LEBANON – BUILDING DESTRUCTION AND DEBRIS QUANTITIES ASSESSMENT

Baalbek-Hermel Governorate

Satellite imagery: 7 and 10 January 2025 | Published: 22 January 2025

This publication presents the findings of a remote assessment of building destruction and debris quantities in areas affected by the recent conflict impacting Lebanon since October 2023. The assessment is conducted by the United Nations Human Settlements Programme (Lebanon), the University of Balamand, and the Center for Environmental Research of the Eastern Mediterranean (CREEMO) at Saint Joseph University. It covers two districts, Baalbek and Hermel, in Baalbek-Hermel Governorate.

This assessment is part of a series of similar assessments covering also South, Nabatiyeh and Bekaa governorates, whose findings were published separately.

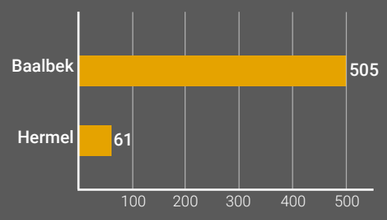
Building destruction

Number of totally and partially destroyed buildings

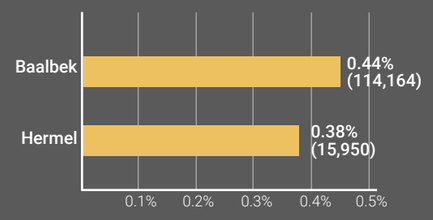
566

Percentage out of the total number of 130,114 pre-conflict buildings

0.44%



Number of totally and partially destroyed buildings per district



Percentage of totally and partially destroyed buildings out of the total number of pre-conflict buildings (indicated in parentheses above) per district

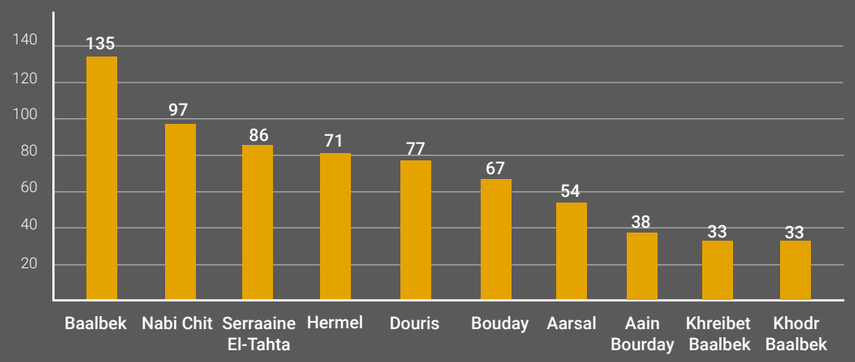
Unit destruction

Number of totally and partially destroyed units

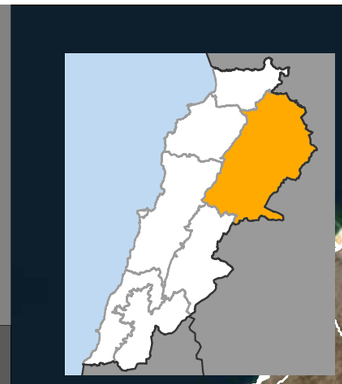
1,081

990
in Baalbek District

91
in Hermel District



Number of totally and partially destroyed units per cadastre (top 10)



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UN-HABITAT

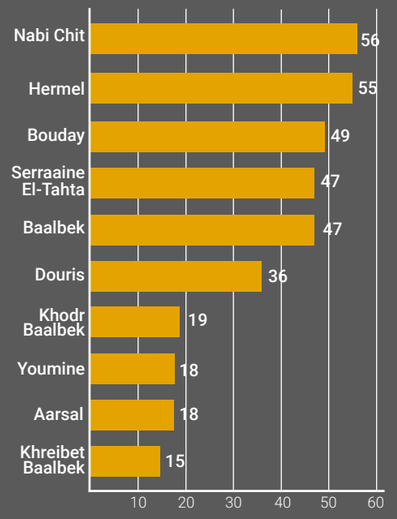
UNIVERSITY OF BALAMAND

CREEMO

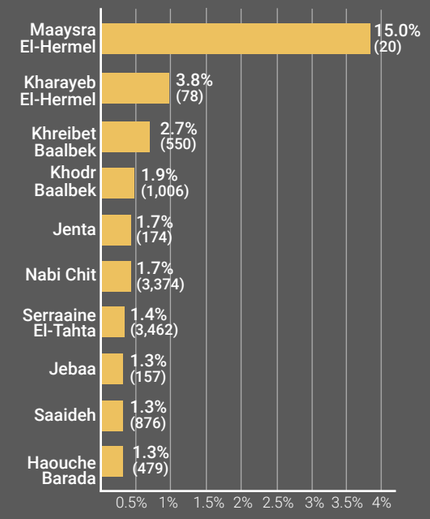
Affected cadastres

Number of cadastres with totally or partially destroyed buildings
55

Percentage out of the total number of 96 cadastres in Baalbek-Hermel governorate
57.3%



Number of totally and partially destroyed buildings per cadastre (top 10)



Percentage of totally and partially destroyed buildings out of the total number of pre-conflict buildings (indicated in parentheses above) per cadastre (top 10)

Debris quantification

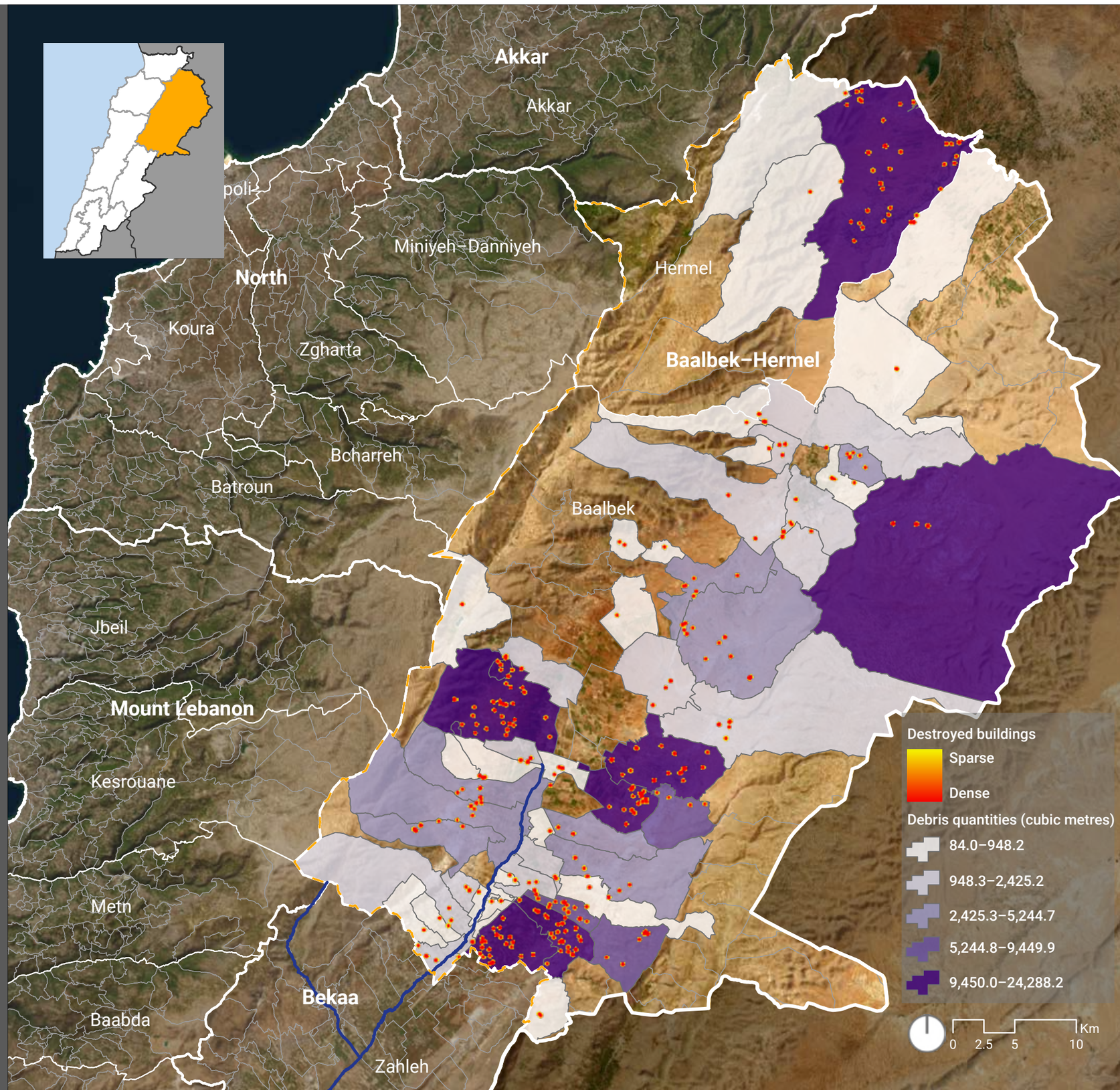
Debris generated from destroyed buildings

Volume in cubic metres
199,347
Baalbek District: 183,651
Hermel District: 15,697

Weight in tonnes – upper estimate
448,532
Baalbek District: 413,214
Hermel District: 35,318

Weight in tonnes – lower estimate
336,897
Baalbek District: 310,369
Hermel District: 26,528

Sum of cubic metres of debris generated per cadastre (top 10)	
Baalbek	24,288
Nabi Chit	17,098
Douris	14,869
Serraaine El-Tahta	14,804
Hermel	14,778
Aarsal	12,182
Bouday	11,414
Aain Bourday	9,450
Khodr Baalbek	6,283
Khreibet Baalbek	5,862



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Methodology

To detect areas with building destruction, a visual change detection analysis of pre-conflict and recent PlanetScope satellite images (downloaded from Planet Labs), dated 1 September 2023 and 7 & 10 January 2025, respectively, was conducted. The mid-range spatial resolution of 3 to 5 metres of the PlanetScope satellite images allowed for the detection of totally and partially destroyed buildings.

The areas where building destruction was detected were then overlaid with the pre-conflict building footprint layer from Microsoft Bing, downloaded on 25 September 2024 from GitHub. Consequently, the number and percentage of totally and partially destroyed buildings were calculated.

The number of units (or apartments)[1] per floor for each building was calculated based on an assumption that, in the Lebanese context, the surface area of an apartment is up to 150 square metres in urban (relatively densely populated) areas and is up to 250 square metres in rural areas. Urban and rural areas were identified using the application of the Degree of Urbanization (DEGURBA) methodology in Lebanon. Afterwards, the population density from WorldPop was superimposed over the urban/rural areas for cross-validation. The data on pre-conflict building heights was downloaded in June 2024 from the World Settlement Footprint 3D (WSF3D) layer available from the German Space Agency. The number of floors was calculated using the buildings' height, based on an assumption that the normal floor height is up to 3 metres. Therefore, the number of units per building was calculated as follows:

Number of units per building = Number of units per floor x Number of floors

Then, the debris volume was calculated in cubic metres (m^3) using the below formula:

Debris volume (m^3) = Number of buildings x Average built-up area of buildings (m^2)[2] x Volume of debris per every square metre (m^3/m^2)

The volume of debris per square metre (m^3/m^2) of a building was calculated by dividing the total volume of the building's material by the total built-up area of the building.[3] For buildings with three or fewer floors, the volume per square metre was estimated to be 1.1 m^3/m^2, based on UN-Habitat's internal calculations, validated through key informant interviews (KIIs), and supported by engineering models. For buildings exceeding three floors, the estimated volume per square metre is 0.8 m^3/m^2, derived also from UN-Habitat's internal calculations, validation through KIIs and engineering models, and extrapolation using the 2012 paper by Tamraz, Srour and Chehab (which adopts a volume per square metre of 0.73 m^3/m^2).

Then, the debris weight in tonnes was calculated by multiplying the volume (m^3) by a debris density using the below formula:

Debris weight (tonnes) = Debris volume (m^3) x Debris density (t/m^3)

The debris weight was obtained using two approaches:

- Using a lower density: The volume (m^3) was multiplied by a density of 1.69 t/m^3.[4] This density value was obtained from the United Nations Environment Programme (UNEP), based on a pilot debris project conducted in Gaza in collaboration with the United Nations Development Programme (UNDP) and European Union (EU) sources. Therefore:

  Lower estimate of debris weight (tonnes) = Debris volume (m^3) x 1.69 (t/m^3)

- Using a higher density: The volume (m^3) was multiplied by a density of 2.25 t/m^3.[5] This value was determined by the Materials Lab of the American University of Beirut for the 2012 study by Tamraz, Srour and Chehab. Therefore:

  Higher estimate of debris weight (tonnes) = Debris volume (m^3) x 2.25 (t/m^3)

Limitations and caveats

- This is a preliminary analysis and has not yet been validated in the field.
- The methodology and findings of this assessment have been discussed with different partners, including UNEP, Mercy Corps Lebanon Crisis Analytics Team (LCAT), and Miyamoto International, which have conducted their own remote damage assessments based mostly on Sentinel 1 (sometimes also Sentinel 2) satellite imagery of 10-metre spatial resolution and using various automated damage detection tools. Furthermore, the estimated debris quantities are comparable with those calculated by UNEP, which employed a different methodology, increasing confidence in the results. While the findings of these other partners have not been integrated into this publication, discussions are ongoing to compare methodologies and cross-validate findings, especially in selected areas, with the hope that they will help better inform similar remote assessment efforts in the future. In addition, as co-lead of the United Nations Debris Task Force, UN-Habitat has coordinated with the rest of the task force regarding the debris quantification included in this publication.
- The top-down satellite imagery view and mid-range resolution hindered the detection of minor and major damages, as well as some instances of total or partial destruction, particularly when roofs have retained their original shape. This also applies to destroyed facades.
- The Microsoft Bing building footprint layer requires refinement. Its inaccuracies regarding the location and shape of the footprints have affected the count and surface area of buildings, thus impacting also the accuracy of debris quantification. UN-Habitat has already started a manual refinement of this layer, which is expected to be completed in the future.
- Due to the lack of building use data, the analysis could not differentiate between residential, commercial, religious or other types of buildings.
- There might be some errors in the building heights due to the WSF3D layer's low spatial resolution (90 metres). Moreover, the above-mentioned Microsoft Bing building footprint layer's inaccuracies have affected the accuracy of building heights.
- Debris was calculated for both partially and totally destroyed buildings (considering that partially destroyed will be demolished at a later stage).
- Underground basements could not be detected through satellite imagery and were not considered in debris quantification.

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[1] A unit/apartment could include a residential unit, commercial unit/office, etc.
[2] Average built-up area of buildings = Average of the total [Surface area of each building (m^2) x Number of floors of each building].
[3] The total built-up area (m^2) is calculated by multiplying the surface area of the building by the number of its floors.
[4] This density is estimated for mixed debris, as opposed to pure rubble material.
[5] This density takes into consideration the construction demolition waste (CDW) produced from the main building structure only (concrete, masonry, steel and tiling), which comprises the majority of CDW. No additional allowance is made for doors, kitchen and toilet fixtures, and electromechanical items, as these had been removed when the quantification process was carried out for the purposes of the Tamraz, Srour and Chehab study.

Douris – 1 September 2023

Douris – 7 January 2025

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