of sewage pumps and wastewater treatment facilities have been rendered inoperative due to bombardments, leading to widespread discharge of raw sewage into urban zones and agricultural lands. Historical precedents underscore the gravity of this situation; during the 2008-2009 war, the failure of the Al Zeitoun sewage plant alone resulted in over 100,000 m^3 of wastewater inundating farmlands and residential areas, which led to contamination of groundwater coliform bacteria. Current dynamics suggest similar impacts have occurred, with informal waste dumping, damaged infrastructure, and the absence of regulated disposal mechanisms exacerbating soil and aquifer contamination. **Gaza's naturally sandy and porous soil heightens the risk of infiltration, allowing untreated effluent and leachate from solid waste – especially infectious medical waste and non-organic materials such as plastics, glass, and metals – to enter the groundwater system.** The primary landfill at Johur al Dik in central Gaza, already beyond its safe capacity prior to the war, is no longer viable for safe waste containment. In this context, the proliferation of informal dumpsites near urban and agricultural zones, coupled with the inability to manage hazardous waste streams, has **significantly accelerated the toxification of soil and the nitrate contamination of Gaza's shallow coastal aquifer, posing enduring risks to agricultural productivity.**

Increased Groundwater Salinity Resulting from Overextraction of Remaining Accessible Wells

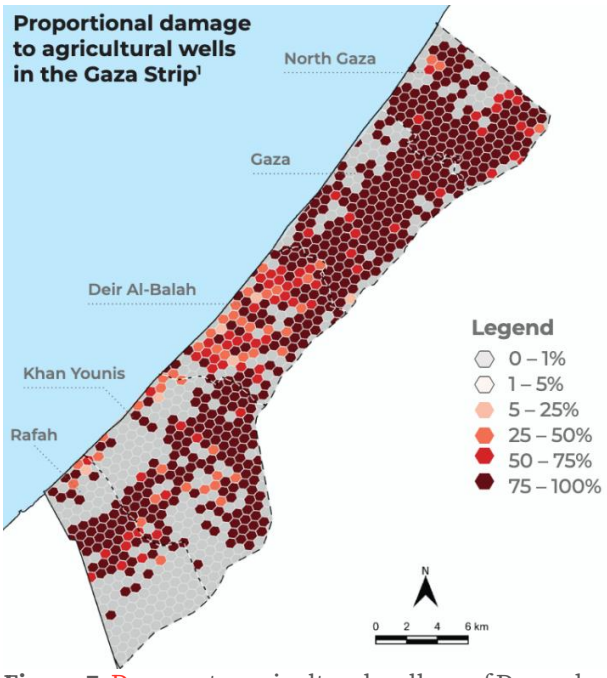

Figure 7: Damage to agricultural wells as of December 31, 2024. Each hexagonal tile shows the proportion of damaged wells to total wells within the 40 ha area.

Agricultural wells across the Gaza Strip have sustained extensive damage over the course of the war. **In the eastern regions of Gaza, where agricultural activity was once concentrated, nearly all irrigation infrastructure and wells have been destroyed.**[18] Even for those that were not damaged or destroyed, the ceasefire boundaries have rendered them inaccessible to farmers. Additionally, most small private wells remain non-functional due to fuel shortages and the absence of reliable power sources, such as generators.

In some areas, a limited number of agricultural wells continue to provide relatively good-quality water, suitable for the cultivation of vegetables. However, as many families have relocated to and remain in formerly agricultural zones – chief among them Al Mawasi – these wells are increasingly being repurposed for domestic use. **This shift in usage places additional pressure on already fragile groundwater reserves and elevates the risk of seawater intrusion, which compromises water quality by increasing salinity and diminishing its suitability for agricultural purposes.** In some wells, salinity has increased up to tenfold compared to pre-war levels, rendering the water increasingly unsuitable for irrigation, especially for salt-sensitive crops.[19]

[18] KII, June 23, 2025.
[19] KII, June 23, 2025.

Population Displacement and Water Degradation in Al Mawasi

The extreme concentration of displaced populations in Al Mawasi has imposed severe strain on the local environment. The coastal areas' sandy soils, shallow water table, and coastal proximity render it highly vulnerable to rapid infiltration and seawater intrusion. **The influx of over a million displaced individuals over the course of the war accelerated the overextraction and contamination of limited water resources, challenges exacerbated by the complete absence of potable water and wastewater infrastructure**. Humanitarian efforts have introduced new wells to address water scarcity, but intensive groundwater abstraction in some areas has heightened the risk of seawater intrusion.

After the first year of the war, salinity levels in Al Mawasi wells rose to approximately 4,000 mg/L – more than double their pre-conflict values. Water samples collected from these locations reveal increased electrical conductivity levels, signaling rising salinity that directly degrades irrigation water quality. **Elevated salinity has caused severe agricultural impacts, particularly in salt-sensitive crops such as vegetables, leading to reduced yields and, in some cases, complete crop failure**. Young olive trees in nurseries have been notably affected, with many scorched or dying due to salinity stress. Additionally, the dense population has generated an estimated 90,000 daily sewage disposal pits ("cups") infiltrating the sandy soil, facilitating human waste contamination of groundwater. Field analysis has also detected the presence of fecal matter in several well samples, confirming the direct contamination of groundwater by untreated human waste. To counteract pathogen proliferation harmful to crops, vegetable farmers have resorted to soil sterilization with methyl bromide, a toxic biocide banned in many countries due to its ozone-depleting effects, highlighting the severe environmental and agricultural challenges confronting the area.

The Israeli Blockade and Restrictions: Driver of Collapse and Obstacle to Recovery

Alongside the destruction of the agricultural sector, including its crucial inputs and infrastructure, Israel's blockade on Gaza has also significantly impaired efforts to pursue agricultural activities beyond the smallest scale. **As introduced above, the expectation that a suffocating blockade will remain in place even in a post-ceasefire context is also one of the biggest barriers to rehabilitating the sector.** Throughout the course of the war, farmers have been completely and deliberately isolated from the outside world, forced to make do with what little resources still existed in Gaza. These restrictions govern even the most basic needs and minute items, with Israel going as far as prohibiting the import of high-yield seeds from seed banks in the West Bank, which are crucial to resuming planting. Israel has also restricted the import of fertilizers, plastic sheets, and other infrastructure necessary to construct or rehabilitate basic infrastructure, such as greenhouses. **In some instances, farmers have resorted to using domestic or *baladi* alternatives, especially in the cases of seeds and fertilizer, but the effectiveness of these local variants is limited and yields have suffered as a result.**

These local innovations will not be enough to rehabilitate farming activities beyond the most basic levels. Rather, heavy machinery, sophisticated mechanical parts, and regular and widespread provision of key inputs are necessary if the sector will have any prospect of genuine recovery.

However, many of these items, including fertilizers, tractors, tilling equipment, and rubble-removal machinery, are classified by Israeli authorities as "dual-use" goods, meaning they have both been prohibited during the war and are likely to remain barred or heavily restricted in a post-ceasefire reality. In other cases, Israel deems the items as not strictly humanitarian and bars their entry on such grounds. The rehabilitation of laboratories capable of conducting the sophisticated studies on the health of land, water, and other fundamentals of agriculture with also require access to specialized equipment and parts.[20] In January 2025, the Food and Agriculture Organization (FAO) estimated that $74.5 million would be required to meet immediate agricultural needs alone, warning that the full reconstruction of the sector could take "years, if not decades."

Protracted Agricultural Land Access Restrictions Due to UXO Clearance Delays

One of the most immediate and life-threatening threats for farmers intent on resuming agricultural activities is the widespread presence of UXO and ERW scattered, often buried or concealed, across farmland. The clearance of such devices, especially deep-buried aerial bombs, is an arduous and prolonged process. Based on previous operations, the United Nations Mine Action Service (UNMAS) estimates a clearance rate of approximately one deep-buried bomb per month. **Given the unprecedented scale of contamination during the conflict, the agency has emphasized that immediate efforts will focus on surface-level ordnance, with deeper clearance operations delayed indefinitely.** The persistent presence of these explosive dangers constitutes one of the most significant and enduring obstacles to agricultural land access, hindering both crop cultivation and livestock rearing and posing a profound challenge to restoring domestic food production.

Widespread Soil Compaction Requires Lengthy Rehabilitation

Further, Israel's bulldozing and the deployment of heavy military machinery across Gaza have resulted in intense soil compaction, which has substantially reduced the permeability and aeration and impeded water infiltration and root penetration. It has also resulted in the degradation of the topsoil layer, the high organic matter content and microbial activity of which is essential to nutrient cycling and soil fertility. As a result, the affected land has become largely unfit for cultivation, necessitating extensive rehabilitation to restore its use for agriculture. However, the import of essential machinery for re-tilling and leveling the soil is unlikely to be permitted by Israeli authorities, even in a ceasefire context, obstructing the vital revival efforts needed to restore soil health and productivity.[21]

Barriers to the Rehabilitation of Tree-Based Production

The restoration of tree-crop agriculture in Gaza also faces profound long-term challenges that render recovery nearly impossible in the short term. Tree crops such as olives and citrus not only require five to seven years to become productive and up to fifteen years to reach full maturity, but are also considered "highly vulnerable" to the impacts of climate change given their high water demand, further inhibiting prospects for rehabilitation.

Obstructed Repair of Water Treatment Infrastructure and Lasting Ecological Damage

[20] KII, June 30, 2025.
[21] Ibid. KII, June 4, 2025

Prior to the conflict, a growing portion of water for agriculture was sourced from desalination plants capable of treating wastewater. This capacity, however, no longer represents a viable option for agriculture due to systematic destruction, incapacitation by Israeli forces, and prioritization of scarce water supplies for drinking and other non-agricultural purposes. **The restoration of these facilities is highly unlikely in the short term, as their reactivation depends on the importation of critical technical components, many of which are classified as dual-use items and are therefore subject to Israeli restrictions.** Historically, the importation of such components faced frequent delays or outright denials by Israeli authorities, even before the current war, with limited approvals typically occurring only under sustained international pressure.

Agricultural Land Use and Production Dynamics During and After the Conflict

Amid severely restricted access to agricultural land, the trickle of humanitarian aid, and the depletion of existing food reserves, the smallest means of farming have become one of the few remaining sources of local food production, especially fresh vegetables, in Gaza. Cultivation within the limited accessible areas – often under five dunums (5,000 square meters) and frequently organized through cooperative efforts in greenhouses – has **enabled a middling degree of market replenishment while providing a critical, though limited, source of income for agricultural workers and, in some cases, critical source of otherwise unavailable nutrition for their families.** In parallel, backyard or household farming, primarily intended for subsistence, supports direct household consumption and occasionally yields small surpluses for sale, offering an additional yet limited income stream. However, while these adaptive practices serve as vital coping mechanisms, they fall drastically short of addressing the scale and severity of Gaza's dire state of food insecurity.[22]

Urban Agriculture

During the war, agricultural activity has shifted to urban areas, where backyard plots have proliferated as an emergency measure. This practice, commonly referred to as "urban agriculture," has rapidly emerged as a critical strategy for subsistence food production, typically involving small-scale cultivation on plots up to 150 square meters.[23]

At the household level, urban gardens typically host a seasonal rotation of vegetables: in spring and summer, common crops include cucumbers, tomatoes, eggplants, hot and sweet peppers, sweet corn, pumpkins, and honey gourds, while the autumn season sees the cultivation of lettuce, cauliflower, cabbage, and potatoes. In the absence of safe water for irrigation, many have resorted to using untreated wastewater to grow resilient crops such as mloukhiya, badruziliya (Swiss chard), and parsley, all of which require minimal inputs and are known locally as "strong plants" for their ability to thrive in harsh conditions, including sandy soils. These crops are specifically chosen for their tolerance to salinity, drought, and the lack of pesticides or chemical fertilizers.[24] In parallel, the practice of foraging and cultivating wild, self-regenerating plants such as khubeiza (mallow) has re-emerged as a vital coping strategy. **Many of the vegetables listed above are rich in key vitamins and**

[22] KII, June 4, 2025.
[23] KIIs, June 4., 2025. KIIs June 30, 2025.
[24] KII, June 4, 2025.

minerals, including Vitamins A, C, and K, as well as the calcium, potassium, and magnesium. However, with the exception of potatoes, they offer limited calories.

The lack of refrigeration infrastructure diminishes the utility of home gardens harvests, as families are unable to preserve their crops, often resorting to immediate sale or renting costly cold storage facilities.[25] When sold, this modest production provides the growers with a source of income, which can be transformed to meet other urgent household needs.

Crop Cultivation under Greenhouses

Only a minority of Gaza's pre-war greenhouses remain operational, with farmers adopting a collective model to adapt to the damage of the war. **As a result of the pressures of the war, however, the cost to use a functioning greenhouse has risen from $1,000 before the war to $6,000 presently, forcing many farmers to pool their resources and limit individual production.** Under greenhouses, farmers can grow a limited range of crops that are better shielded from harsh climatic and soil conditions, using organic substitutes such as compost and manure due to the unavailability of synthetic fertilizers and pesticides.

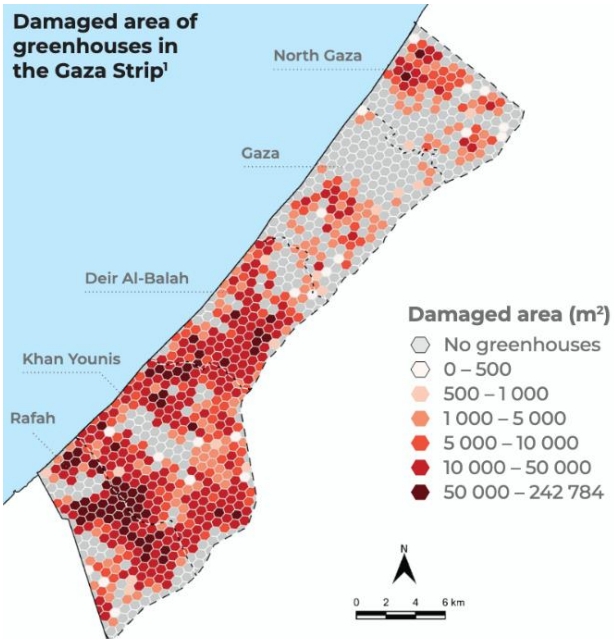

Figure 8: Damage to greenhouses as of October 2025

Seasonality remains a critical determinant in crop selection and productivity. During the summer months, heat-tolerant crops such as mloukhiya, okra, cucumber, French beans, and tomatoes dominate greenhouse plots. **These species are selected for their resilience to elevated temperatures and minimal water requirements.** Leafy vegetables, like parsley, may also be intercropped along plot margins to optimize space**. In contrast, winter conditions are more favorable for greenhouse production, allowing for greater crop diversity and lower maintenance demands.** Crops such as spinach, badruziliya, lettuce, parsley, dill, turnip, and cauliflower can be cultivated successfully under cooler temperatures. Farmers often rotate or pair crops to preserve soil fertility and maximize yield, employing combinations like hot peppers and cucumbers or red cabbage and corn. However, greenhouse output remains constrained by salinity stress, with crops like cucumber and peas particularly vulnerable to salt accumulation. In contrast, tomato and eggplant exhibit moderate tolerance and are thus more commonly cultivated in saline-affected greenhouses.[26]

Restricted Access to Essential Agricultural Inputs

As explored above, Israel has banned the entry of agricultural seeds since the beginning of the war, forcing farmers to rely on pre-war seed reserves.[27] However, as these stored seeds age, their

[25] KII, June 30, 2025.
[26] KII, June 4, 2025. KII, June 23, 2025. KII, June 30, 2025.
[27] Anecdotally, some farmers have reportedly been able to procure seeds through the black market or possibly through smuggling along the commercial track.

germination rates decline significantly, compromising planting success and limiting productivity over time. While some farmers have turned to locally available hybrid seeds, these varieties present their own risks. **In particular, they are often detrimental to soil health, reducing fertility and undermining prospects for sustainable cultivation. Notably, Palestine maintains a seed bank containing over 60 varieties of indigenous seeds, yet the entry of these seeds into Gaza remains prohibited by Israeli authorities.**[28]

Simultaneously, the deterioration or inaccessibility of natural soil due to land toxification, salinization, or destruction has led to increased reliance on artificial soils. **These substrates, once an adaptive solution, are now largely unaffordable: prices have surged to approximately one dollar per seedling, marking a tenfold increase**. Some farmers have attempted to produce alternatives using plant residues or palm fibers, yet these experimental approaches have so far yielded limited success.[29]

Potential Expansion of Agricultural Land & Potential for Cultivation

The analysis concludes by projecting how access to cropland may change in the short-term. Specifically, it focuses on the prospect that the Yellow Line may be expanded and Palestinians gain access to greater land across Gaza. The American ceasefire plan envisions such an outcome, stipulating Israel's withdrawal from the Yellow Line following the deployment of the yet-to-be-established International Stabilization Force. Such a withdrawal will give the people of Gaza access to the entirety of the territory with the exception of a so-called buffer zone that will extend approximately one kilometer inwards from the territory's perimeter. **Though a single, sweeping withdrawal should be considered unlikely – with Israel more likely to conduct piecemeal redeployments that open up only small segments of land at a time – the analysis and mapping provided below provides the full picture of land that may become accessible at various points and its level of destruction or lack thereof.**

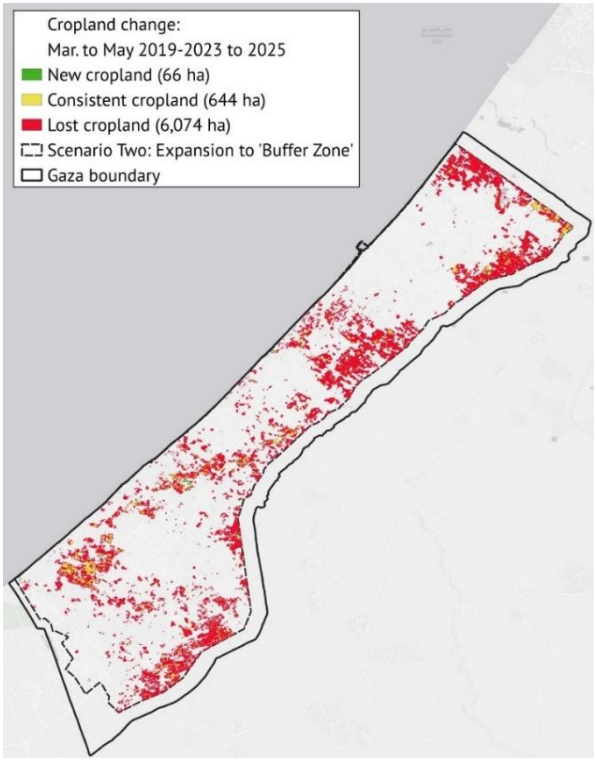

Figure 9: A comparison in changes of cropland character up to the projected "buffer zone", comparing March – May cycles from 2019 – 2023 to the cycle in 2025.

Overall, land beyond the Yellow Line is as devastated as land within it. Out of 6,718 ha of pre-war cropland, 90 percent (6,074 ha) has been destroyed. This includes the particularly fertile tracts in eastern Khan Yunis and Beit Hanoun, which provided many of Gaza's vegetable and field crops in the period before the war. Much of the cropland is located directly adjacent to the projected boundaries of the buffer zone, which presages limited access and persistent military threats, further reducing the possibility for rehabilitation or successful cultivation.

[28] KII, June 30, 2025.
[29] Ibid.

Conclusions and Prospects for Recovery

The war in Gaza precipitated a profound collapse of its agrifood system, destroying virtually every component essential to local food production. This includes the widespread destruction of agricultural land and infrastructure, as well as the imposition of no-go zones and restrictions that has left only four percent of all farmland accessible for cultivation and undamaged. These constraints are further compounded by the physical degradation and contamination of soil and water sources and the persistent and near-total restrictions on vital agricultural inputs.

The failure of local food production has far-reaching implications for humanitarian planning. Aid actors will need to plan for a reality where the population will remain in a state of near-total reliance on external sources of food, whether obtained from the private sector or, in the case of the vast majority of the population, provided through emergency food assistance. **In addition to continuous provision of significant volumes of aid, meeting this immense need will also have to account for the systematic Israeli restrictions on the quantity and type of food and humanitarian assistance permitted to enter Gaza.** This situation underscores the urgent need for recovery strategies that integrate agricultural rehabilitation into post-conflict response and resilience planning.

Safeguarding the remnants of Gaza's agricultural sector and identifying the key steps ahead is essential to laying the foundation for long-term recovery. As soon as conditions allow, immediate priorities should include **comprehensive environmental and engineering assessments to evaluate the extent of soil and water contamination**, **identifying sources of pollution**, **relocating the temporary waste dumps** – many containing non-biodegradable materials – away from agricultural zones to prevent further soil degradation, and **initiating the clearance of UXO and ERW**.

Rehabilitating agricultural infrastructure is equally critical. This encompasses the **reconstruction of farm roads and damaged greenhouses, restoration of electrical and water networks**, and **repair of irrigation wells**. Land reclamation will require **debris removal**, **soil re-tilling and leveling**, **and the reintroduction of organic fertilizers** – an urgent measure given the collapse of livestock production and the resulting shortage of natural soil options.

Revitalizing agricultural nurseries is also a priority, with an emphasis on **scaling up the production of seedlings and trees**, **conserving native cultivars**, **and focusing on mother nurseries for plant cloning** to preserve varieties best adapted to Gaza's environmental conditions. Protective interventions, such as the **installation of vegetative and metal fencing**, must be deployed to shield rehabilitated lands from overgrazing and intrusion by stray animals.

In parallel, **legal and rights-based assistance** will be necessary to clarify land tenure for smallholder farmers and to **establish social security mechanisms for affected agricultural communities**. Finally, significant **investment in large-scale training and capacity-building programs** will be essential, especially considering the extensive loss of many agricultural workers and agronomists.[30]

[30] KII, June 4, 2025. KII, June 23, 2025.

Alternative Solutions for Reviving Gaza's Agriculture in the Aftermath of War

In the course of discussions on the state of Gaza's agriculture and prospects for rehabilitation, key informants provided several examples of innovative techniques with potential to drive the sector's recovery and incorporate modern agricultural practices. These perspectives and suggestions have been supplemented by research on appropriate techniques from relevant contexts. **Most of the methods and technology identified will remain inaccessible or impractical in the immediate and near-term, but have value as part of longer-term planning.** As the region grapples with acute water scarcity, degraded soils, chronic energy shortages, it is imperative to explore and implement modern approaches that not only alleviate current pressures but also build sustainability into the agricultural system.

Smart Farming Solutions for Gaza's Recovery

Solar Panel Power

In the context of Gaza's electricity crisis - intensified by widespread infrastructural damage and near-total blackouts – solar energy is a critical enabler of smart farming solutions capable of sustaining and revitalizing agriculture. **Gaza offers significant solar potential, with the ability to provide farmers with a dependable, clean energy source to operate essential systems such as water pumps, irrigation systems, cold storage units, and post-harvest processing independently of the destroyed electrical grid.** This autonomy will reduce dependence on costly diesel generators, lower production costs, and significantly mitigate environmental pollution.

Beyond fixed installations, mobile solar energy units represent a particularly valuable innovation for Gaza's post-conflict recovery. **These systems can be deployed flexibly across locations, making them well-suited for powering decentralized water infrastructure, including mobile groundwater pumping stations and compact water treatment plants.** Given the urgent need for irrigation in both summer and winter seasons, alongside the persistent challenge of bringing in the necessary equipment, mobile solar technologies provide a scalable solution to restore water access and enhance resilience. Evidence from the war shows that farmers who were able to preserve pre-existing solar infrastructure and private water sources were significantly more resilient. These outcomes underscore the strategic importance of investing in decentralized, solar-powered energy as a cornerstone of post-war agricultural recovery.[31]

Automated Drip Irrigation

Drip irrigation is an efficient technique that delivers water slowly and directly to the root zone of plants, maintaining consistent soil moisture levels. This localized application not only conserves water but also helps keep plant foliage dry, thereby reducing the incidence of diseases and insect damage. In pre-war Gaza, manual drip irrigation systems were already widely used in greenhouses to improve water use efficiency. However, dependence on manual operation often leads to irregular watering and overapplication, resulting in water waste, crop stress, and diminished fruit weight. **Rebuilding systems to incorporate automated drip irrigation (i.e., equipped sensors, timers, solenoid valves, and programmable controllers) can enhance the precision and timing of water**

[31] KII, June 30, 2025.

delivery in accordance with crop needs and is especially critical in a context of acute water scarcity. Moreover, applied irrigation water productivity has been evaluated across various crops in Gaza, providing a critical foundation for the effective design and implementation of automated irrigation strategies.

Hydroponic Agriculture

Hydroponic agriculture is a soilless cultivation technique in which plant roots are grown directly in nutrient-rich water solutions or in substrates such as gravel, coconut coir, or vermiculite. This method allows for significantly higher plant densities while also enabling precise control over environmental variables such as temperature and humidity. In Gaza, the most widely adopted hydroponic system before the war was the low-cost deep water culture (DWC) method, wherein plants are cultivated on floating rafts in aerated nutrient basins. This system has demonstrated impressive productivity, achieving yields of up to 24 lettuce heads per square meter, in contrast to approximately six under conventional farming methods. A 2017 comparative study conducted in Beit Lahia between a 150 m^2 hydroponic greenhouse and four traditional soil-based greenhouses highlighted the economic advantages of hydroponics: despite higher initial setup costs ($7,000 versus $1,750), the hydroponic system generated a net profit of approximately $7,000, compared to only $800 from soil-based production. Moreover, hydroponics drastically reduces water and fertilizer use (by approximately 90 percent and 85 percent, respectively) making it particularly suitable for water-scarce contexts. These systems can be implemented in non-arable or urban areas, ranging from small-scale installations to industrial-scale farms. **However, despite these advantages, hydroponic farming remains constrained by the initial implementation cost and technical complexities that require precise nutrient monitoring by trained agronomists.**

Recycling Agricultural Debris

The war has rendered large swaths of agricultural land unusable due to extensive debris, including plastic waste from damaged greenhouses and mulch covers. Addressing this issue is essential for restoring agricultural productivity and mitigating environmental degradation. **A valuable precedent can be found in a pre-war pilot project conducted in northern Gaza, which focused on the removal of plastic waste from farmland. The collected materials were recycled and repurposed into agricultural inputs such as irrigation pipes and plastic bags.** This intervention not only prevented the harmful practice of open-air plastic burning but also facilitated land rehabilitation and generated employment for local residents. The project offers a replicable and environmentally sustainable model for post-conflict agricultural recovery.

Decentralized water solutions aimed at alleviating pressure on the aquifer

In the context of Gaza's acute water scarcity, caused by the ongoing destruction of agricultural wells and the collapse of water infrastructure, the identification of alternative water sources has become essential to sustain cultivation. These technologies, though limited in scale, help protect groundwater resources and could serve as stop-gap interventions to support food production and agricultural resilience during the early stages of post-conflict recovery.

Rainwater Harvesting

In Gaza, annual precipitation ranges between 200 and 300 mm, with nearly 90 percent falling during the winter months. Rainfall harvesting presents a valuable opportunity to capture and store an estimated 5-10 million cubic meters of water annually, a quantity that, while constituting only three to five percent of Gaza's total water demand, can play a crucial role in alleviating pressure on overtaxed water sources. Harvested rainwater is generally close to meeting WHO standards for potable use and can be redirected for agricultural purposes. **To supplement quantities gathered through natural rainwater, this source can also be mixed with greywater or partially treated wastewater, particularly for irrigating moderately sensitive crops.** The practicality and affordability of rainwater harvesting lies in its relatively simple infrastructure, namely collection tanks, impermeable linings to prevent infiltration, evaporation-reducing covers, and solar-powered pumps that support decentralized and off-grid operation.

Small-Scale Desalination Plants

Small-scale desalination (SSD) refers to decentralized water treatment technologies that utilize solar energy to extract salts and other impurities from brackish or saline water, rendering it suitable for agricultural or domestic use. As demonstrated by the Omari well in northern Gaza, SSD systems have been shown to produce approximately 50 cubic meters of desalinated water per day. These systems can be installed on freshwater wells, with output often blended with saline groundwater to achieve salinity levels appropriate for irrigation. **Solar-powered SSD systems offer a sustainable and context-appropriate solution, particularly given Gaza's widespread infrastructure damage and limited energy access.**

However, high upfront costs for critical components, which includes reverse osmosis membranes, photovoltaic panels, and energy storage systems, can restrict scalability and generally confine SSD deployment to smallholder operations or localized pilot projects. **Given these constraints, SSD should be understood not as a standalone solution, but rather as a complementary measure within a broader, integrated water resource management strategy.**

Mobile Wastewater Treatment Plants

The destruction of sanitation infrastructure in Gaza has resulted in the uncontrolled leakage of untreated wastewater, posing serious public health risks and causing significant damage to nearby crops and agricultural lands. By recycling wastewater that would otherwise flow untreated into the environment, these systems contribute not only to localized water reuse but also to the broader goal of protecting critical groundwater reserves. Among the available approaches, individual household-level systems have demonstrated greater effectiveness and manageability compared to community-based models, which often face operational and accountability challenges. These smaller-scale units are typically more cost-efficient, easier to maintain, and better suited to the needs of rural communities. However, the broader adoption of such systems is complicated by the fact that critical components, such as oxygenation equipment, are designated as dual-use goods and restricted under Israeli regulations.[32]

[32] KII, June 27, 2025.

Atmospheric Water Generators

Atmospheric Water Generation (AWG) technology represents a promising emergency solution capable of producing potable water directly from ambient humidity. Coupled with solar-power, this method is especially valuable in energy-constrained, off-grid settings like Gaza. AWGs offer notable environmental and practical advantages, particularly by reducing dependence on overexploited groundwater resources. Furthermore, their ability to function independently of seasonal rainfall makes them well-suited to regions experiencing high climate variability.

However, several limitations must be considered before AWGs can be scaled in Gaza. Principal among these is the low output, often no more than 10 cubic meters per day under optimal conditions, which is insufficient for large-scale agricultural needs. Moreover, many AWG systems lack integrated filtration mechanisms, raising concerns about the potential contamination of harvested water due to the region's compromised air quality. The financial barriers are also considerable; a mid-sized commercial AWG unit typically costs between $30,000 and $50,000, excluding the additional infrastructure required for water storage, distribution, and routine maintenance. Scaling such systems for community or agricultural use would necessitate significant capital investment, technical expertise, and supply chain access, challenges that are exacerbated by the ongoing restrictions on the import of essential components, and killing, injury, or departure of many of Gaza's talented agronomists and technicians. Consequently, while AWGs may play a supportive role in localized or emergency contexts, they are best treated as a complementary measure within a larger water management strategy.

While each of the methods identified above offers an innovative means to address Gaza's agriculture crisis and restore a fraction of pre-war productivity, they must be assessed in light of the political factors that will play the most influential role in determining their viability. As addressed throughout, Israel is likely to maintain its near-total blockade on all but the most essential items permitted into Gaza, expected to exclude a range of critical agriculture inputs and certainly advanced technology and equipment. Even among those that may ultimately be permitted in exceptional circumstances, other factors will need to be considered by humanitarian actors and others involved in agricultural rehabilitation, including value-for-money, the intended objectives (i.e., expanding nutritional diversity vs. restoring farming households' income), the presence of experts who can establish and maintain advanced systems, and the place of any program within larger rehabilitation strategies. Given the complex nature of such deliberations, humanitarian actors would benefit from incorporating such topics in ongoing discussions and strategizing around agriculture and early recovery, boosting ultimate readiness and integration when the moment comes that Gaza is able to transition to a post-war reality.