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The contribution of the Gaza Envelope Region to Israel's food security

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Abstract

Background Armed conflicts can severely impact food security by displacing farmers, destroying farms and agricultural infrastructure, disrupting supply chains, and limiting governance control over highly volatile food markets. In this study, we aim to gain an initial understanding of the impact of the ongoing Israel-Hamas War on local food production in Israel.

Methods This study examined the challenges of food production in the Gaza Envelope region, a border area in Israel that has been profoundly affected by the recent conflict. The analysis focused on the allocation of land to specific agricultural crops and sectors, along with the nutritional output of these edible crops. The nutritional output was standardized based on the dietary needs of the Israeli population, considering population size and demographic factors. These methods aimed to understand the effects of conflict on crop diversity, the risks posed to specific crops, and the implications for nutritional security.

Results We found that the Gaza Envelope region is crucial for the propagation of several key crops, notably cherry tomatoes, radishes, and sweet potatoes. We identified 16 crops whose local production is particularly vulnerable due to their proximity to the conflict, including radishes and potatoes. The nutritional output of the edible crops from the Gaza Envelope region is extensive, producing over 50% of the annual caloric requirements of the Israeli population. Beyond the caloric contribution, the produce from the region is nutrient-dense, supplying more than 100% of the annual Dietary Reference Intakes for the Israeli population of 12 vital nutrients, which include dietary fiber, six vitamins such as Vitamin A, Vitamin C, and Vitamin K, and five minerals including potassium and iron. These findings suggest that the Israel-Hamas War is having detrimental ramifications on local food production in Israel.

Conclusions The ongoing conflict highlights the critical need for data informed agricultural support and policy adjustments to protect food production in conflict-affected areas. Up-to-date and accurate land use data are essential to assess the initial impact of any disaster swiftly and reliably on these zones. This approach will enable more effective responses to safeguard food security under crisis conditions.

Keywords War, Violent conflicts, Food insecurity, Agriculture, Disaster assessment

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Introduction

War and military conflict can severely undermine local food security through the displacement of populations, destruction of agricultural infrastructure, and disruption of market systems. Collectively, these elements can negatively impact every facet of regional food security, encompassing food production, distribution, and accessibility [1]. In July, the ACLED [2] conflict index results (hyperlink to ACLED) showed that ten countries were classified at an "extreme" level on the conflict index, with Palestine, Myanmar, and Syria ranked as the three most affected regions. An additional twenty countries, including Israel, were given a "high" conflict index. Unfortunately, these statistics underscore the widespread nature of ongoing conflicts, with many regions and a significant portion of the world's population directly affected.

Conflicts can cause prolonged disruptions to local food production, leading to years of reduction in food production in areas affected by the conflict, even after the conflict has been resolved [3–5] and in some cases trigger ripples across global food supply chains. The Russo-Ukrainian War, for instance, led to significant volatility in the global agricultural markets, particularly affecting the grain markets since Russia and Ukraine contribute approximately 30% of the global wheat supply. The crisis also impacted all agriculture sectors due to the soaring prices of fertilizer, as Russia and Belarus are key fertilizer producers [6].

The Israel-Hamas War is no different, with devastating effects on local food security. In the Gaza Strip, around 182 km^2 of the total 360 km^2 is dedicated to farmland. Most of these farms are small, family-run operations, with over 20,000 such farms in the region [7]. Due to the ongoing conflict, an estimated almost 80% of the Gazan population is internally displaced (according to the December 2023 report by World Food Programme: Palestine), with 18% of the farmland damaged (Palestinian Central Bureau of Statistics (PCBS) reported in December 2023). Based on these reports, we can assume that local food production in the Gaza Strip has been drastically reduced because of the conflict. In Israel, displacement due to the conflict has been affecting two regions: the Gaza Envelope region, which borders the Gaza Strip, and the Northern Galilee region, which borders Lebanon, with the population displaced due to a ripple effect of the war and escalating tensions between Israel and Hezbollah. Moreover, it's crucial to note that there was agricultural trade between Israel and Palestine, and Israeli agriculture depended, in part, on the Palestinian workforce [8]. Consequently, the food security of both nations was interconnected before the war began. Our study concentrates on the impact of the Israel-Hamas War on local food production within Israel, specifically within the Gaza Envelope region. This area was impacted by the hostilities that started on October 7th, 2023, in which agricultural workers—both local and foreign—experienced extreme violence, and the local population has been evacuated and forced to live as refugees across other parts of Israel.

Here, we aim to extensively analyze the agricultural significance of the Gaza Envelope region to understand its importance for Israeli local food production. We assessed the region's contribution to different agricultural sectors, examined individual branches and specific crops, and assessed the overall nutritional value these crops contribute to the annual nutritional requirement of the Israeli population.

Materials and methods

Agricultural land proximity to the Gaza strip

Agricultural plot data sets were obtained from the Israeli Ministry of Agriculture, GIS division (downloaded November 28th, 2023) (hyperlink to data). Three datasets were downloaded, each containing a spatial data file of the three sectors of agriculture (plant, poultry and livestock). The three shape files were then merged and subset based on distance from the Gaza border at 5 km, 10 km, and 20 km bands, and the whole country of Israel with the assumption that damage to agriculture production increased with increased proximity to the Gaza border (Fig. 1).

Agricultural land use analysis

Agricultural land use was analyzed at three resolutions of agricultural practices. First, at the sector level with relative land mass (Eq. 1) of each agricultural sector (plant, poultry, and livestock) calculated to determine the relative amount of agricultural land of a given sector found near the Gaza border (Fig. 2). Second, given the vast contribution of the plant sector to Gaza Envelope region and the diversity of crop types in the plant sector. The contribution of specific categories (Fig. 3), individual crops (Fig. 4), and crop propagation (Fig. 5) in the plant sector was analyzed to understand the region's contribution to national food security further. For each category or crop, two types of analysis were conducted: total land mass and relative land mass (Eq. 1). The Total Land Mass is the cumulative area of agricultural land utilized for a given category, crop, or crop propagation within a specified distance from the Gaza border."

- The Plant Sector Categories: The Israeli Ministry of Agriculture uses six categories to describe the plant sector. These categories are Field Crops, Vegetables, Citrus, Ornamental (Flowers), Plantation, and Other.

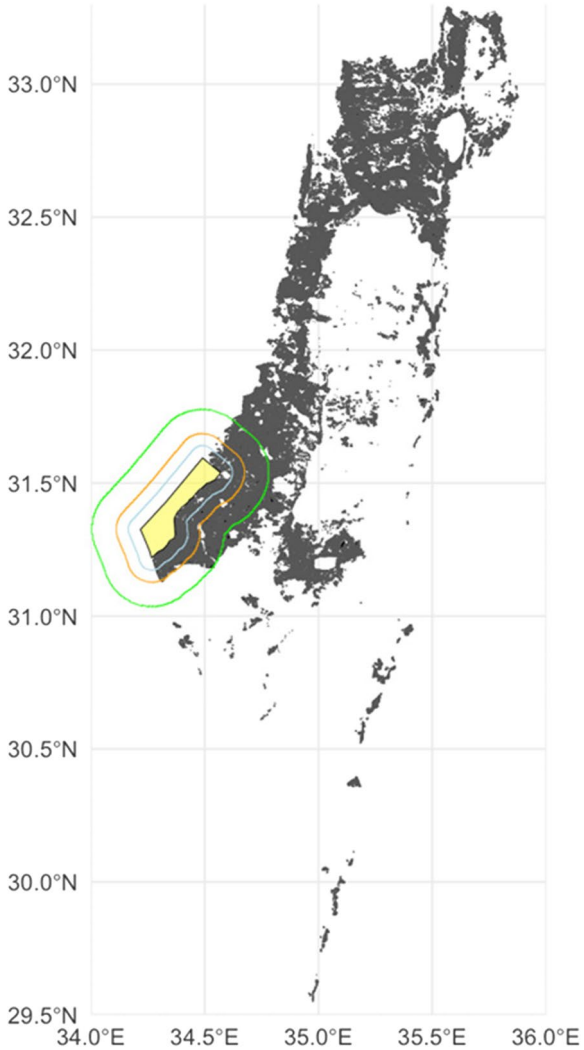

Fig. 1 The spatial distribution of Israeli* agricultural plots in Israel and the West Bank in relation to their proximity to the Gaza Strip. The agricultural plots are represented by black polygons, with the Gaza Strip being a yellow polygon. Surrounding the Gaza Strip are concentric rings indicating varying distances from the border: a blue ring for the 5 km zone, an orange ring for the 10 km zone, and a green ring for the 20 km zone. *Israeli plots inside the West Bank were included as they are part of the current national agriculture production. That said, the authors do not intend for this map or analysis to be interpreted as a legal or political statement of ownership and/or control of the West Bank

- Individual Crops: The Israeli Ministry of Agricultures Plant sector data each plot is categorized by crop type at the resolution of species (i.e., apple, wheat etc.), except for the citrus plot data where the crops are categorized down to the resolution of cultivar. In the Gaza envelope region, 74 different citrus cultivars are being grown. These citrus cultivars were classified into five crop types to align with the USDA FoodData database and the FAOSTAT yield database. These new crop type categories were Oranges, Lemons/Limes, Mandarins, Pomelos/Grapefruits, and Other Citrus. This categorization follows the system used by the Israeli Ministry of Agriculture [9].
- Equation 1: Relative Land Mass (RLM)

$$RLM = LA_{dist} LA_{total}^{-1} 100 \quad (1)$$

RLM: Relative amount of agriculture land for a given sector, category or crop found in a given distance from the Gaza border (% of total)

LA_{dist}: Land area for a given sector, category or crop found in a given distance from the Gaza border (hectares)

LA_{total}: Land area of all local production for a given sector, category or crop (hectares)

Calculating yield

All edible crops grown in the Gaza Envelope region were analyzed for their nutritional contribution. Yield per hectare for each crop was calculated using global averages for the years 2016-2021. A multi-year average was applied to mitigate the impact of environmental variations in any single year. Data was obtained from FAO. [10], [Crop Production, Yield, Harvested Area], FAOSTAT and downloaded on December 1st, 2023. The total yield of each edible crop grown within 20 km, 10 km, and 5 km of the Gaza border was then calculated (Eq. 2). A summarized table of the calculated yield data across all crops grown in the Gaza Envelope region is provided (supplementary data Table 1-3).

Supplementary data Table 1: Calculated yield data of crops grown within 5 km of the Gaza border*.

Supplementary data Table 2: Calculated yield data of crops grown within 10 km of the Gaza border*.

Supplementary data Table 3: Calculated yield data of crops grown within 20 km of the Gaza border*.

*All supplementary data tables were published on Mendeley Data (Hyperlink here).

- Equation 2: Yield of a given crop

$$Y = Y_{avg} LA \quad (2)$$

Y: Yield of a given crop, measured in tons
Y_{avg}: Average world Yield per hectare (ton ha^{-1})
LA: Land area of a given crop, measured in hectares

Nutritional requirements of the Israeli population

The nutritional requirements for the Israeli population were established based on the National Institutes

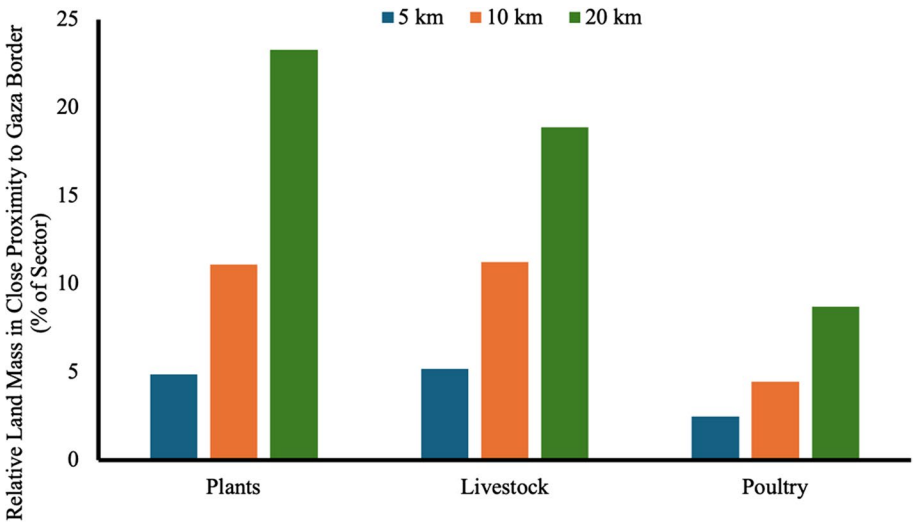

Fig. 2 Contribution of the Gaza Envelope region to agricultural sectors. The contribution of the region to each sector is expressed as the relative land mass (colored columns), within three proximity zones to the Gaza border: ≤ 5 km (blue), ≤ 10 km (orange), and ≤ 20 km (green)

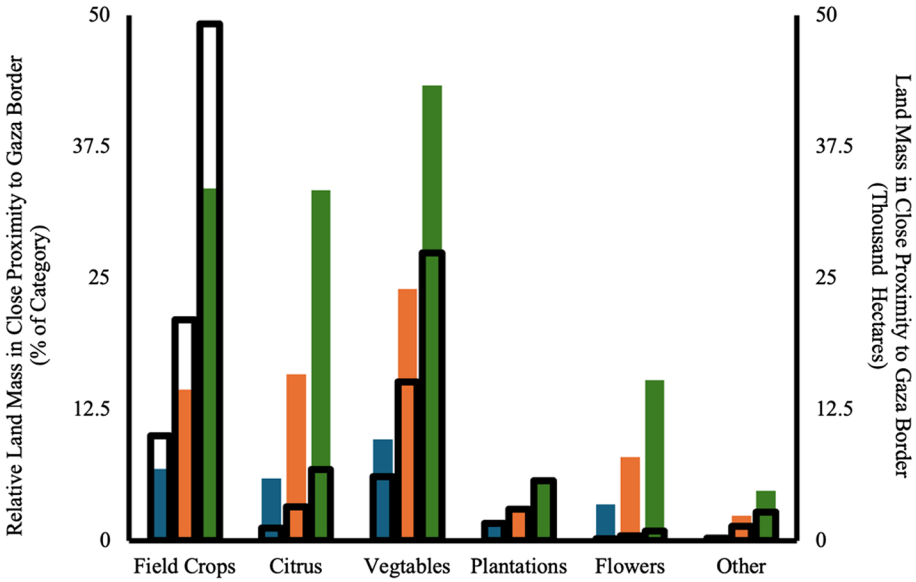

Fig. 3 Contribution of the Gaza Envelope region to plant sector categories. The contribution of the region to each category is expressed as the relative land mass (colored columns) and the total land mass (clear columns with black borders), within three proximity zones to the Gaza border: ≤ 5 km (blue), ≤ 10 km (orange), and ≤ 20 km (green)

of Health (NIH) guidelines, which provide the Dietary Reference Intakes (DRI) of vitamins, minerals, and macronutrients. The DRI is based on the Recommended Dietary Allowance (RDA) or Adequate Intake (AI) when RDA cannot be established. These guidelines account for variations due to age, gender, and increased needs during pregnancy and lactation [11, 12]. Demographic data, including age and gender distribution, were sourced from the Israeli Central Bureau of Statistics. The 2019 demographic data were presumed to reflect the current year's population structure, with an assumption of negligible change since then. This dataset was accessed and downloaded on November 15th from the Israeli Central Bureau of Statistics (hyper link to the dataset). The total population size, recorded in November 2023, was estimated at 9.827 million individuals. The proportion of pregnant and lactating women was inferred from the number of births in

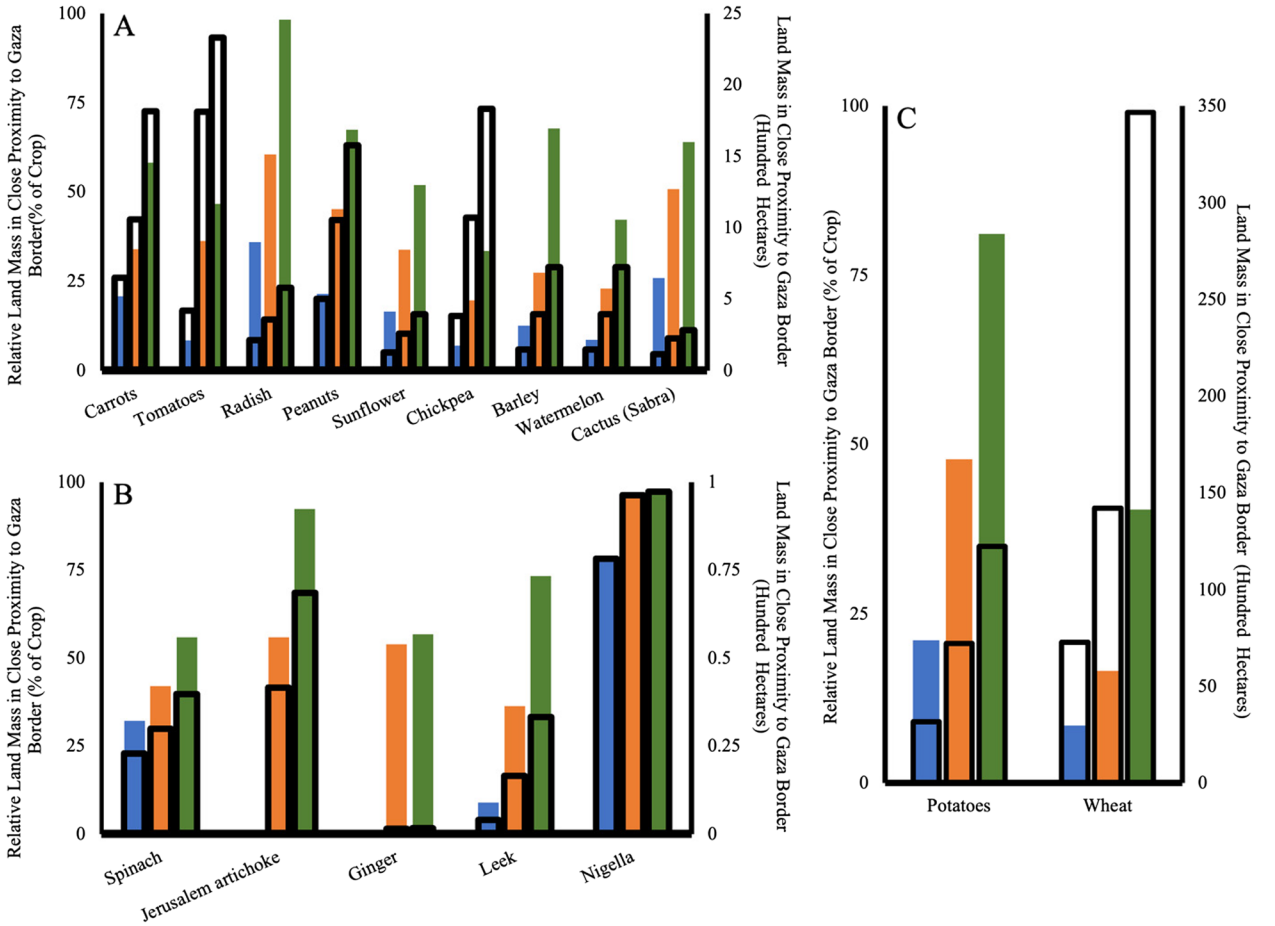

Fig. 4 Contribution of Gaza envelope region to individual crops. The contribution of the region to each crop is expressed as the relative land mass (colored columns) and the total land mass (clear columns with black borders), within three proximity zones to the Gaza border: ≤ 5 km (blue), ≤ 10 km (orange), and ≤ 20 km (green). Three graphs were used in the figure to match a given crop to an appropriate scaling of the secondary y-axis. *watermelon refers to watermelon grown for seed consumption

2020 relative to the population size that year (hyperlink to dataset). The yearly caloric requirements (Eq. 3) and the yearly nutritional requirements (Eq. 4) of the Israeli population were calculated using these resources.

• Equation 3: Yearly Caloric Requirement of the Israeli Population

$$CR_{yearly} = CR_{avg}PD \tag{3}$$

CR_{yearly}: Yearly Caloric (Kcal) Requirement of the Israeli population.

CR_{avg}: Average daily caloric requirement per person, assumed to be 2,285 kcal [13]

P: Total population (9.827 million people)

D: Number of days in the year (365)

• Equation 4: Yearly Nutritional Demand of the Israeli Population

$$DRI_{yearly} = \sum(P_i DRI_i D) \tag{4}$$

DRI_{yearly} : Yearly Dietary Reference Intakes of the Israeli population

P_i: Size of the i^{th} segment of the population, segmented by age, gender, and pregnancy/lactation status*

DRI_i : Daily Dietary Reference Intakes for the i^{th} segment

D: Number of days in the year (365)

*P_i value is derived by taking the total population (P) and multiplying it by the fraction representing the i^{th} segment's proportion within the population.

Nutritional contribution of edible crops in the Gaza Envelope Region

We examined the edible crops cultivated in the Gaza Envelope to ascertain their contribution to the annual

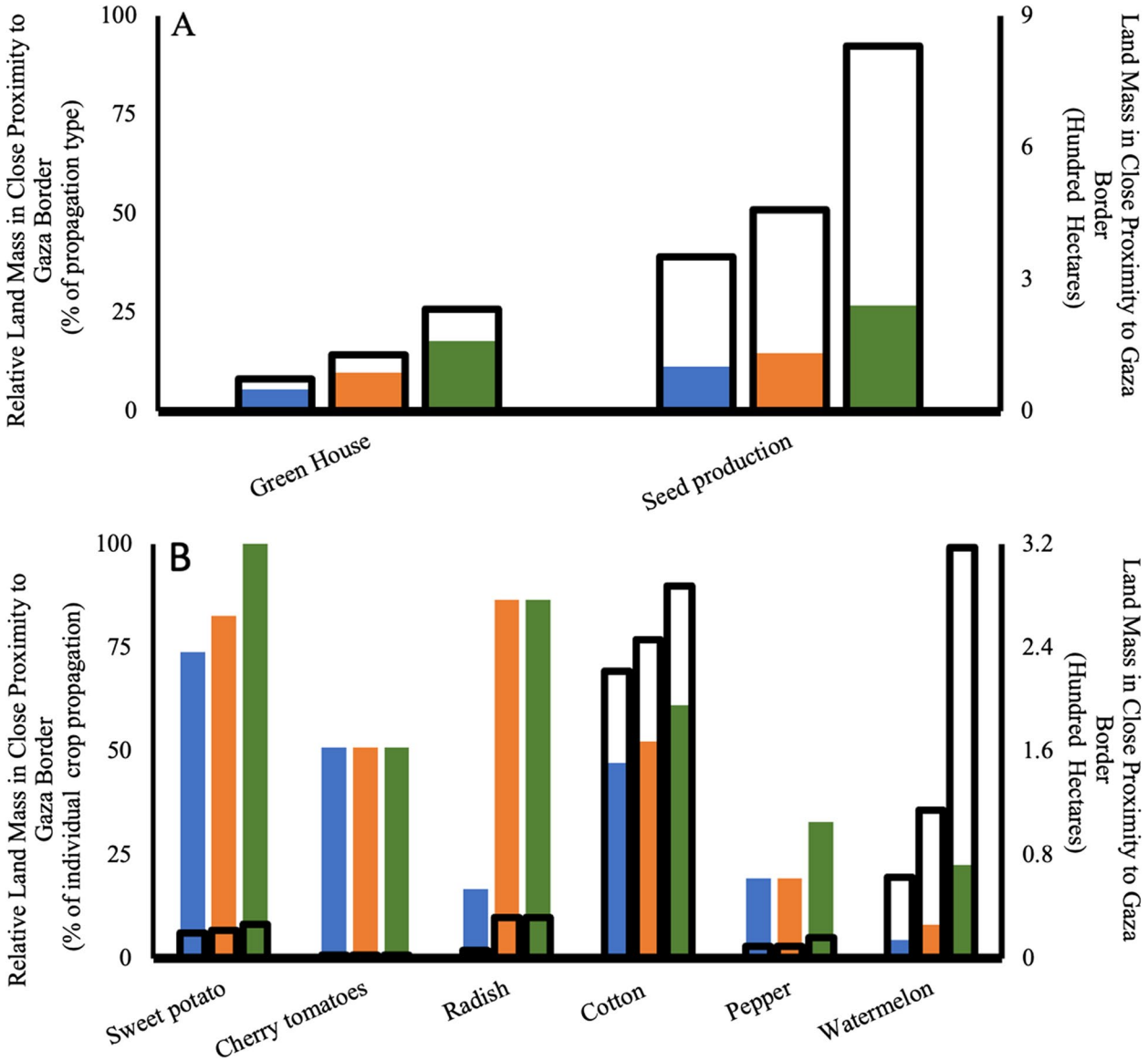

Fig. 5 Contribution of Gaza Envelope region to propagation of crops. The contribution of the region to crop propagation is expressed as the relative land mass (colored columns) and the total land mass (clear columns with black borders), within three proximity zones to the Gaza border: ≤ 5 km (blue), ≤ 10 km (orange), and ≤ 20 km (green). The total contribution of the region to the greenhouse (vegetative) and seed (reproductive) propagation is shown in graph (**A**). The contribution to individual crops is shown (**B**) within three distance categories from the border: up to 5 km (blue), up to 10 km (orange), and up to 20 km (green)

nutritional requirements of the Israeli population. We applied the established Dietary Reference Intakes (DRI) as defined by the NIH guidelines, tailored to the demographic structure of the Israeli population by utilizing the demographic data from the Israeli Central Bureau of Statistics to calculate yearly caloric [13] and nutritional requirements of the Israeli population. The nutritional contribution of agricultural land in the Gaza Envelope was calculated by integrating world average yield data from FAOSTAT, agricultural land usage data from the Israeli Ministry of Agriculture, and crop nutrient data from the USDA. Based on this integration, we evaluate the contribution of the Gaza Envelope's crops to the yearly nutritional demand of the Israeli population (Fig. 6).

We extracted nutrient data from USDA FoodData Central API (U.S. Department of Agriculture, Agricultural Research Service. FoodData Central, 2019. fdc.nal.usda.gov). Nutritional data were extracted for each edible crop using the crop-specific FoodData Central number

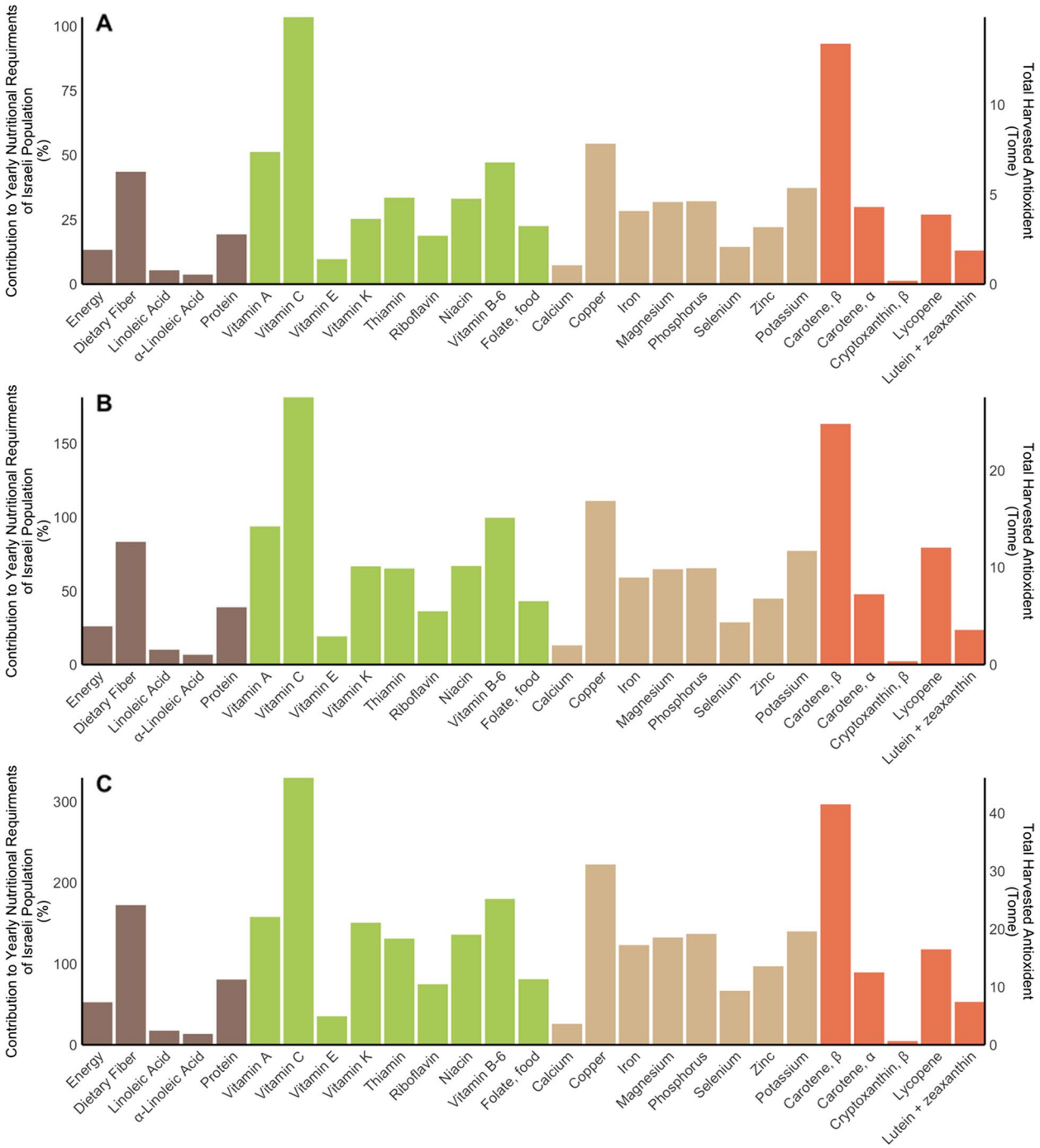

Fig. 6 Nutritional contribution of edible crops grown in Gaza Envelope Region. The nutritional contribution of edible crops was analyzed for crops Five (**A**), Ten (**B**), and Twenty (**C**) kilometers from the Gaza border. The nutrient profile of crops as a percentage of the Israeli population's total nutritional requirements for Macronutrients, Vitamins, and Minerals are depicted in brown, green, and tan bars, respectively. Additionally, orange bars illustrate the total antioxidant output from select carotenoids in these crops, aligned with the secondary y-axis to the right

(FDC_number). Our nutrients of interest included macronutrients, vitamins, minerals, and antioxidants. We then calculated the total nutrient content per edible crop by scaling the nutrient concentration, nutrient per 100 g of crop yield, according to our calculated yield of a given crop. A summarized data table of the nutrient content across all crops grown in the Gaza Envelope region is provided (supplementary data Table 4-6).

Supplementary data Table 4: Nutrient content of edible crops grown within 5 km of the Gaza border*.

Supplementary data Table 5: Nutrient content of edible crops grown within 10 km of the Gaza border*.

Supplementary data Table 6: Nutrient content of edible crops grown within 20 km of the Gaza border*.

*All supplementary data tables were published on Mendeley Data (Hyperlink here).

Data processing and visualization

We used R language and environment [14], accessed through RStudio [15], for all data analyses. We conducted our spatial analysis using the 'raster' [16] and 'sf' packages [17]. The 'httr' [18] and 'jsonlite' [19] packages were used to interface with the USDA FoodData Central API. We used the 'ggplot2' [20] and Microsoft Excel for Mac (Version 16.80) to produce graphs and visualizations.

Results

The agricultural contribution of the Gaza Envelope Region

The Gaza Envelope region is found in the northwestern part of the Negev desert of Israel, making up just under 10% of the Negev. The Negev desert stretches from the city of Ashdod to Eilat and encompasses more than half of Israel's Landmass. While the Gaza Envelope region is a relatively small portion of the country's land mass, it is highly fertile, with almost 70% of the land in the region dedicated to intensive agricultural practices (Fig. 1).

The contribution of the Gaza Envelope Region to agricultural sectors

Our findings reveal that the Gaza Envelope is agriculturally prosperous, hosting substantial portions of major sectors. Specifically, over 23% of the plant sector and nearly 20% of the livestock sector are found in the Gaza Envelope, within 20 km of the Gaza border. Moreover, areas within a 10 km distance from the Gaza border are particularly fertile, contributing over 10% to both the plant and livestock sectors (Fig. 2). These results underscore the vital role of the Gaza Envelope in local agricultural production.

The Contribution of the Gaza Envelope Region to crop categories

We found that the Gaza Envelope region is vital for edible crop production (Fig. 3). The main plant sector categories that we found to be prevalent in the Gaza Envelope region are field crops, citrus, and vegetables. Vegetables are predominantly grown in this region, with approximately 25% of their relative land mass found within 10 km of the Gaza border and over 40% within 20 km of the Gaza border. The high prevalence of vegetable production in the region suggests that it is an important region for the production of nutrient-rich food. Additionally, field crops have the most extensive total land mass in the Gaza Envelope, followed by vegetables (Fig. 3). Suggesting the region's importance for calorically rich food production.

The contribution of the Gaza Envelope Region to individual crop

To understand the war's effect on individual crops, we searched for crops where over 40% of their relative land mass is located in the Gaza Envelope region (20 km from the Gaza border). We identified 16 crops at particular risk, with over 50% of their relative land mass found in the Gaza Envelope region, of reduced production due to their proximity to the conflict (Fig. 4). Radishes are in particular danger, with all Israeli production locations in the Gaza Envelope. Furthermore, 80% of all Israeli potatoes are grown in the Gaza Envelope (Fig. 4C). Potatoes are second only to wheat in regional land use. Additionally, ten crops: leek, Jerusalem artichoke, ginger, spinach, nigella, carrots, peanuts, barley, and sabra, are primarily cultivated in this region, with over 50% of the relative land mass found in the Gaza Envelope region (Fig. 4).

The contribution of the Gaza Envelope Region to crop propagation

We identified four crops (cherry tomatoes, cotton, radishes, and sweet potatoes) that have over 50% of their relative land mass found within 20 km of the Gaza border (Fig. 5B). Three crops (cherry tomatoes, cotton, and sweet potatoes) have 50% of their crop propagation relative land mass within 5 km of the Gaza border. Sweet potato propagation is particularly susceptible, with all local agriculture land dedicated to its propagation found in the Gaza Envelope region (20 km of the border) and nearly 75% of it within 5 km of the border. These results highlight the potential for long-term damage to the local production of cherry tomatoes, cotton, radishes, and sweet potatoes due to damage to local propagation infrastructure.

Nutritional contribution of edible crops grown in the Gaza Envelope Region

Our analysis revealed that the harvested crops in the Gaza Envelope region can have a significant contribution to the caloric and nutritional demand of the Israeli population. Specifically, the edible crops in the Gaza Envelope produce enough calories to fill the caloric requirements

of 13.4%, 26%, and 52.6% of the Israeli population for crops grown within 5 km, 10 km, and 20 km of the Gaza border, respectively. In addition to their caloric value, the region's crops are a nutrient-rich food source. Our analysis of vitamins and minerals showed that six vitamins—Vitamin A, Vitamin C, Vitamin K, Thiamin, Niacin, and Vitamin B6—and five minerals—Potassium, Phosphorus, Magnesium, Iron, and Copper—met or exceeded 50% of the annual nutritional requirements for cropland within 10 km of the border and over 100% for cropland within 20 km of the border. Moreover, the region's crops are a crucial source of antioxidants, predominantly carotenoids, with an annual yield of 78.5 tons, underscoring the significant antioxidant contribution of these crops (Fig. 6). These results highlight the contribution of the region to the food security of the Israeli population as a locally grown, nutrient-rich food production region.

Discussion

The present study addresses the relationship between armed conflicts and local food security. Specifically, we analyze the effect of the Israel-Hamas War on food production in Israel.

Our methodological approach focuses on regional land use data to analyze the importance of a region of conflict in agricultural production. Our analysis focused on identifying crops whose local production has been in jeopardy due to the presence of a significant percentage of local production or propagation in the conflict region. Furthermore, to gauge the significance of the region to local food security, we analyze the nutritional contribution of the edible crops in the conflict region relative to the nutritional requirement of the population.

Main findings

We found that the Gaza Envelope region plays a critical role in Israel's agricultural landscape, and contributes significantly to both plant and livestock sectors (Fig. 2). Further analysis of the plant sector showed that the region specified three categories of edible crops: field crops, citrus, and vegetables (Fig, 3). Our analysis identified sixteen edible crops whose local production is likely to be significantly affected due to their concentration in the region of conflict by the Israel-Hamas War (Fig. 4). Furthermore, we identified three edible crops whose local propagation is in jeopardy due to this conflict (Fig. 5) underlining the susceptibility of key crops, such as sweet potatoes, to the ongoing strife. We further calculated the contribution of edible crops to national food security and the nutritional and caloric production of the edible crops in the region relative to the nutritional requirement of the population. We found that the Gaza Envelope region produced 52.6% of the national caloric requirement. Beyond the caloric contribution, the produce of the region is nutrient-dense, exceeding 100% of the annual Dietary Reference Intakes for 12 nutrients, including dietary fiber, six vitamins, and five minerals (Fig. 6C). Furthermore, the inner circles closer to the Gaza border, where it can be assumed that damage to local food production is even more severe, are also significant producers of nutrient-rich food and produce 13.4%, 26% the national caloric requirement (at 5 and 10 km buffers from the Gaza border respectively). These results suggest that the Israel-Hamas War is having a deleterious effect on Israeli's local food production.

Limitations of findings

The actual impact of the Israel-Hamas War is likely more extensive than what we report here. War can have adverse effects on a nation's agricultural productivity beyond the areas in direct conflict, by impeding the entire agricultural supply chains and distribution networks [5] as a direct result of the war or indirect consequence of economic restraints and reduced workforce. Impeded distribution networks further inhibited national food security due to increased postharvest waste, reducing the contribution of the produced food to the nutritional requirements of the population. Postharvest food waste is a significant issue even during non-war times, with estimates varying from 10-40% of food being lost postharvest [21]. During armed conflict, it can be assumed that postharvest waste is high, especially when food distribution networks and storage facilities are damaged.

Additionally, war can cause the relocation of large segments of the population, adding additional strain to the food distribution network. Our methodology did not take into account the rippling effect of the war on the entire food production and distribution chain. Furthermore, we did not consider the effects of the war on the geopolitical stability of the region and the escalating tensions between Israel and Hezbollah, leaving displaced persons along Israel's Lebanon border.

Given the volatile and multifaceted impact of the war on food production, distribution, and access, stakeholders and policymakers must have an evidence-informed understanding of the impact of the conflict on local food production. Here, we present a methodology to allow for a quick assessment of the effect of the conflict on local food production and food security. The main advantage of our approach is the speed at which evidence-informed analyses of the impact of the conflict on the agricultural sector can be analyzed due to the fact that the analysis is conducted exclusively on the pre-conflict data, requiring only the classification of the area afflicted by the conflict. Stakeholders and policymakers can then use this analysis to guide their decision-making processes. Furthermore,

this approach could just as easily be applied to natural-occurring disasters and not limited to armed conflict as was done in this study.

Defining the afflicted region

Destruction of agricultural production in a region of conflict can be driven by many factors, including the displacement of the local population resulting in loss of workforce, inability to get materials and equipment to the fields, and damage to the agricultural fields and their infrastructures [1]. In our study, the internal displacement of the local populations was the main factor used to define the afflicted zone in Israel. This judgement was based on two main factors. First, internal displacement of Israeli populations was closely monitored and influenced by the Israel government making it easy to access this information. Second, the displacement of local populations is a crucial factor governing both direct and future damages resulting from an armed conflict [22] because the local population is an essential stakeholder managing the investment of resources in agricultural production and development during and post-conflict. Furthermore, the agricultural villages and towns that were evacuated were all within 20 km of the Gaza border, except for the city of Ofakim, which is located slightly over 20 km from the border. Ofakim was only included in the list of officially evacuated towns between the dates of October 7th and December 10th of 2023. Agricultural towns within 7 km of the border were given official evacuation status (which enables subsidies for temporary relocation) through at least July 1st, 2024, at the time of writing this article [23], with land within 4 km considered as inside the firing zone, meaning civilians are unable to enter without military approval [24]. Since agricultural land, associated with agricultural villages, extends beyond the direct borders of residential areas, we extended the inner circles of analyses beyond the displacement criteria of 4 km and 7 km and subset the area in 5, 10, and 20 km radiuses from the border (Fig. 1).

The Knesset (Israeli parliament) established that agricultural land located within a 20 km radius of the Gaza border is eligible to receive significant subsidies for war-related damages, while agricultural land situated within a 40-km radius of the border qualifies for more modest subsidies. (Israel Knesset announcement), November 15th, 2023).While difficult to quantify during an active conflict, it can be assumed that damage to agricultural land and infrastructure increases with proximity to armed conflict. Furthermore, armed conflict and military activity have a profound impact on soil health, with wars negatively influencing the physical, chemical, and biological composition of the soil [25]. Said destruction is sometimes conducted with the intention to sabotage enemy infrastructure but is more often the unintentional result of military activity and hostilities. Heavy military machinery and vehicular movements can destroy irrigation systems and the compression of soil particles, reducing pore spaces and limiting the soil's ability to absorb water and nutrients [26]. Furthermore, armed conflict can inhibit the accessibility of people and equipment necessary for field maintenance. Therefore, it can be assumed that the inner circles of 10 km and especially 5 km radii from the Gaza border have more extensive damage, which is confounded by the extended displacement of much of the population.

The broader implication of the conflict on food security in Israel

The volatility in food accessibility in Israel, as a result of the current conflict, was partially managed due to the fact that the ports continued functioning throughout the conflict, allowing for the import of foreign produce. Within days of the outbreak of the conflict, Israel increased its import of fresh vegetables, such as tomatoes, mainly from neighboring countries such as Turkey and Jordan, to compensate for a reduction in local production [27]. That said, food prices in Israel have increased since the onset of the war, mostly driven by a drastic increase in the cost of fresh produce [28]. This situation has left low-income Israelis susceptible to poor food access, with limited access to nutrient-rich fresh produce in particular.

The negative impact on low-income Israelis has been further aggravated by the fact that farmers' donations of surplus produce represent a key source of fresh produce to the lowest income households in Israel. In Israel, agricultural surpluses are collected through donations from private farms by the NGO Leket Israel, which manages the collection and redistribution. Leket Israel ensures that the donated produce does not enter the market but rather reaches low-income households. This mechanism relies on strong local production and leaves low-income households at increased risk when local production suffers, as no alternative governmental assistance program is currently in place [29].

The current military conflict occurs against the backdrop of Israel's agricultural reform, which opened up the local markets to increased agricultural imports (reported by the Israeli Ministry of Agriculture on the September 9th, 2023). The agricultural reform was largely opposed by Israeli farmers, with many fearing that the reform would put economic strain on their farms and potential closures [30]. The current conflict has led to an increase in the influx of foreign produce reaching the Israeli market, accelerating the trend caused by the agricultural reform. Furthermore, in light of the current conflict,

there is a discussion regarding how best to invest in Israeli agriculture, with calls to invest in the development of new agricultural land, such as in the central Negev region of Ramat Negev [31] in addition to calls to rebuild the afflicted regions of the Gaza Envelope region by groups like Regrow Israel [32]. Israel's agriculture sector is currently at a decision point, and it is crucial that stakeholders and policymakers make evidence-informed decisions when navigating Israel's food security. Understanding the contribution of the afflicted area of the Gaza Envelope region is a critical piece for current and future decisions.

A global look at conflict, food insecurity, and its health implications

Food insecurity that results in famine can have short- and long-term effects on the afflicted population. In the short-term resulting malnutrition may increase the risk for co-infection and exaggerating disease outbreak in the starved population [33]. Additionally, poor infostructure for food distribution and preservation can lead to increased episodes of food contamination resulting in food poisoning [34]. The most famous example of disease outbreak during armed conflict is the 1918 influenza pandemic. With estimates that one third of the world population was infected resulting in the death of over 50 million people [35]. Since 2000, outbreaks of Cholera have been documented in several countries with onging armed conflict including Sudan, Iraq, Syria and Yemen. Contamination in food, water along with disrupted access to health services have been suggested as key elements resulting in said outbreak [36]. These same elements have been suggested as key in the outbreaks of Measles and Poliomyelitis [37] in several regions during ongoing conflicts. Measles outbreaks in the Darfur region of the Sudan [36] and in Borno state of Nigeria [38] where documented with food insecurity suggested as a potential contributor to these outbreaks.

Food insecurity, particularly when it leads to famine, has profound short- and long-term impacts on affected populations. In the short term, malnutrition weakens the immune system, increasing susceptibility to co-infections and exacerbating disease outbreaks [33] Furthermore, inadequate infrastructure for food distribution and preservation in conflict zones can lead to food contamination, raising the risk of foodborne illnesses [34].

One of the most well-known examples of disease outbreak during armed conflict is the 1918 influenza pandemic, during which an estimated one-third of the global population was infected, resulting in over 50 million deaths [35]. Since 2000, cholera outbreaks have been documented in conflict-ridden countries such as Sudan, Iraq, Syria, and Yemen. Contaminated food and water, alongside limited access to healthcare services, have been identified as key factors in these outbreaks [36].

Similarly, the same conditions have contributed to outbreaks of diseases like measles and poliomyelitis in regions facing ongoing conflict. Measles outbreaks, for example, have been documented in Sudan's Darfur region [36] and in Borno State, Nigeria [38], with food insecurity suggested as a contributing factor to these public health crises.

Children, and particularly those affected in utero, are highly vulnerable to the long-term detrimental effects of famine on their health [39]. With active armed conflicts at their highest levels since World War II [10], these conflicts have significantly worsened the global famine crisis. In 2023, an estimated 283 million people faced acute hunger, representing a nearly 8.5% increase from 2022. Conflict zones, such as Gaza and Sudan, have contributed substantially to these alarming numbers [40]. In 2020, an estimated 99 million people were experiencing food insecurity directly due to armed conflict [41]. The long-term health impacts of famine are particularly concerning in regions like the Gaza Strip, where a significant portion of the population is young, further emphasizing the urgent need for action [42].

Conclusion

In this study, we examined the impact of the Israel-Hamas conflict on local food security and agricultural production in Israel, focusing on the Gaza Envelope region. Our findings reveal that this region is crucial to Israel's agricultural output, significantly contributing to both plant-based and livestock sectors. The production of edible crops in the Gaza Envelope region accounts for over half of the national caloric intake requirement and meets or exceeds the annual dietary reference intakes for 12 essential nutrients. Our analysis identified sixteen crops at high risk due to their proximity to the conflict zone, with three additional edible crops, including sweet potatoes, jeopardized by localized cultivation near conflict areas. The broader impacts of the conflict likely extend beyond direct damage to agricultural lands, impacting the entire agricultural supply chain and exacerbating postharvest food loss. This disruption worsens food insecurity, particularly affecting low-income Israelis who depend on locally produced, nutrient-rich foods. The ongoing conflict necessitates a reevaluation of agricultural policies and support systems, urging stakeholders and policymakers to implement data-informed practices when planning future agricultural and food security strategies. Additionally, up-to-date and accurate land use data are essential to swiftly and reliably assess

the initial impact of any disaster on these zones, enabling more effective responses to safeguard food security under crisis conditions.

Supplementary Information

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Supplementary Material 1.

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Authors' contributions
ABS was responsible for the work's design, including the acquisition, analysis, and interpretation of data, and drafted the manuscript. NDF and UR contributed substantively to the writing and revisions of the manuscript. SR provided the funding and also contributed to the manuscript revisions.

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Data availability
The datasets generated and/or analysed during the current study are available in the Mendeley Data repository, [Hyperlink here] [43].

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
Beyond the positionality of the authors stated below, the authors declare that they have no conflict of interest.
Positionality Statement: The authors of this paper are all Israeli citizens who relied heavily on Israeli media and governmental sources to analyze the effect of the current Israel-Hamas War on Israeli food security. While the scope of our analysis did not include the effects of the conflict on Gaza, we recognize the dire effects of the conflict on the food security of the Palestinian people living in Gaza and the pressing need to study and act to ensure that the people of Gaza have appropriate access to nutrient-rich food and sustainable food security during and following the current conflict. It is our deepest desire that we will live in a world free of wars and with food security for all, as forseen by the prophet Isaiah: "And He shall judge between the nations, and shall decide for many peoples; and they shall beat their swords into plowshares, and their spears into pruninghooks; nation shall not lift up sword against nation, neither shall they learn war any more" (Isaiah 2:4). The responsibility to build such a future lies on all of us.

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