



Remote Sensing based Structural Damage Assessment to determine probable Shelter Needs in the Gaza Strip

Dr. Kit Miyamoto ¹, Rohan Shinde ², Subhajit Das ³, David Hodgkin ⁴

Remote Sensing Structural Damage Assessment to determine probable Shelter Needs in the Gaza Strip

Report 2

19 Feb 2024

Dr. Kit Miyamoto ¹, Rohan Shinde ², Subhajit Das ³, David Hodgkin ⁴



Miyamoto International, Inc.

707 Wilshire Blvd
Los Angeles, California 90017, USA

©2024 Miyamoto International, Inc. All Rights Reserved.

*This report or any part of it should not be reproduced in any form without the written permission of
Miyamoto International, Inc.*

EXECUTIVE SUMMARY

The technical bulletin presented in this report provides an estimate of the structural damage and shelter needs in the Gaza Strip based on remote sensing data. The report describes the apparent levels of damage in multiple cities, along with a summary of the common building typologies across the area. Color-coded damage maps outline the areas and levels of damage across the region while pie charts provide a breakdown of probable damage severity. A range of publicly available open-source data such as UNOSAT, OpenStreetMap and LandScan Global were used in this assessment report.

The damage results are produced using UNOSAT data dated January 7, 2024. At that slice in time about 50% of the Gaza Strip had been affected; more than 69,000 structure have been directly affected with 22,000 destroyed, 14,000 severely damaged, and 33,000 moderately damaged. Approximately 68% of all buildings in North Gaza were damaged to varying degrees, including moderate, severe, or destroyed with moderately damaged structures accounting for about 30% of all damaged structures. Similarly, 58% of the building stock in Gaza appears to have sustained varying levels of damage.

At the time of writing this report, the situation in the Gaza Strip has continued to expand to the south resulting in significantly more damage than indicated in the last UNOSAT dataset release. It is expected that many of the southern areas of the Strip such as Khan Younis, Deir Al-Balah and Rafah will now have suffered a similar level of damage as the north. Approximately 35% of the buildings in Khan Younis and 20% of the buildings in Deir Al-Balah appear to have sustained various levels of damage. As the conflict is progressing further south, approximately 10% of the buildings in Rafah are estimated to have differing levels of damage.

There are nearly 180,000 structures across the entirety of the Gaza Strip. If the pattern of damage has remained similar then it is likely that more than 60% of buildings, approximately 110,000 structures that are mainly residential, are likely now damaged and uninhabitable across the entire area. As a result, approximately 1.2 million people are likely to be without adequate safe housing and in urgent need of emergency shelter and housing recovery assistance. Many more people from non-damaged structures are also likely to be temporarily displaced through fear and lack of adequate services. On January 10, 2024, the Shelter Cluster estimated 1.9 million internally displaced persons (IDPs) in Gaza, nearly 85% of the population.

Housing recovery and reconstruction efforts in Ukraine and other recent global disasters has shown that once safe access is available, rapid repairs to light to moderately damaged structures can be one of the fastest, most cost effective and most dignified ways to address the emergency shelter needs of the affected population. Rapid emergency repairs can also help kick-start early recovery, ensuring a more rapid transition to permanent durable solution for those who have been displaced.

Note: The information in this bulletin is based on the most recent available data. Miyamoto intends to update this and provide further updates as new reliable data sources become available.

1. Profile of The Gaza Strip

The Gaza Strip is a narrow strip of land that extends along the Mediterranean coastline north from the Egyptian border. The Strip covers an area that is about 45km in length, with a width that ranges between 6 – 12km, creating a total area of about 360sq.km (see Figure 1).

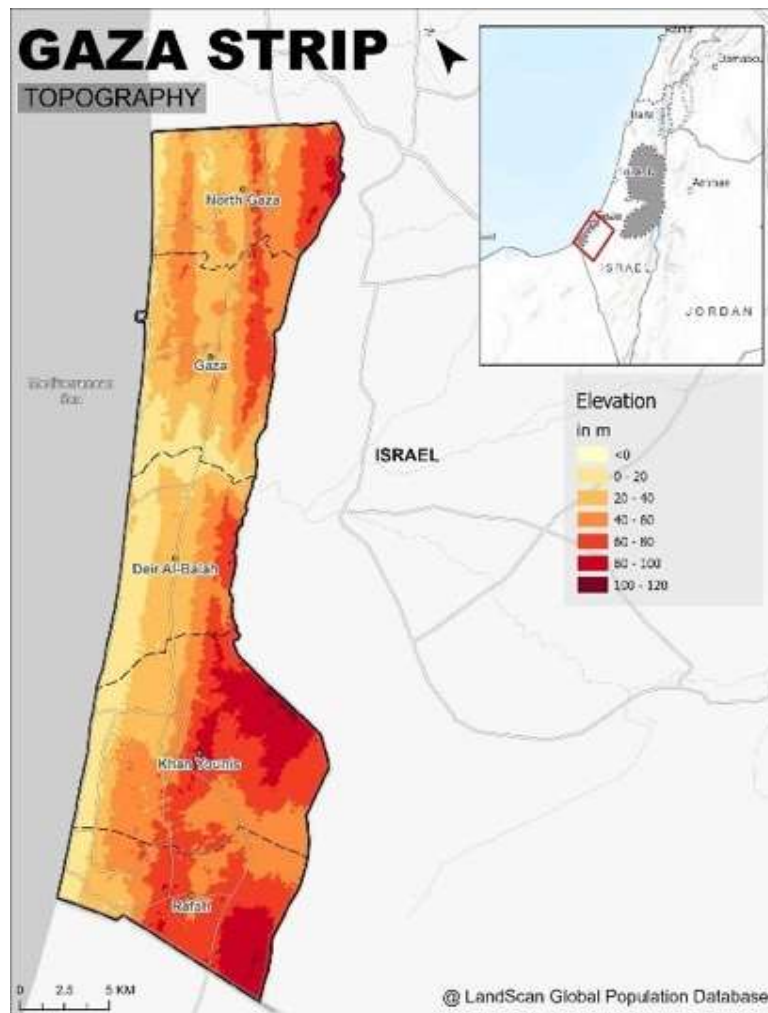


Figure 1: Topography of the Gaza Strip

Recent UN estimates indicate there are approximately 2.1 million people living across the 360sq.km of the Gaza Strip, which includes five major cities and many smaller rural communities. This amounts to an average of more than 5,800 people per square kilometer making it one of the most densely populated areas of the world. Gaza is the largest city in the Strip, covering an area of about 45sq.km. The Topography of the Gaza Strip is dominated by three ridges that run parallel to the coastline as per Figure 1.

2. Exposure: Built-up Environment and Population

In this section, the built-up area and the exposed population are discussed. Pre-damage building data from the open street maps was analyzed using GIS. Figure 3, shows the details of the urban areas in the Gaza Strip. The total number of buildings is 174,148, encompassing a total ground floor building area of around 49sq.km.

The approximate building and population distribution across the Gaza Strip are shown respectively, in the two maps below in Figure 3. These maps are based on data from Open Street Maps and the most recent LandScan population data of 1.97M, respectively. While this population data is slightly lower than recent UNRWA estimates of 2.1M the distribution is likely still relatively accurate. The color-coded heat map shows the hot spots of high population density within the strip. Notably North Gaza and Gaza are amongst the most highly populated areas within the Strip with their coinciding high building and population density clearly indicated. The broad distribution of building coverage in the map to the left highlights the high level of less-populated dispersed peri-urban and rural settlements across the area.

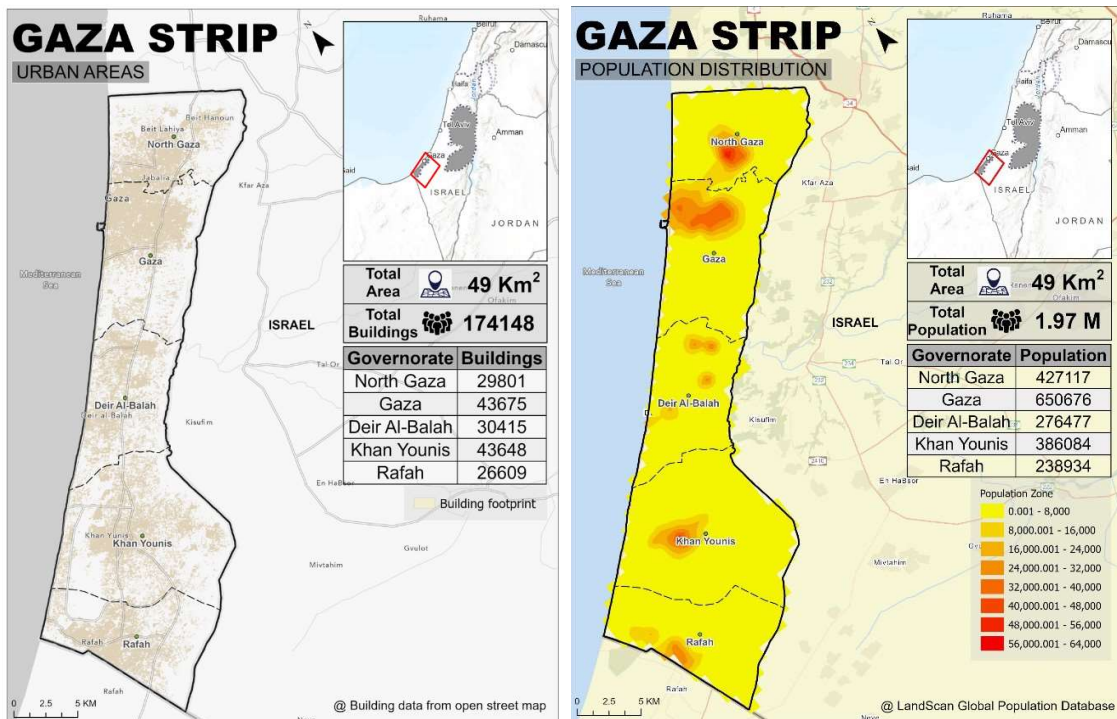


Figure 3: Built-up environment and population distribution

3. Estimated Damage Assessment by Miyamoto International

The following figures demonstrate the estimated damage to structures across the Gaza Strip from the current situation. This damage assessment is based on UNOSAT data from January

7, 2024. As shown in Figure 4, there has been particularly extensive damage to buildings in the cities of Northern Gaza and Gaza. Out of 174,148 buildings in all of Gaza, an estimated 69,146 buildings appear to have been damaged. As per the map below it is evident that the damage density is much higher in the northern part of the Gaza Strip. The total ground floor built-up area is about 49sq. km.

As shown in Figure 5, around 22,000 structures have been destroyed, 14,000 severely damaged, and 33,000 moderately damaged. This comprises 18% of the total building structures in the Gaza Strip (UNOSAT, January 7, 2024).

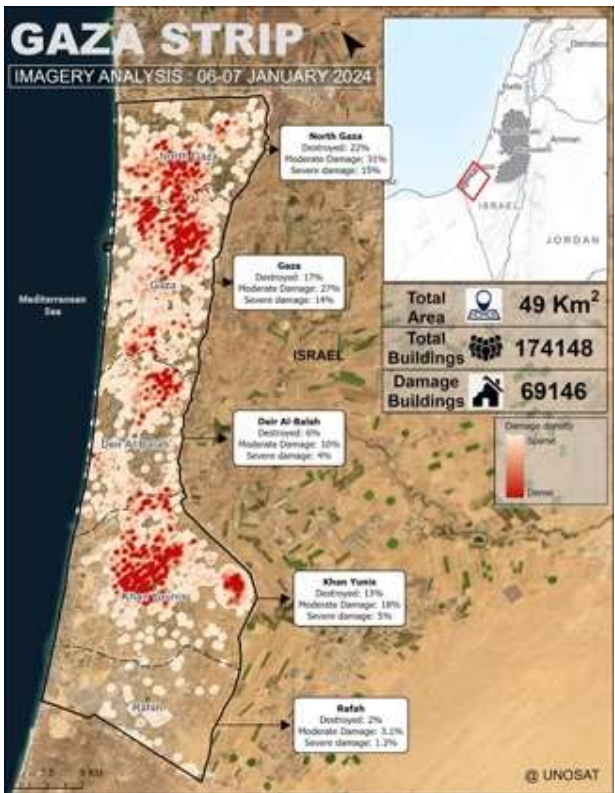


Figure 4: Damaged buildings in the Gaza Strip

Affected buildings comparison from November 2023 to January 2024

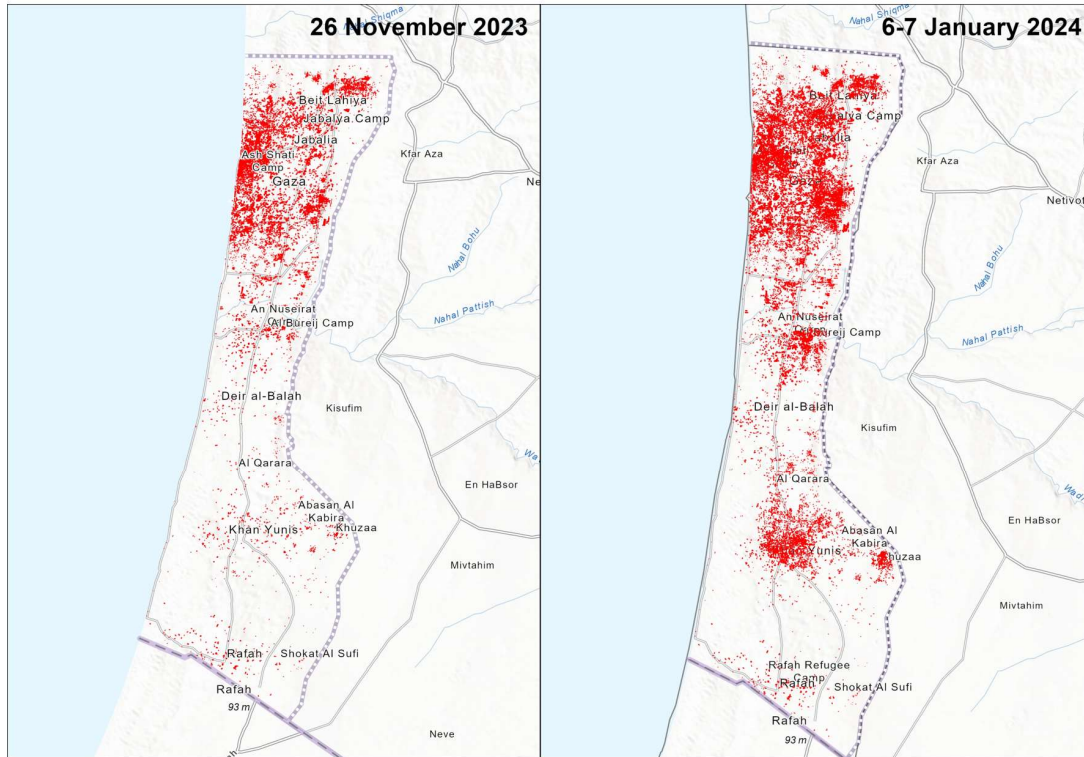


Figure 5: Damaged buildings comparison in the Gaza strip

As shown in Figure 5, the damaged area has increased in 1.5 months, from November 2023 to January 2024. There is a significant increase in damaged buildings in Northern Gaza. As the conflict is expanding southwards, we can see the hotspots in the South Gaza as well close to Khan Younis Governate.

Gaza Strip Damage status based on the analysis of January 06-07 UNOSAT data and OSM data

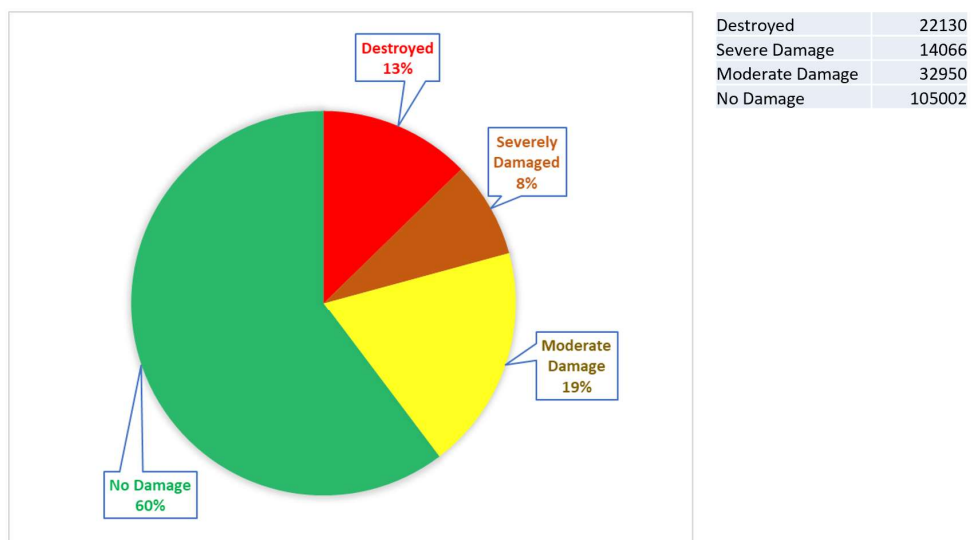
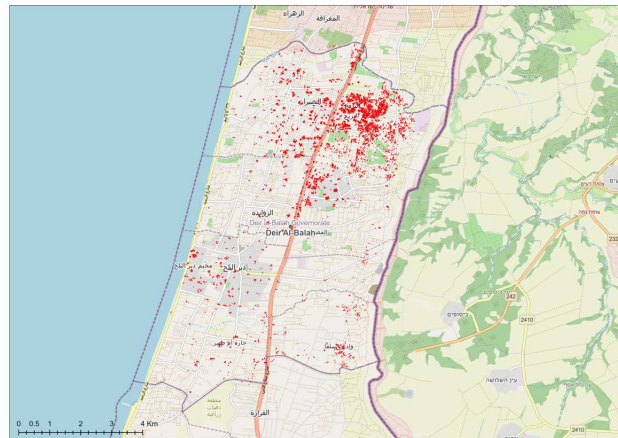
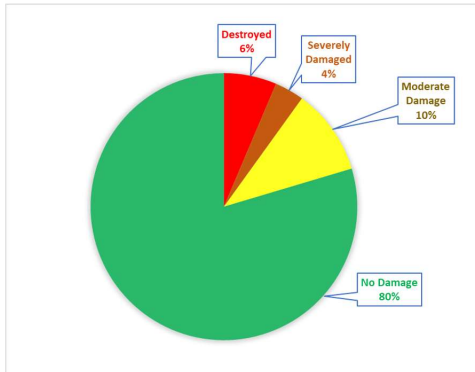


Figure 6: Overall damage in the Gaza strip

The following pages provide pie charts of building damage levels by region, across the Gaza strip as on January 7, 2024. Figure 7 shows that approximately 68% of buildings in North Gaza have suffered varying levels of damage, from moderate, severe, to totally destroyed. Moderately damaged structures account for about 30% of those damaged structures.

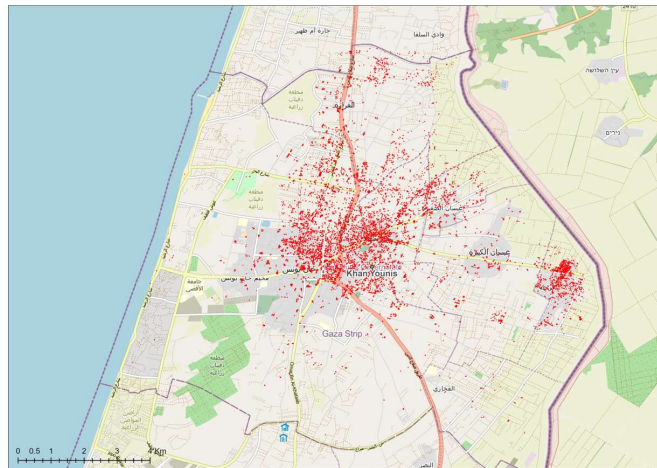
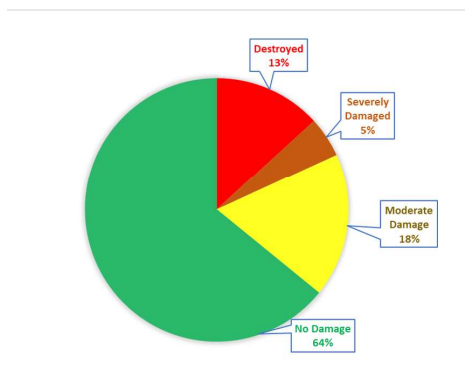
Deir Al-Balah

| | |
|-----------------|-------|
| Destroyed | 1944 |
| Severe Damage | 1083 |
| Moderate Damage | 3177 |
| No Damage | 24211 |



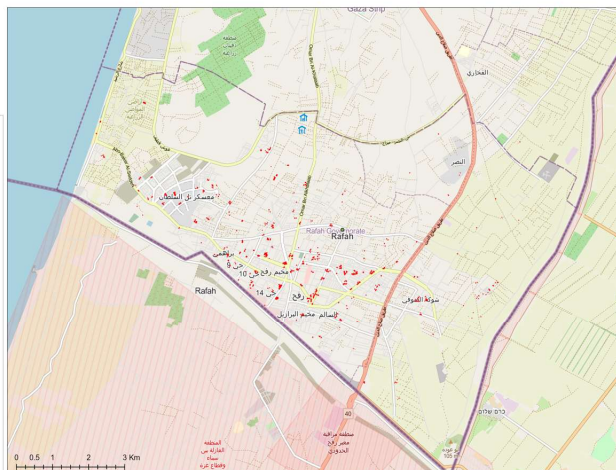
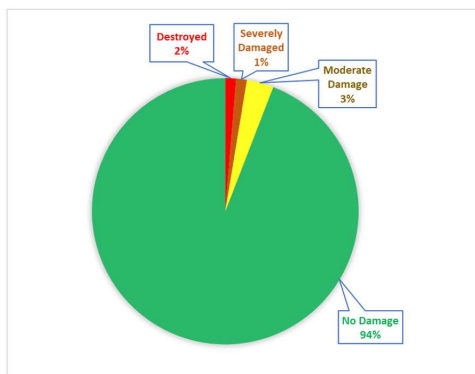
Khan Younis

| | |
|-----------------|-------|
| Destroyed | 5754 |
| Severe Damage | 2172 |
| Moderate Damage | 7721 |
| No Damage | 28001 |



Rafah

| | |
|-----------------|-------|
| Destroyed | 348 |
| Severe Damage | 345 |
| Moderate Damage | 868 |
| No Damage | 25048 |



UNOSAT Structural Damage by municipality

Jan 06-07, 2024

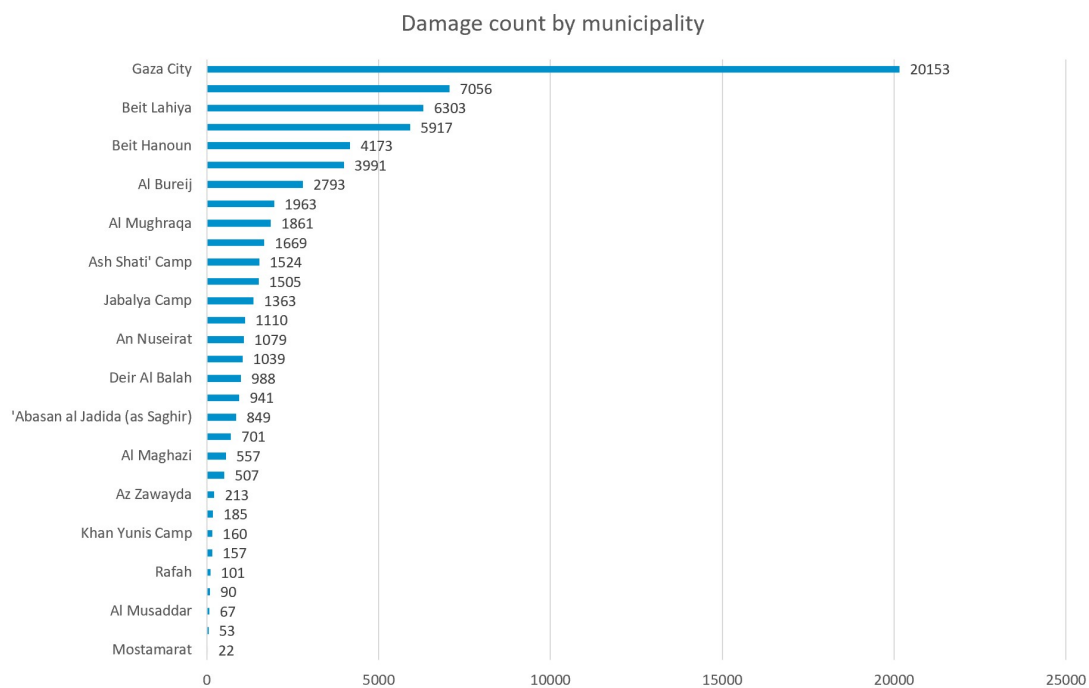


Figure 7: Structural damages across the regions in the Gaza strip

4. Common Building Typologies in the Gaza Strip

The architectural design of houses in the Gaza strip has changed dramatically over recent decades, moving from predominantly traditional stone and mud, one to two-story courtyard type construction to predominantly multi-story multi-purpose concrete construction. The rising population density and changes in availability of building materials appear to have been the major influences in bringing about such rapid qualitative shifts in the creation and design of buildings in general and houses in particular. Based on the predominant construction material, concrete buildings, sandstone buildings, and mud houses are the three most common building typologies prevalent in the Gaza Strip.



Figure 8: An overview of Gaza City showing the concrete buildings (Source: Muhaisen, 2016)

Most of the new buildings in the major city centers of Gaza are of concrete construction. These buildings vary from lower density one to two-story, single or multi-tenancy houses through to larger multi-storey, multi-tenancy, and at times multi-purpose buildings. Buildings of this typology are widely constructed using a structural frame system made from reinforced

concrete. By and large, roofs are flat concrete, and walls are constructed from plastered concrete hollow blocks, while windows are mostly single glazed, aluminum frames. For a range of reasons, including presumably land availability, cost and availability of skills and materials, concrete houses now appear to be the preferred building typology for most residents, over sandstone and mud houses. Figures 8 and 9, show examples of concrete buildings in Gaza.



Figure 9: Multi-story concrete buildings in Gaza (Source: Muhaisen, 2016)

The second most common building type is sandstone houses. Sandstone has been used in Gaza over very long periods of time. The houses are built mainly of sandstone with a load-bearing wall structural system. The walls are thick enough to bear both dead and live loads, with some of the crevices in the wall used as small shelves for storage. The roofs are commonly made of sandstone and take the form of intersecting vaults based directly on the walls appearing flat from above. The houses consist mainly of one floor and, in some cases, two floors maximum (Muhaisen, 2016). Typical sandstone Gaza houses with crevices are shown below in Figure 10.

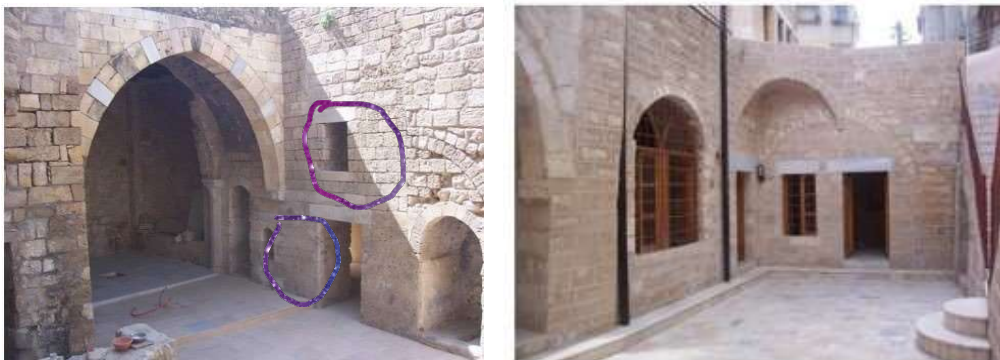


Figure 10: Sandstone buildings in Gaza (Source: Muhaisen, 2016)

The third common building typology in the Gaza Strip is mud or clay construction. These buildings are less prevalent in inner city areas but remain relatively common across peri-urban and rural areas. Buildings of this typology are constructed mainly from clay, as the base building material. Clay blocks are used to construct the walls and clay is also used to construct flat roofs, which are commonly supported by branches of locally available trees, such as palm, sycamore, and eucalyptus.

Some examples of mud houses are shown in Figure 11.



Figure 11: Traditional Mud House in Gaza (*Source: BBC, 2009*)

CONCLUSIONS

Open-source data dated January 7, 2024 (from UNOSAT, OpenStreetMap, and LandScan Global) was used for the analysis of housing damage, as well as to provide an initial estimate of probable shelter and housing recovery needs. This data shows that in northern Gaza approximately 68% of the building stock had sustained damage to varying degrees. The evolving situation in the Gaza strip has since expanded considerably to the south since the release of the last UNOSAT dataset, and it is expected that this region will have sustained similar levels of damage as the areas to the North. It is estimated that approximately 35% of the buildings in Khan Younis and 20% of the buildings in Deir Al-Balah appear to have sustained various levels of damage. In which case, approximately damage levels are now likely around 110,000+ structures (mostly residential), leaving an estimated 1.2 million+ people without adequate housing. As of January 10, 2024, the Shelter Cluster reported 1.9 million internally displaced persons (IDPs) in Gaza, nearly 85% of the population. Miyamoto intends to update this Technical Assessment report as soon as more up-to-date datasets on damage become available.

On-ground rapid assessments will of course be required to verify these remote-data based damage assessments and more accurately identify the shelter and housing recovery needs of the affected population. However, initial analysis indicates that about 50% of damaged structures are likely only light to moderate damaged and therefore rapidly repairable. Housing recovery efforts in Ukraine and other major global disasters have shown that rapid repairs to light to moderate damaged structures can be one of the fastest and most dignified ways to address immediate shelter needs as and when the current situation stabilizes, and safe access can be assured. The early provision of technical support and cash for rapid emergency repairs to light to moderately damaged housing stock, may diminish the need for other costly and often prolonged interim emergency shelter solutions, while providing a more rapid pathway to permanent durable housing recovery for many of those currently displaced.

REFERENCES

- British Broadcasting Corporation (BBC) (2009)
- Fulaih N. and Ali H. Assessment and Repair of Damaged Concrete Structures due to War Case Study (The Republic of Yemen), *International Journal of Engineering Research & Technology*, Vol. 11, Issue 01 (January 2022)
- LandScan Global (2023)
- Muhaisen A. (2016). Development of the House Architectural Design in the Gaza Strip, *Athens Journal of Architecture*.
- The World Bank – Gaza Damage Assessment Bi-Weekly Report
- OpenStreetMap (2023)
- United Nations Satellite Centre (UNOSAT) (2023)

miyamoto.

Sacramento | San Francisco | Pleasanton | San Jose | Los Angeles | Ontario | Orange County | San Diego | Reno
Las Vegas | Phoenix | Washington, D.C. | Puerto Rico | Mexico | Costa Rica | Colombia | Haiti | Italy | Ukraine
Turkey | Uzbekistan | Afghanistan | India | Morocco | Nepal | Indonesia | Japan | New Zealand