

## 1) Estimate Building Debris:

Based on historical data provided, derive a formula to estimate debris in tone based on the inputs:

- Building Area: Assume footprint in sqm
- Number of floors
- Completion Rate

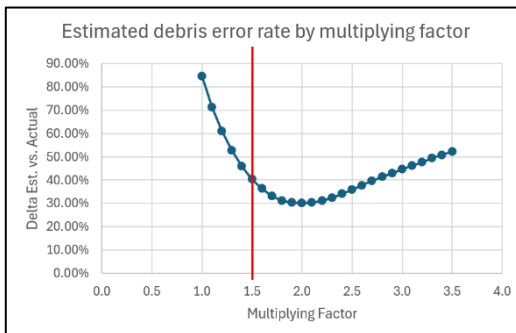
The provided spreadsheet (Rubble Removal Master Plan final.xlsx) has incomplete data regarding debris collected from damaged buildings in the conflict zone. Analysis is based on the values in these columns:

- Building Area:** Assumed to be building footprint in square meters
- Number of floors:** Number of levels in the building as an indication of height
- Completion Rate:** How much of the building has been removed, assume 100% for blanks
- The amount of aggregate removed to date is "tons":** Debris collected assume metric tons.

From the spreadsheet provided original estimate tonnage is derived by multiplying: **Area x Floors x 1.5**

In this spreadsheet there are:

- 208 records
- 66 records with blank or 0 tonnage removed – that are eliminated for analysis
- 142 valid records remaining
- Estimating debris weight by multiplying Area x Floors x 1.5 results in average error 64.40%
- Removing 10% highest outliers (14 records) results in an average error 40.42%
- Basic analysis of available data (with outliers removed) indicates that a multiplying factor of 2 would reduce the error rate to 30.16%



- Note: An Internet search (see other document **weight of debris.pdf**) estimates that for reinforced concrete the multiplying factor is 1.25 for Structural Dead Load and 2.00 for overall building debris. These figures are not out of line with what is indicated in the spreadsheet.
- There is still a rather high error rate, a more refined model may be obtained with greater data volumes, the inclusion of more attributes, and especially the analysis of actual field data available as it is collected with KoboToolbox.

**Suggest that the multiplying factor be changed to a value of 2.0 initially and reviewed regularly as more data becomes available.**

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## 2) Extrapolate model over Gaza strip:

To derive estimated debris volumes for the following inputs are required over the whole conflict area (The Gaza strip).

- Building footprints over the entire study area
- Elevation of buildings (if the number of floors is not provided with footprints)
- Damage level (assuming that partially damaged buildings will be only part removed)

Seek open data sources for the inputs required:

- Building footprints:** HDX [State of Palestine Buildings \(OpenStreetMap Export\)](#) file can be analysed in ArcGIS it provides the following attribute fields:
  - geom:: Value polygon: **Footprint** area can be derived
  - building: Values yes / greenhouse (filter on “yes”)
  - building:levels: Values mostly <Null>
  - building:materials Values mostly <Null>

\* Search for other data source with building levels data

- b) **Elevation:** If number of levels data exists at a high enough rate in footprints file use that, otherwise search for DEM data to estimate levels at 3m per level or change analysis to be based on building height if substantial variations exist in the actual height of levels from one building to another.

*\* Note SRTM data dates back to **Feb 2000** and may not be representative. LiDAR if available would be more recent and have a far better resolution*

- c) **Damage level:** Align with completion rate, assumes a building 50% damaged will yield half the debris of a building totally damaged (verify this assumption) UNOSAT [Gaza Strip Comprehensive Damage Assessment](#) provides a GDB including the following attribute fields:

UNOSAT point data superimposed over OpenStreetMap “HOT” building footprints to combine:

- Geom: Building footprint area (OSM)
- ConfidenceID -low/high/medium/very high (UNOSAT)
- Main\_Damage\_Site\_Class – Destroyed/Severely damaged/Moderately damaged/Possibly damaged (UNOSAT)
- Territory (UNOSAT)
- Governate (UNOSAT)
- Municipality (UNOSAT)
- Neighbourhood (UNOSAT)



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### 3) Create a Web App tool with the following functionality:

- Presentation of a map with pan and zoom
- User draws a polygon to delimit a site
- Tool returns downloadable pop-up table indicating:
  - Number of buildings
  - Building footprint (area m<sup>2</sup>) for each building
  - Number of floors per building
  - Level of damage per building
  - Estimated tonnage of debris per building and total for site

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### 4) Define and document processes:

- Field crew uses web app tool to estimate buildings and debris for a site
- Required equipment is requisitioned and intervention scheduled with the number of days required
- Field crew documents actual damage levels and volume of debris
- Actual values from field data are used to refine estimating

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### 5) Create StoryMap to communicate with sponsors (in parallel):

- Underscore quantities of debris, importance to estimate, methods used
- Provide real time dashboards
- Accept sponsor queries and requests / provide other contact details
- Store copies of regular reports issued