



Assessment of physical damage caused to buildings by the war on Gaza

October 2023 – April 2024



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Economic and Social Commission for Western Asia

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The note is in line with the new framework proposed by UNESCWA to international humanitarian and development actors regarding recovery in Gaza and the entire Occupied Territory. It includes guiding tenets related to enhancing Palestinian ownership, strengthening Palestinian institutional capacities, reinforcing coordination and collaboration between United Nations agencies and academic research institutions.

Combined methods of remote sensing, using satellite imagery, synthetic aperture radar (SAR) and very-high resolution aerial imagery, in addition to field work, are essential to test and validate the assessment of damage caused by disasters and wars. They are also essential to detect with precision damage that is difficult to see and to quickly assess its magnitude, as was the case during the damage assessment of the Haiti earthquake disaster in 2010 conducted by the World Bank.¹

UNESCWA collaborated with PCBS and UNOSAT on integrating high resolution satellite imagery with official statistics on geolocated data from surveys and census in the State of Palestine. UNESCWA organized the exchange of maps and geolocated data on the most damaged types of buildings and areas to direct immediate relief, knowing the types of buildings and the extent of damage in the district. A simultaneous collaboration was established with the Decentralized Damage Mapping Group-University of Oregon (DDMG) from an academic and research perspective that used InSAR data analysis methods for damage detection.

1 [Post- disaster building damage assessment using satellite and aerial imagery interpretation, field verification and modeling techniques. World Bank /GFDRR IMAGECAT Report 2010.](#)

Key messages

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- *The catastrophic damages caused by the war on Gaza since 7 October 2023 have been of unprecedented and unparalleled speed and extent in recent times. 2 per cent of the population have been killed; 4 per cent injured; almost the whole population displaced; more than 50 per cent of the total structures in the Gaza Strip destroyed and 360,000 housing units damaged.*
-
- *The Palestinian Central Bureau of Statistics (PCBS) regularly reported casualties and damages to buildings on its website: 34,388 people were killed; 290,000 housing units were partially damaged; more than 25,010 buildings and 79,000 housing units were destroyed; 405 schools and universities were damaged or destroyed; about 700 health facilities and hospitals were affected or damaged; three churches, 290 mosques and 168 government premises were destroyed, as at 28 April 2024.*
-
- *On 19 April 2024, UNOSAT identified a total of 123,706 damaged structures in Gaza (about 1,000 per cent higher than the first assessment conducted on 15 October 2023), of which 34,115 were destroyed; 17,055 severely damaged and an estimated 128,904 damaged housing units.*
-
- *The Decentralized Damage Mapping Group-University of Oregon (DDMG) reported, in the assessment of 29 January 2024, that 138,200 structures were likely damaged as a low estimate, with most damage in Gaza, Khan Younis and North Gaza. The combined and integrated methods provided clarifications on the damage to buildings, housing units and structures: 94,860 buildings (43 per cent of total buildings) were "likely damaged" and 253,930 housing units across Gaza were "likely damaged", or 56 per cent of total housing stock.*
-
- *The collaboration improved the accuracy of the estimations of the extent of the damage caused to buildings and of the types of buildings damaged in the administrative districts of Gaza. Reliable and timely data were provided on the social and economic repercussions of the war, post-war recovery and for the needs assessment for the State of Palestine.*
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Introduction

The toll of the raging Gaza war, which erupted on 7 October 2023, on human life and survival has been unprecedented and unparalleled. It has already caused massive losses of life (2 per cent of the population have been killed, 4 per cent injured and almost the whole population displaced). Infrastructure has sustained tremendous damage, as more than 50 per cent of the total structures in the Gaza Strip were destroyed and 360,000 housing units damaged. This will have short and long-term socioeconomic consequences, and will cause long-term deprivation and setbacks in human development, as reported in the UNESCWA-UNDP policy brief on the expected socioeconomic impacts of the war on the State of Palestine.²

As of 28 April 2024, more than six months into the war, the heavy death toll reported in Gaza due to Israeli bombardment and military operations reached 34,879 people (72 per cent were women). 82,237 people were injured and 8,100 were reported missing under the rubble, trapped or dead (figure 1).³ Given the large numbers of victims and huge destruction of the health sector, the Palestinian Ministry of Health stopped reporting the number of killed people disaggregated by age and sex by 23 December

2023, when the number of people who had been killed had reached 20,057, including 7,870 children and 3,496 women. The reported death toll, reached in only four weeks, had already by far surpassed the toll of all past violent escalations since 2007 combined. The number of children killed in Gaza in this war exceeded the total number of all children killed in armed conflicts each year since 2020 in more than 22 countries.⁴

With the catastrophic displacement of two million people in Gaza and the immense damage to 360,000 housing units since 7 October 2023,⁵ the speed and extent of the damage incurred have been unparalleled.⁶ According to the World Bank interim damage assessment of March 2024, one million among Gaza's population have lost their homes, and the cost of the direct damage to the built infrastructure of Gaza by end of January 2024 was estimated at \$18.5 billion. Of this amount, \$13.3 billion was the cost of the direct damage to housing,⁷ (90 times more than in the previous 11-day-hostilities in May 2021 in Gaza, where social sectors were hit the most, making up more than half of the total damage, with housing alone representing almost 93 per cent of the sector's total RDNA.⁸

2 ESCWA, [Gaza war: expected socioeconomic impacts on the State of Palestine \(E/ESCWA/UNDP/2023/Policy brief.1\)](#).

3 Ministry of Health, State of Palestine. [Daily report on the repercussions of the Israeli aggression on the State of Palestine, Update of 25 March 2024](#).

4 ESCWA, [Gaza war: expected socioeconomic impacts on the State of Palestine \(E/ESCWA/UNDP/2023/Policy brief.1\)](#).

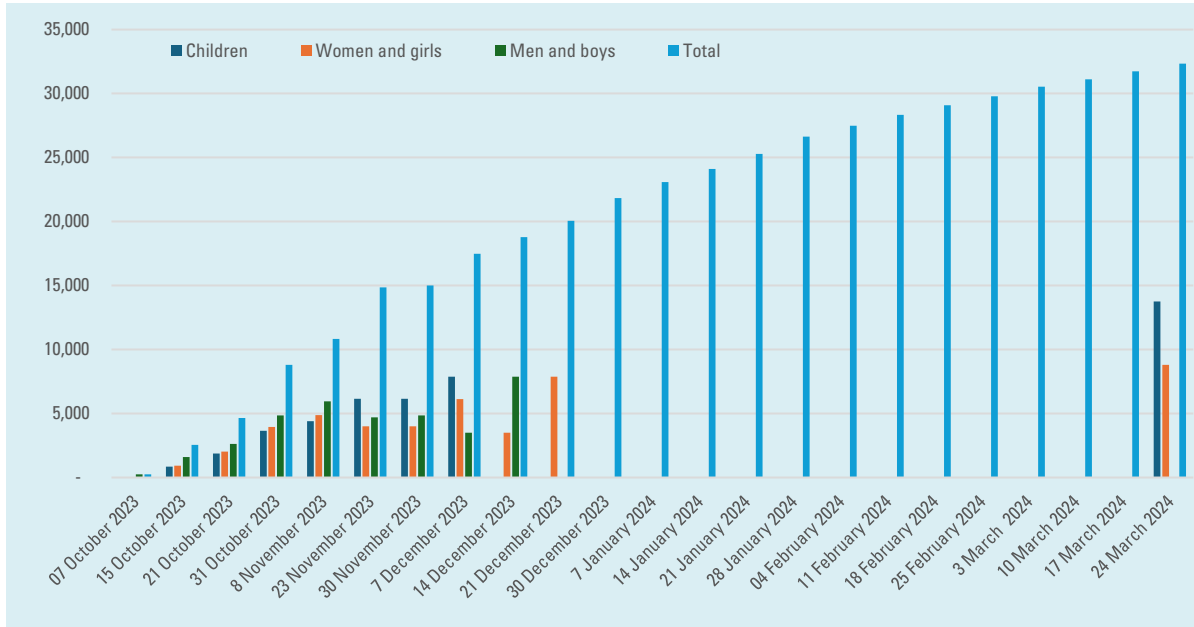
5 PCBS, [Israeli occupation aggression on Palestine since Oct.7th 2023, Latest Update 12:00, 01/04/2024](#).

6 The World Bank, [impacts of the conflict in the Middle East on the Palestinian economy. December 2023 Update](#).

7 EU-WB_UN, [Gaza Strip interim damage assessment summary note, 29 March 2024](#).

8 The World Bank press release, [6 July 2021, The rebuilding of Gaza amid dire conditions: damage, losses and needs](#).

Figure 1. Number of people killed in Gaza in the war on Gaza (7 October 2023 to March 2024)



Sources: Data from the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) and the World Health Organization (WHO) in the Occupied Palestinian Territory (OPT) and the Palestinian Ministry of Health.

1. Damage to buildings and infrastructure: comparative methodology, combined data and integrated results

Given the above, it was necessary to better understand the different methodologies, integrate the data from different sources whenever possible, and obtain more consistent reliable and detailed information on the physical damage to the different structures, to differentiate between buildings, housing units and structures, with the aim of providing good basis for the estimation of the damage in monetary terms and enabling adequate reconstruction.

Combined methods of remote sensing, using satellite imagery, synthetic aperture radar and very high resolution aerial imagery, in addition to field work, are essential to test and validate the assessment of damage caused by disasters and wars. They are also essential to detect with precision damage that is difficult to see, and to quickly assess the amount of damage, as was the case during the damage assessment of the Haiti earthquake disaster in 2010 undertaken by the World Bank.⁹

In this context, UNESCWA statistics team suggested to the three partners (UNOSAT, DDMG and PCBS) producing data on damage

caused to buildings and structures to hold regular meetings and make joint efforts to make better use of the methods based on satellite imagery, and to integrate the results whenever possible and depending on the needs.

This methodological note summarizes the outcomes of several general and technical joint meetings that were held to address the details of the different methodologies used to estimate the damage to buildings and housing units. The note will feed into a report that UNESCWA and the United Nations Development Programme (UNDP) are preparing as part of the series of reports on the repercussions of the war on Gaza, and the estimation of post-disaster needs for recovery and reconstruction, guided by the World Bank Conceptual Framework for the Damage and Loss Assessment caused by disasters.¹⁰

In the literature, assessment undertaken by the World Bank of the damage caused to buildings by the Haiti Earthquake disaster in 2010 showed that satellite images identified (in phase 1) approximately 5,200 severely-damaged buildings in Port-au-Prince as having been completely

9 WORLD BANK/GFDRR IMAGECAT REPORT 2010, [Post- disaster building damage assessment using satellite and aerial imagery interpretation, field verification and modeling techniques](#).

10 The International Bank for Reconstruction and Development/[The World Bank \(2010\). Damage, loss and needs assessment. Guidance Notes](#).

destroyed or severely damaged.¹¹ In phase 2, very high 15 cm-resolution aerial imagery allowed to test and validate the assessment of urban damage and to detect with precision around 30,000 buildings in Port-au-Prince and surrounding areas with damage that was difficult to see, such as partial roof collapses, shifting of buildings off foundations, etc.).

The delineation of building footprints for severely damaged buildings is crucial in quantifying the amount of building floor space that was eliminated by the earthquake. This information, in turn, is helpful in determining a rough order-of-magnitude cost for replacing and/or repairing damaged buildings to estimate the total floor space associated with all the damaged buildings. This option was not

available for assessing damage caused by the war in Gaza.

Despite restrictions on the satellite data over the State of Palestine from various data providers, collaboration between the entities (UNESCWA, UNOSAT, PCBS and DDMG) allowed efficient use of the available data. The data were distributed via the web and other channels to a broad range of users from the United Nations and other agencies. The satellite data proved to be extremely valuable in determining the scope of the damage caused by the war and in prioritizing field surveys. The pre-war satellite images information available was crucial in helping to discern damage patterns from the war and in comparing pre-war and post-war images.

11 WORLD BANK /GFDRR IMAGECAT REPORT 2010, [Post- disaster building damage assessment using satellite and aerial imagery interpretation, field verification and modeling techniques](#).

2. The Palestinian Central Bureau of Statistics (PCBS)

The Palestinian Central Bureau of Statistics (PCBS) is responsible for the development and coordination of the Palestinian official statistical system based on national legislation. Information extracted from the Population, Housing and Establishments Census in 2017 provides essential information on the population, economy and socio-economic characteristics of households in the State of Palestine. In 2015, PCBS, in collaboration with UNESCWA, conducted a survey to assess the impact of the Israeli aggression on the Gaza strip in 2014, and on the socioeconomic living conditions of Palestinian households in the West Bank and the Gaza

strip.¹² PCBS plans to undertake a listing of the buildings after the war ends.

During this war, PCBS regularly reported on its website the number of victims and damage to buildings. On 28 April 2024, it reported on 290,000 partially damaged housing units, more than 25,010 destroyed buildings and 79,000 destroyed housing units, 405 damaged or destroyed schools and universities, about 700 affected or damaged health facilities and hospitals, in addition to three churches, 290 mosques and 168 government premises that were destroyed (table 1).¹³

Table 1. PCBS update on damage to housing on its website

	26 December 2023	13 February 2024	28 April 2024
Partially damaged and destroyed housing units	258,000	290,000	360,000
Destroyed and severely damaged buildings	25,010	25,010	25,010
Out of service hospitals	23	30	32
Hospitals damaged due to missile strikes	25	25	25
Health facilities affected ^a			649
Partially destroyed schools and universities ^a			305
Destroyed schools and universities			100
Churches destroyed	3	3	3
Mosques destroyed	115	161	290
Government premises destroyed	126	140	168

Source: Ministry of Public Works and Housing. www.pcbs.gov.ps/site/lang__en/1408/Default.aspx.

^a EU-WB_UN Gaza Strip Interim Damage Assessment Summary Note March 29, 2024.

12 UNESCWA (2015). *Measuring and monitoring the living conditions in Palestine*.

13 PCBS Website: https://www.pcbs.gov.ps/site/lang__en/1408/Default.aspx.

OCHA's 22nd flash update dated 28 October 2023 reported that about 45 per cent of housing units in Gaza (178 thousand units) were damaged: 150,000 were

moderately/lightly damaged and about 30,000 units were destroyed or rendered uninhabitable, since the start of the hostilities.¹⁴

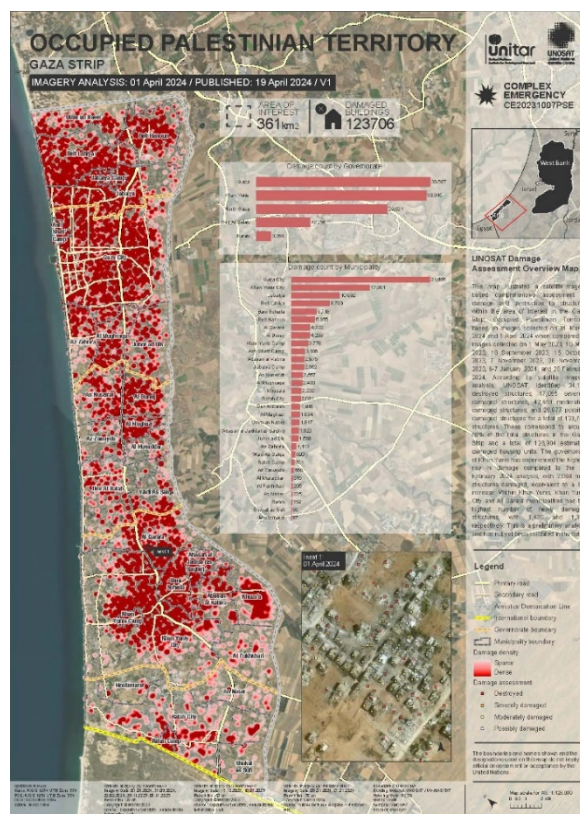
3. UNOSAT comprehensive damage assessment of buildings in the Gaza Strip and integration with geolocated data from PCBS

UNOSAT is the main provider for United Nations agencies and other users of mapping information on damages due to disasters and wars. UNOSAT's analysis for the State of Palestine, with input from Impact Initiatives, used satellite imagery of WorldView-3 on different dates after the war. Resolution: 30 cm, copyright: © Maxar 2023, source: Department of State, Humanitarian Information Unit and compared with pre-war satellite imagery (2): WorldView-2, imagery date: 15 October 2023, 10 May 2023. Resolution: 50 cm, copyright: © Maxar 2023, Source: Department of State, Humanitarian Information Unit. The Boundaries from: OCHA oPt, UNESCO, REACH, schools and hospitals from OCHA oPt, and roads from OSM. Analysis.

As for the methodology used for building comprehensive damage assessment, UNOSAT employs change detection analysis to assess the extent of damage to buildings, utilizing raster datasets collected at different times to identify changes in shape indicative of destruction. The detected damage is classified into three categories, based on severity: destroyed, severely damaged and moderately damaged. The confidence level of the assessment is determined by the extent of the

damage observed and by additional indicators such as debris.

Figure 2. UNOSAT Map updated and published on 19 April 2024



Source: <https://unosat.org/products/3821>.

For the UNOSAT housing unit comprehensive damage assessment, to estimate the number of damaged housing units (HU), UNOSAT combines data from PCBS with a baseline dataset, using interpolation to predict HU values in areas lacking data. This results in a raster dataset covering the Gaza Strip with estimated HU values. The damaged HU information is then calculated using the UNOSAT building comprehensive damage assessment, where the total HU at each damaged location is extracted from the HU raster dataset and adjusted based on the level of damage observed by UNOSAT analysts (destroyed: 100 per cent of HU, severely damaged: 80 per cent of HU, moderately damaged: 20 per cent of HU). See [UNOSAT Gaza Strip building comprehensive damage assessment infographic](#) for information.

For the Gaza war, UNOSAT produced five comprehensive assessments on the damage to buildings and to the agriculture sector in Gaza since the start of the war until 7 February 2024, based on high resolution satellite-imagery, to detect damage and destruction to structures within the area of interest in the Gaza Strip,

Occupied Palestinian Territory, and based on images collected on multiple dates in October and December 2023 when compared to images collected on 1 May 2023, 10 May 2023, 18 September 2023 and consequent dates.

For the latest update on 19 April 2024, UNOSAT produced a map (figure 2) where it identified a total of 123,706 damaged structures in Gaza (about 1000 per cent higher than the first assessment on 15 October 2023), of which 34,115 destroyed structures, 17,055 severely damaged structures, 42,659 moderately damaged structures, and 29,877 possibly damaged structures. These correspond to around 50 per cent of the total structures in the Gaza Strip and a total of 128,904 estimated damaged housing units.

The governorate of Khan Younis has experienced the highest rise in damage compared to the 29 February 2024 analysis, with 3,068 new structures damaged, equivalent to a 9 per cent increase.

This was a preliminary analysis and has not yet been validated in the field.

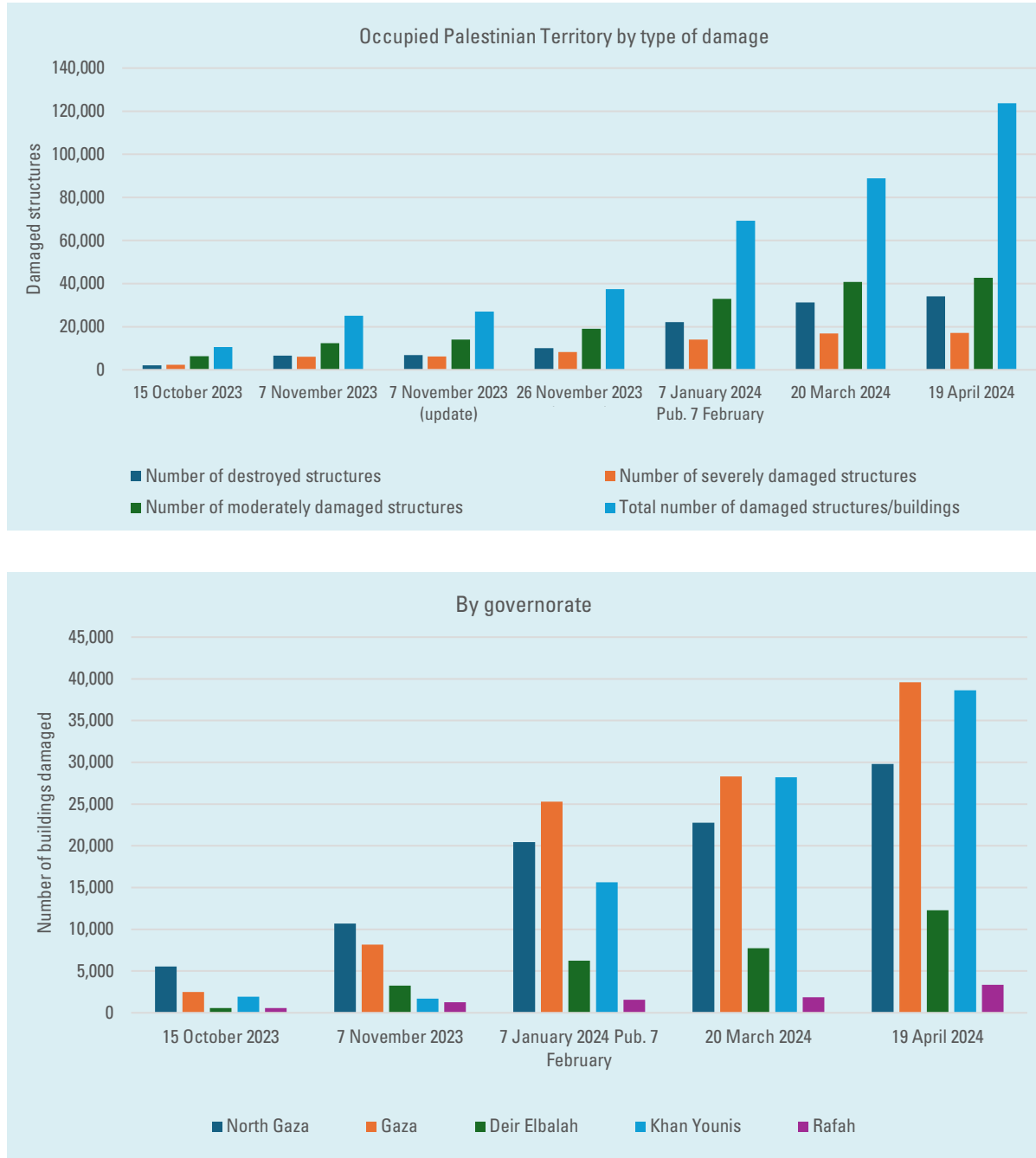
Table 2. Assessment of damage to buildings in Gaza (UNOSAT at different dates of the war)

	15 October 2023	22 October 2023	28 October 2023	7 November 2023	26 November 2023	7 January 2024	20 March 2024	19 April 2024
Maps links	Link			Link	Link	Link	Link	Link
Number of destroyed structures	2,017			6,583	10,049	22,130	31,198	34,115
Number of severely damaged structures	2,282			6,062	8,243	14,066	16,908	17,055
Number of moderately damaged structures	6,285			12,405	19,087	32,950	40,762	42,659

	15 October 2023	22 October 2023	28 October 2023	7 November 2023	26 November 2023	7 January 2024	20 March 2024	19 April 2024
damaged structures								
Possibly damaged structures								29,877
Total number of damaged structures	10,584			25,050	37,379	69,146	88,868	123,706
Number of damaged housing units						93,800	121,400	128,904
By governorate								
North Gaza	5,535			10,680	14,486	20,456	22,755	29,821
Gaza	2,491			8,175	14,418	25,278	28,324	39,587
Deir al-Balah	564	775		3,241		6,240	7,723	12,298
Khan Younis	1,915			1,701		15,647	28,197	38,645
Rafah	576		1,277	1,253		1,561	1,870	3,355
Number of newly damaged structures in Gaza				2,397		10,319	12,279	
Number of newly damaged structures in Khan Younis						11,893		
Number of newly destroyed structures in Gaza City						8,926		
Number of newly destroyed structures in Khan Younis							6,663	

Source: ESCWA compilation from UNOSAT satellite-imagery products on comprehensive assessment of damage and destruction to structures within Gaza Strip, Occupied Palestinian Territory, <https://unosat.org/products/>.

Figure 3. UNOSAT satellite-imagery based comprehensive assessment of damage and destruction to structures within Gaza Strip, Occupied Palestinian Territory by type of damage (top) and by governorate (bottom)



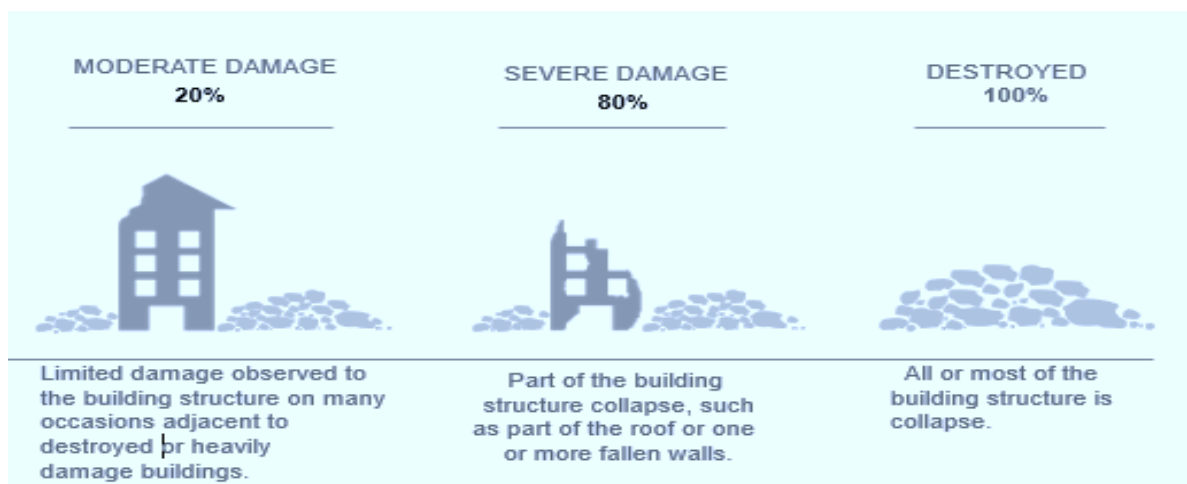
Source: ESCWA compilation from UNOSAT satellite-imagery products on comprehensive assessment of damage and destruction to structures within Gaza Strip, Occupied Palestinian Territory, <https://unosat.org/products/>.

UNOSAT and PCBS agreed to share and exchange data and maps: UNOSAT on high resolution images, and PCBS on geolocated data of buildings and household units from censuses and surveys. Regarding the housing unit estimates, for the 220,000 PCBS (cadastral) points, only 197,000 had actual housing unit information (the rest are “null”). According to UNOSAT building count, there were 283,000 buildings in Gaza. Thus, 86,000 buildings did not have any housing unit information, or approximately 30 per cent of the PCBS points were missing information or did not have a footprint match. UNOSAT was able to calculate the remaining 30 per cent by determining the approximate height of the buildings and assigning it an average number of housing units according to the building height, and one that will carry an elevated error margin of - +20 per cent.

UNOSAT’s “Gaza Strip building footprint” is a combination of the open street map (OSM) and MS Bing Gaza building footprints that were corrected and completed when any new structures were not digitized. Some shifting between the polygons drawn by UNOSAT, the PCBS maps and any satellite images used was expected, as all satellite images were not collected on the same angle. PCBS agreed to

collaborate with data on buildings and housing units in Gaza from household surveys and censuses. The following steps were taken:

- PCBS did an initial match of UNOSAT’s building footprint polygons with the PCBS cadastral data points (60 per cent to 80 per cent match expected).
- PCBS shared the updated building footprint polygon dataset with UNOSAT so the remaining 40 per cent to 20 per cent of the PCBS cadastral points that do not match manually can be assigned. UNOSAT assigned a damage level to each polygon based on the latest Gaza damage assessment from 26 November 2023 and calculated the total number of damaged households per affected building based on the known damage level using this formula: destroyed = 100 per cent of the households destroyed, severe damage = 80 per cent of the households damaged, and moderate damage = 20 per cent of the households damaged (as per the infographic below).
- UNOSAT then automated this last step (calculation of the total number of damaged households) to speed up the process once a new damage assessment is conducted in Gaza.

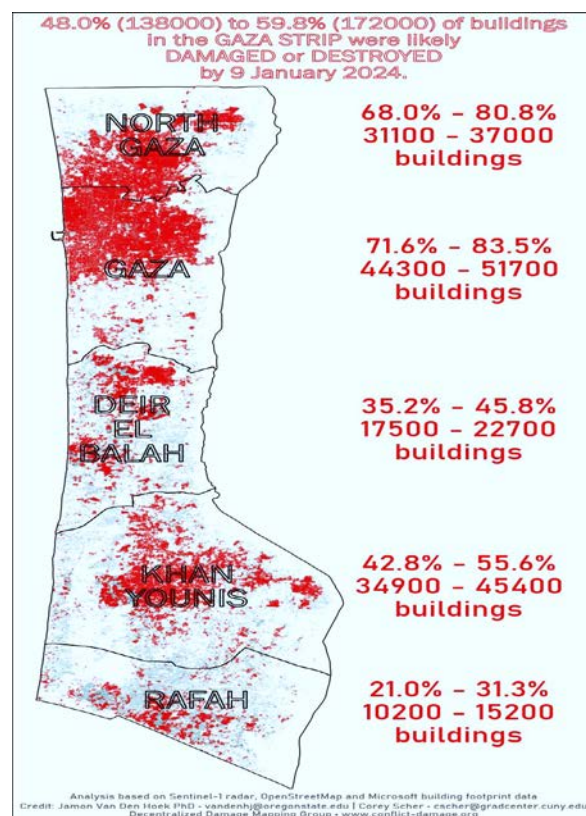


4. The rapid assessment for building damage by the Decentralized Damage Mapping Group-University of Oregon (DDMG)

The work of the scholars and members of the DDMG, Corey Scher of CUNY Graduate Center, and Jamon Van Den Hoek of Oregon State University, on the Gaza war damage mapping is based on the use of satellite imagery and geospatial data to examine relationships between forced displacement, climate vulnerability and land cover/land use change in conflict-affected regions around the world to improve the transparency, accountability and equity in reporting, and awareness of the war's effects on people and places.

The damage maps are based on a multi-date analysis of European Space Agency Copernicus Sentinel-1 data. A coherent change detection approach was used, related to the method presented in [NASA ARSET training \(Part 1\)](#) on mapping urban damage during armed conflict. The methods presented in the training are meant to familiarize a new user with radar interferometry. However, the specific algorithmic workflows that were developed for mapping damage in the Gaza Strip represent the culmination of years of research and are distinct from the approach presented in the training.

Figure 4. Buildings damaged or destroyed



Source: Damage analysis of Copernicus Sentinel-1 Satellite data by [Corey Scher](#) of CUNY Graduate Center and [Jamon Van Den Hoek](#) of Oregon State University.

For the Gaza war, their assessment used automated interferometric synthetic aperture radar (InSAR) workflow for damage detection, updated SAR images over the Gaza Strip every five-six days, (Sentinel-1-10 meter resolution). Their method relies on tracking changes in coherence, an indicator of structural stability and presence, across many years of data. Regions that show a significant decline in coherence since the onset of the war are presumably damaged. Likely damaged regions are then post-processed to remove false positives and are cross-referenced with building footprint datasets to estimate the number of likely damaged buildings across the Gaza Strip. This approach provided sub-weekly Gaza Strip-wide coverage and results that can be directly compared to earlier/later damage maps or even other geographies. The agreement is comparable to published papers comparing InSAR damage detection and very high-resolution damage maps.

The authors have been published and reported in about 200 major news and media outlets around the world on the damage to buildings in Gaza. In the rapid assessment of 9 January 2024, they estimated that around 138,000 to 172,000 buildings (48 per cent-59.8 per cent) have been likely damaged or destroyed in Gaza Strip: at least 68 per cent in North Gaza, 71.6 per cent in Gaza, 35.2 per cent in Deir al-Balah,

42.8 per cent in Khan Younis and 21 per cent in Rafah (figure 4, table 3).¹⁵

The authors noted that the assessment of 9 January 2024 has been quite a turning point in mapping the scale of likely damage.

- At least a third of all structures in Gaza ...
- At least 60 per cent of structures in North Gaza and Gaza ...
- At least 20 per cent of structures in Khan Younis ...

Have likely been damaged or destroyed by 11 December 2023.

The author wrote: *"The numbers on damaged buildings are increasingly irrelevant at reflecting the consequences of a war that has reduced kindergartens and lecture halls to rubble, compelled millions from their homes (many into the desert), forced doctors to operate on their own children, and shattered whatever sense of normalcy there was before the war. There is no way to quantify horror and suffering at this scale. Counts of damaged buildings and square kilometers of likely damage to cities attest to non-human aspects of the war. Brick and concrete. We may report 25 per cent of buildings damaged here or there, but 100 per cent of some neighborhoods and an untold number of businesses and homes are gone. Some places are 100 per cent rubble"*.¹⁶

15 Damage analysis of Copernicus Sentinel-1 satellite data by [Corey Scher](#) of CUNY Graduate Center and [Jamon Van Den Hoek](#) of Oregon State University.

16 [https://www.linkedin.com/feed/update/urn:li:activity:7140708321828777985/?commentUrn=urn%3Ali%3Acomment%3A\(activity%3A7140708321828777985%2C7144234748423430144\)&dashCommentUrn=urn%3Ali%3Afsd_comment%3A\(7144234748423430144%2Curn%3Ali%3Aactivity%3A7140708321828777985\)](https://www.linkedin.com/feed/update/urn:li:activity:7140708321828777985/?commentUrn=urn%3Ali%3Acomment%3A(activity%3A7140708321828777985%2C7144234748423430144)&dashCommentUrn=urn%3Ali%3Afsd_comment%3A(7144234748423430144%2Curn%3Ali%3Aactivity%3A7140708321828777985)).

Table 3. likely damage to human settlements (cities, towns, villages) across the Gaza Strip

ADM2_EN	Area Sq.km	Total Num Buildings	Date of the map	Num Likely Damaged Low Estimate	Num Likely Damaged High Estimate	Per cent Likely Damage Low Estimate	Per cent Likely Damage High Estimate
Deir al-Balah	57	49,663	11 December 2023	8,534	11,691	17.2	23.5
Gaza	75	61,890	11 December 2023	37,909	45,129	61.3	72.9
Khan Younis	110	81,695	11 December 2023	16,450	22,598	20.1	27.7
North Gaza	61	45,738	11 December 2023	27,476	33,359	60	73
Rafah	63	48,678	11 December 2023	4,680	7,214	10	15
Total	365	287,664	11 December 2023	95,049	119,991	33	42
Deir al-Balah			5 January 2024	14,900	19,400	30	39
Gaza			5 January 2024	44,000	51,200	71	83
Khan Younis			5 January 2024	31,200	40,300	38	49
North Gaza			5 January 2024	31,100	36,900	68.1	80.8
Rafah			5 January 2024	8,900	13,000	18.3	26.8
Total			5 January 2024	130,200	160,800	45.3	55.9
Deir al-Balah			9 January 2024	17,500	22,700	35	46
Gaza			9 January 2024	44,300	51,700	72	84
Khan Younis			9 January 2024	34,900	45,400	35	46
North Gaza			9 January 2024	31,100	37,000	68.0	80.8
Rafah			9 January 2024	10,200	15,200	21.0	31.3
Total			9 January 2024	138,000	172,000	48.0	59.0

Source: Damage analysis of Copernicus Sentinel-1 satellite data by Corey Scher of CUNY Graduate Center and Jamon Van Den Hoek of Oregon State University.

5. InSAR and high resolutions imagery analyses results and integration with national data

The comparison of the results from both InSAR and high resolutions imagery analyses revealed inconsistencies with InSAR estimates of building damage higher than UNOSAT results. Potential reasons for those inconsistencies could be that small-scale structures are likely missed by DDMG or the later date likely contributes to missed detections by the DDMG map, especially in north-western Gaza: 1) InSAR is not inherently limited in terms of severity of damage, and 2) InSAR approach is sensitive to lateral (side-structural) damage, which overhead imagery cannot capture.

Integration with national data from PCBS: The maps based on the analysis of open-access radar satellite data were shared with PCBS, UNOSAT and ESCWA teams. All damage maps have been clipped to the boundary of the Gaza Strip and are based on 40-meter spatial resolution data. The maps are readable in geographic information system software such as Quantum GIS or ArcGIS and most other online mapping platforms. These maps represent likely damage to human settlements (cities, towns, villages) across the Gaza Strip. The approach is not designed to be sensitive to potential damage in agricultural or other vegetated ("natural") regions.

The DDMG team worked on operationalizing separate satellite image-based workflows to

characterize war impacts in vegetated regions. These maps will be integrated in regular data releases. In general, however, these maps are intended for visualization/cartography but are not intended for analytical (quantitative and/or spatially explicit) comparisons with other data, such as population or building footprints.

When comparing InSAR likely damage map of 5 November 2023 to damage maps produced by UNOSAT based on 30 cm very-high resolution commercial satellite imagery, approximately 70 per cent of the building damage locations were consistent with those reported by UNOSAT in their [7 November 2023 assessment](#). A better agreement is expected if the analysis was performed using same-date imagery. The 70 per cent detection is as high as any published study using satellite radar to detect damage recorded by UNOSAT with very high-resolution imagery, and notable given that DDMG analysis is based on 10-meter resolution data.

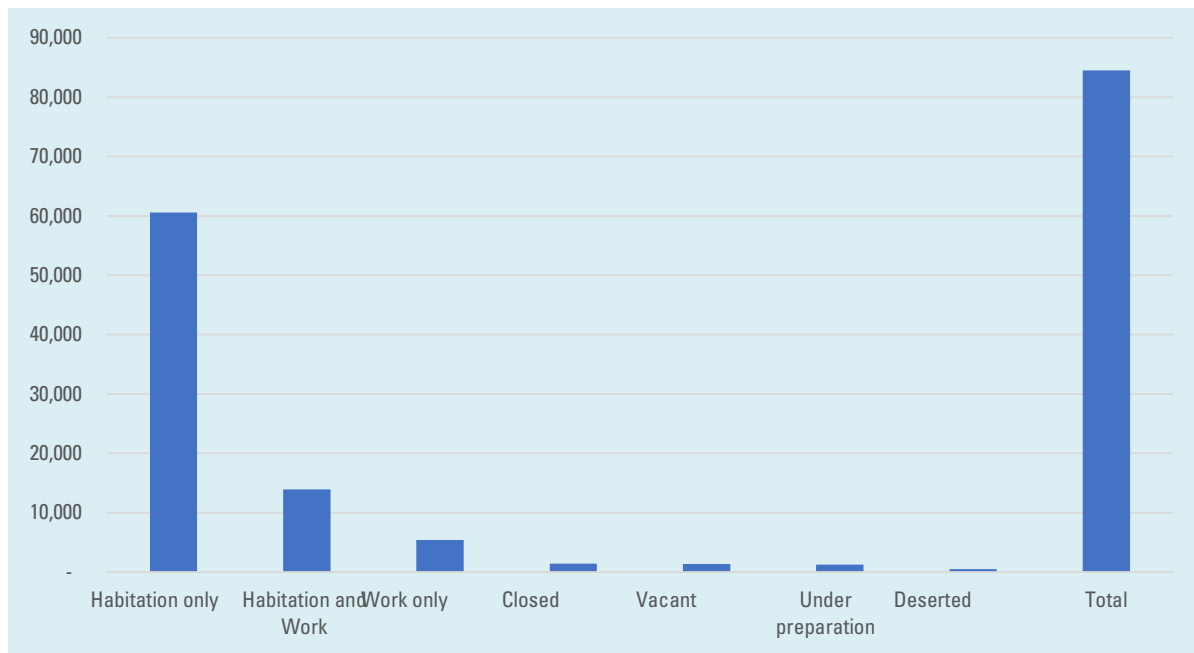
When compared with the data shared from PCBS on 220,000 building locations, to the most recent "total likely damage" DDMG map from 29 January 2024, found that 94,860 building locations (43 per cent of total) that intersect one of our "likely damaged" building footprints. 84,498 of these locations have information on building utilization (figure 5). Of these, it was found that more than 60,000 "habitation only"

and nearly 14,000 "habitation and work" buildings have likely been damaged/destroyed (figure 4). When tallying up the number of "likely damaged" housing units, the value of 253,930 housing units across Gaza was obtained. This corresponds to 56 per cent of total housing stock, which is very close to the 60 per cent of homes that have been destroyed in Gaza

More work is required to get the PCBS building location data intersect the geometry of a likely damaged building footprint that the InSAR analysis is based on. There are many

mismatches that need to be addressed to have a more faithful 1:1 relationship between the building locations and building footprints. In addition, the analysis considered building footprints that are completely covered (filled) by the damage pixels. These footprints form the basis of the low-end estimates of damage. Adjustments to either condition - improving the spatial agreement between locations and footprints or lowering the threshold for 'damage' at the building-level – will only increase the estimates of likely damaged housing units and locations.

Figure 5. Types of utilizations of damaged buildings



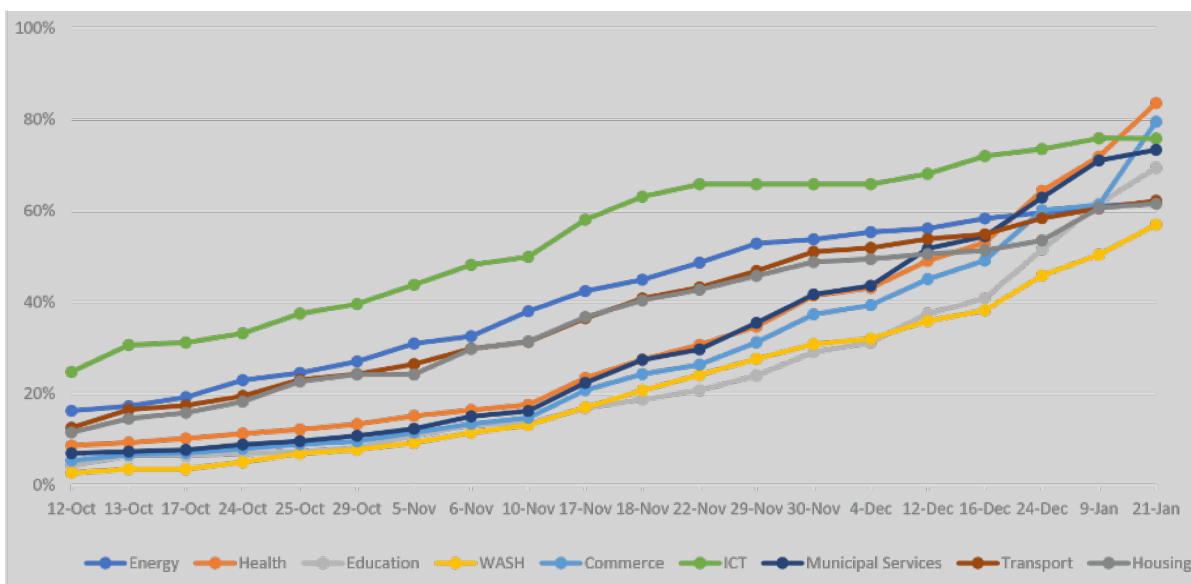
Source: DDMG Data analysis based on exchange with PCBS on building footprint.

6. Damage assessment of the infrastructure and productive sector

The World Bank, in its interim report of March 2024, estimated the damage to the infrastructure and productive sector from (SAR) satellite imagery,¹⁷ (figure 6):

- 84 per cent of the physical infrastructure in the health sector.
- 50 per cent of all primary, secondary and tertiary roads are damaged or destroyed.
- 80 per cent of commerce, industry and services sector establishments have been damaged or destroyed.

Figure 6. Impact (Damaged and Destroyed) Percentage by Sector 12 October–21 January 2024



Source: World Bank/IPSOS.

7. Agricultural damage assessment - December 2023

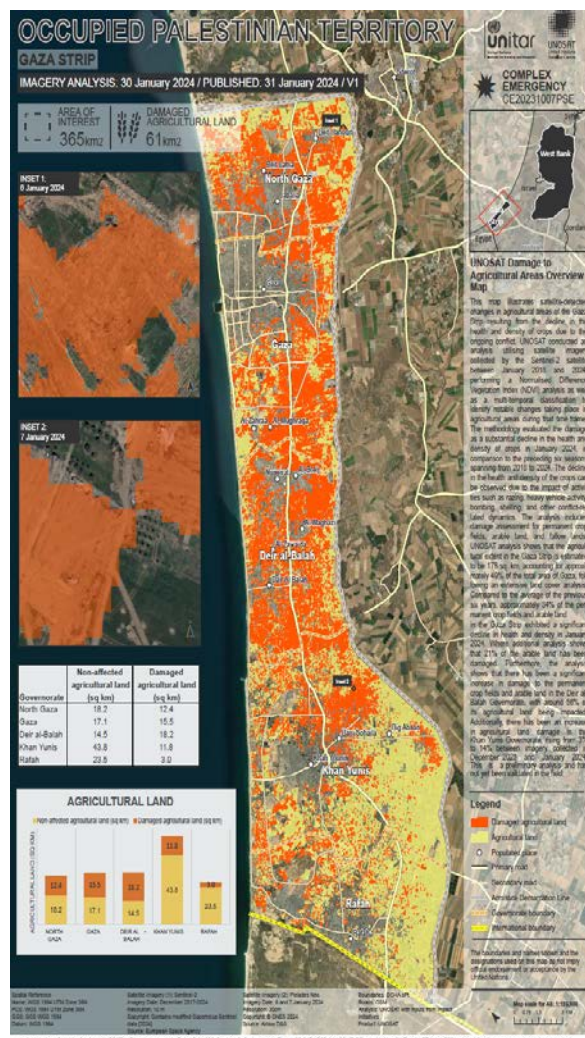
The agricultural sector plays a vital role in Gaza Strip's gross domestic product (GDP), contributing about 11 per cent in 2022 and providing crucial employment opportunities. The agricultural extent in the Gaza Strip is estimated to be 185 sq. km, accounting for approximately 50 per cent of the total area of Gaza. PCBS estimated the direct daily losses due to halted production at \$1.6 million, exacerbated by the destruction of agricultural property, resulting in a total loss exceeding \$180 million.¹⁸

UNOSAT conducted three agricultural damage assessments for the Gaza Strip utilizing satellite imagery collected by the Sentinel-2 satellite and performing a normalized difference vegetation index (NDVI) analysis as well as a multi-temporal classification to identify satellite-detected substantial changes in agricultural areas of the Strip.

The methodology evaluated the damage as a substantial decline in the health and density of crops in January 2024, in comparison to the preceding six seasons spanning from 2018 to 2024.

UNOSAT analysis shows that the agricultural extent in the Gaza Strip is estimated to be 185 sq. km, accounting for approximately 50 per cent of the total area of Gaza.

Figure 7. UNOSAT Gaza Strip agricultural damage assessment - January 2024



Source: <https://unosat.org/products/3792>.

In the [fourth analysis](#) between December 2017 and January 2024, the decline in the health and density of the crops was observed due to the impact of activities such as razing, heavy vehicle activity, bombing, shelling and other conflict-related dynamics. The analysis includes damage assessment for permanent crop fields, arable land and fallow lands. UNOSAT analysis shows that the agricultural extent in the Gaza Strip is estimated to be 178 sq. km, accounting for approximately 49 per cent of the total area of Gaza, following an extensive land cover analysis.

Compared to the average of the previous six years, approximately 34 per cent of the

permanent crop fields and arable land in the Gaza Strip exhibited a significant decline in health and density in January 2024. Crop analysis shows that 21 per cent of the arable land has been damaged. Furthermore, the analysis shows that there has been a significant increase in damage to the permanent crop fields and arable land in the Deir al-Balah Governorate, with around 56 per cent of its agricultural land being impacted. Additionally, there has been an increase in agricultural land damage in the Khan Younis Governorate, rising from 3 per cent to 14 per cent between imagery collected in December 2023 and January 2024. This is a preliminary analysis and has not yet been validated in the field (figure 7, table 4).

Table 4. The Gaza Strip agricultural damage assessment by UNOSAT

Gaza surface area 361 sq. km	Date		
	November 2023	December 2023	January 2024
Agricultural extent 185 sq. km 51 per cent of total Area			
Decline in arable land in health and density compared to the average of the previous six years (per cent)	15	18	
Damage to the arable land in the North Gaza Governorate (per cent)	35	39	
Damaged agricultural land (sq. Km)			61
North Gaza			12.4
Gaza			15.5
Deir al-Balah			18.2
Khan Younis			11.8
Rafah			3
Source	unosat.org/products/3745	unosat.org/products/3772	unosat.org/products/3792
Contribution of agricultural sector to Gaza's Strip GDP, 2022 (per cent)		11	
Daily losses of the agriculture sector in Gaza \$1.6 million		1,600,000	
Losses of the agriculture sector in Gaza during the war (in US dollars)		96,000,000	
With loss of agricultural property (in US dollars)		180,000,000	

Source: <https://www.pcbs.gov.ps/site/512/default.aspx?lang=en&ItemID=4643>.

8. Results and Conclusions

The collaboration between ESCWA statistics team, PCBS, UNOSAT and DDMG showed that it was necessary to make joint efforts to make better use of the data and analysis methods of damage assessment of buildings from satellite imagery, radar and high resolutions images, as well as field-proofed geolocated data. This allowed better understanding of the different methodologies and how to integrate the data from different sources whenever possible, to obtain more consistent reliable and detailed information on the physical damage to the different structures, to differentiate between buildings, housing units, and structures, and to

provide good basis for the estimation of the damage in monetary terms and enable adequate reconstruction.

This methodological note summarizes the outcomes of several joint general and technical meetings held to addresses the details of the different methodologies used to estimate the damage to buildings and housing units. The note will feed into a report that ESCWA and UNDP are preparing as part of the series of reports on the repercussions of the war on Gaza, and the estimation of post-disaster needs for recovery and reconstruction.



The speed and extent of the catastrophic damage caused by the war on Gaza have been unparalleled and incomparable in recent times. Since 7 October 2023, more than 50 per cent of all the structures in the Gaza Strip have been destroyed; 360,000 housing units damaged, 5 per cent of the population killed or injured and two million people displaced.

Combined methods of remote sensing, using satellite imagery, synthetic aperture radar (SAR) and very high resolution aerial imagery, in addition to field work, are essential to test and validate the assessment of damage caused by disasters and wars. They are also essential to detect, with precision, damage that is difficult to see, and to quickly assess the amount of damage, as it was done during the damage assessment undertaken by the World Bank of the Haiti Earthquake disaster in 2010.

A methodological note on the assessment of the physical damage to buildings caused by the war on Gaza (October 2023-March 2024) was prepared by UNESCWA-Statistics, in collaboration with the Palestinian Bureau of Statistics (PCBS), the United Nations UNITAR/UNOSAT unit (UNOSAT) and the Decentralized Damage Mapping Group-University of Oregon (DDMG). The assessment integrates high resolution satellite imagery with official statistics on geolocated data from surveys and censuses in the State of Palestine.

The collaboration helped provide a better understanding of the different methodologies, integrate the data from different sources, and obtain more consistent, reliable and detailed information on the physical damage incurred by the different structures, to differentiate between buildings, housing units and structures. The collaboration improved the accuracy of the estimations related to the extent of the damage incurred by buildings and the types of buildings damaged in the administrative districts of Gaza, to provide reliable and timely data on the social and economic repercussions of the war, post-war recovery and needs assessment for the State of Palestine.

