



# Remote Building Damage Analysis of Lebanon Governorate South & Nabatiyeh

December 16<sup>th</sup>, 2024



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**Miyamoto International, Inc.**

1450 Halyard Dr #1  
West Sacramento, CA 95691

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## Executive Summary

Miyamoto International conducted a remote building damage assessment of Lebanon's South and Nabatiyeh Governorates using advanced satellite imagery analysis. The assessment examined 240,445 buildings across seven districts using Sentinel-1 and Sentinel-2 satellite data combined with Microsoft building footprint data.

### Key Findings

- 16% of all buildings show significant damage
- 19,377 buildings (8%) suffered severe damage
- 19,482 buildings (8%) experienced moderate damage
- Marjaayoun and Bent Jbeil districts show the highest damage rates (35-36% of buildings affected)
- Sour district has the highest number of severely damaged buildings (3,121)

### Methodology

The assessment utilized machine learning algorithms to analyze changes in building reflectivity and displacement through radar and multispectral satellite imagery. Damage was classified into moderate and severe categories based on established thresholds.

*It must be noted that while the following assessment provides a relatively accurate overview at the national level, limitations in the quality of publicly available data reduce confidence and accuracy at the local level, increasing the importance of field verification.*

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## 1. Introduction

The following remote building damage analysis of Lebanon builds upon learnings from similar assessments conducted by Miyamoto in Gaza throughout 2023-24.

This assessment provides the most accurate analysis possible from the limited currently available data. Advanced machine learning was used to analyze publicly available pre- and post-damage Sentinel-1 satellite imagery, overlaid against Microsoft building footprint data, to determine significant changes in building reflectivity and displacement across the affected area as the primary indicator of damage.

This rapid assessment is intended to provide initial guidance to improve humanitarian response. It will be updated as more accurate data becomes available.

*It must be noted that while the following assessment provides a relatively accurate overview, limitations in available data reduce confidence and accuracy at the local level, increasing the importance of field verification.*

## 2. Methodology for Damage Detection Using Satellite Data

The methodology for damage detection leverages advanced satellite imagery analysis to assess building damage across Lebanon's affected regions. By combining multiple satellite data sources - Sentinel-1 Synthetic Aperture Radar (SAR) and Sentinel-2 multispectral imagery - the assessment process enables comprehensive detection of structural changes and damage patterns. This approach utilizes various spectral indices and radar measurements to identify and classify damage levels, providing crucial insights for humanitarian response efforts while working within the constraints of publicly available satellite data.

1. **Defining the Area of Interest (AOI)**
2. **Data Collection**
  - Sentinel-1 SAR Data:** Captures radar images to analyze surface changes, for structural damage.
  - Sentinel-2 Multispectral Data:** Provides color and infrared images to detect vegetation loss and debris.
4. **Preprocessing**
  - **Time Filtering:** Data was divided into pre-event (August 2023) and post-event (October–December 2024) periods.
  - **Cloud Removal:** For clear images, we removed clouds and other distortions from Sentinel-2 data.
5. **Change Detection** *We used specific indices to identify changes:*
  - **NVI (Vegetation Index):** *Measures changes in greenery to detect vegetation loss.*
  - **NDBI (Built-up Index):** *Highlights changes in urban and built-up areas.*
  - **Debris Index:** *Identifies rubble and debris from destruction.*

- **SAR Backscatter:** Measures surface changes from radar imagery to detect structural damage
6. **Damage Classification**  
The damage was categorized into levels based on thresholds: Moderate Damage and Severe Damage. This step combined the results from all indices to create a comprehensive damage map.
7. **Results and Visualization**
- *Orange:* Indication of moderate damage
  - *Red:* Indication of severe damage

### 3. Lebanon - South & Nabatiyeh Damage Governorate – Summary of Findings (December 16 , 2024)

The following section details the potential damage of buildings in Lebanon's South and Nabatiyeh Governorates as of December 16, 2024. The assessment covers a total of 240,445 buildings, utilizing satellite imagery from Sentinel-1 and Sentinel-2 to evaluate structural damage.

According to the findings, approximately 16% of buildings show signs of damage, with 8% (19,377 buildings) suffering severe damage and another 8% (19,482 buildings) experiencing potential moderate damage. Figure #2 shows the spatial distribution of damage, with darker areas indicating higher concentrations of structural damage, particularly in the El Nabatieh region.

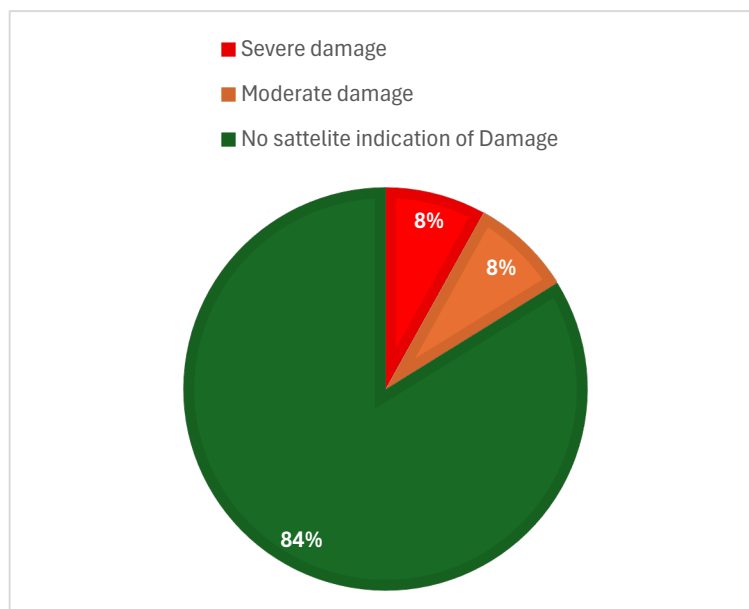


Figure 1: Distribution of Building Damage in Lebanon's South & Nabatiyeh Governorates (December 2024)

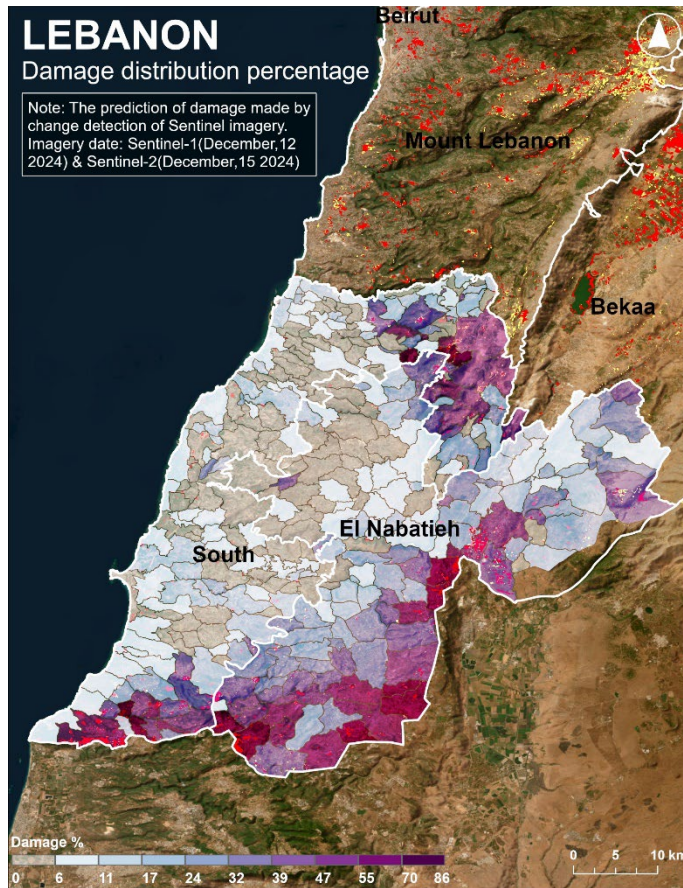


Figure 2: Spatial Distribution of Building Damage in South and Nabatiyeh Governorates, Lebanon (December 12-15, 2024).

### 3.1 Nabatiyeh Governorate

The following sections presents a detailed breakdown of building damage across the four districts of Lebanon's Nabatiyeh Governorate. The data shows significant variations in both the total number of buildings and damage distribution across districts. El Nabatieh has the highest number of buildings at 50,307, with a relatively low damage rate (only about 7% of buildings affected). In contrast, Marjaayoun and Bent Jbeil show more concerning damage patterns, with approximately 36% and 35% of their buildings experiencing moderate to severe damage respectively. Hasbaya, while having the smallest building count at 7,675, shows a moderate impact with about 17% of its structures damaged.

Table 1: Building Damage Assessment in Nabatiyeh Governorate Districts, Lebanon

	Total Bldg Nbr	No Damage	Moderate Damage	Severe Damage
Bent Jbeil	34,483	22,201	7,236	5,046
El Nabatieh	50,307	46,717	1,775	1,815

Hasbaya	7,675	6,365	921	389
Marjaayoun	26,794	17,117	3,786	5,891

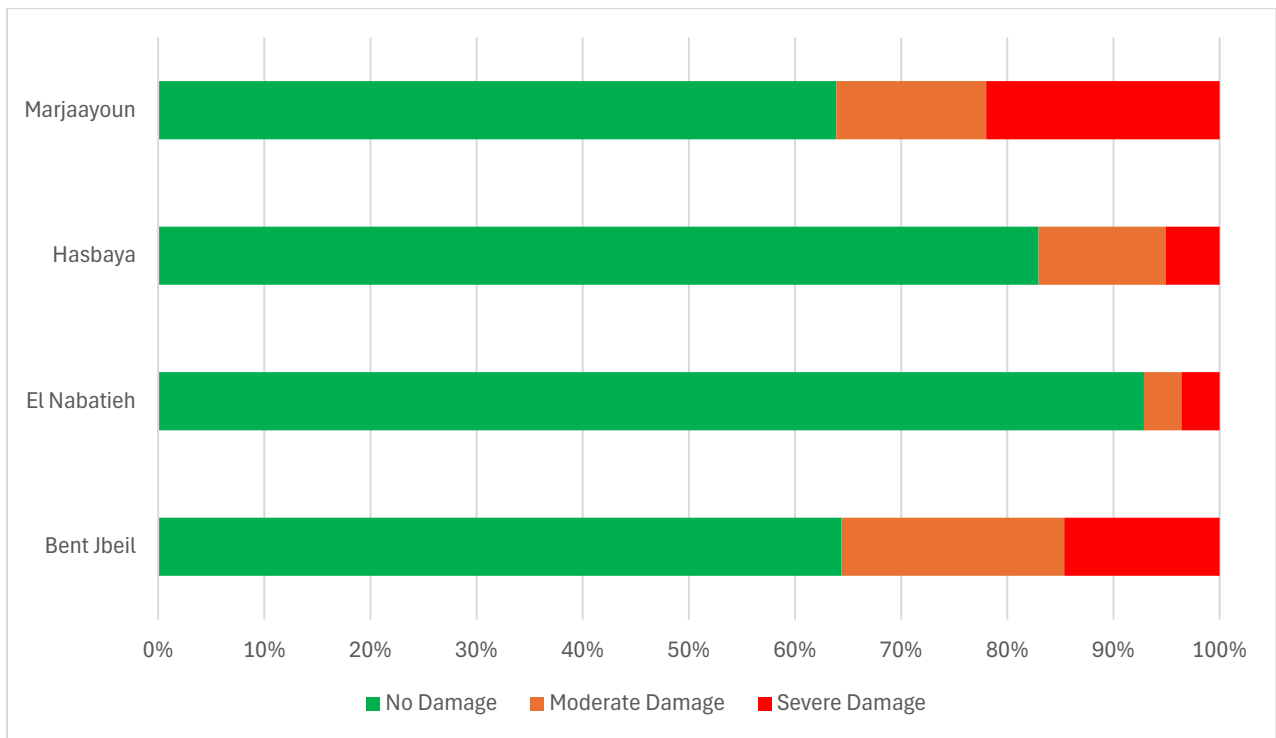


Figure 3: Distribution of Building Damage in Nabatiyeh Governorate Districts

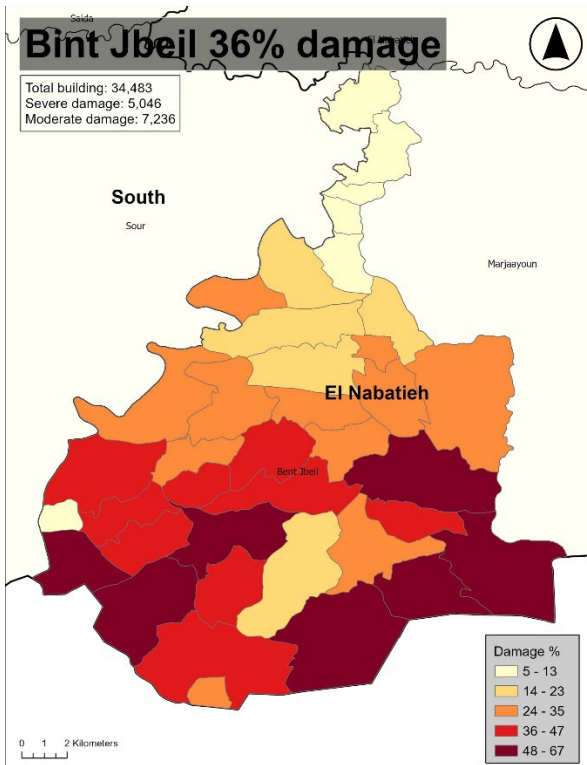


Figure 4: Building Damage in Bint Jbeil District

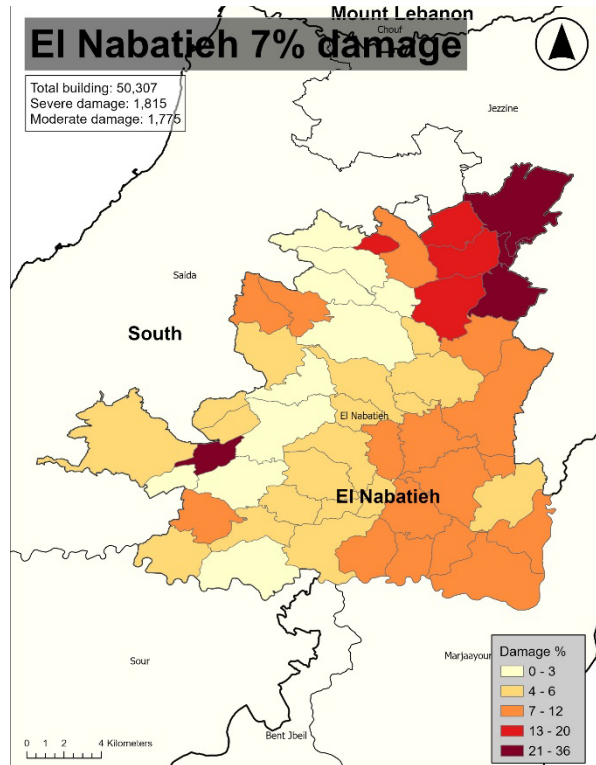


Figure 5: Building Damage in El Nabatieh District

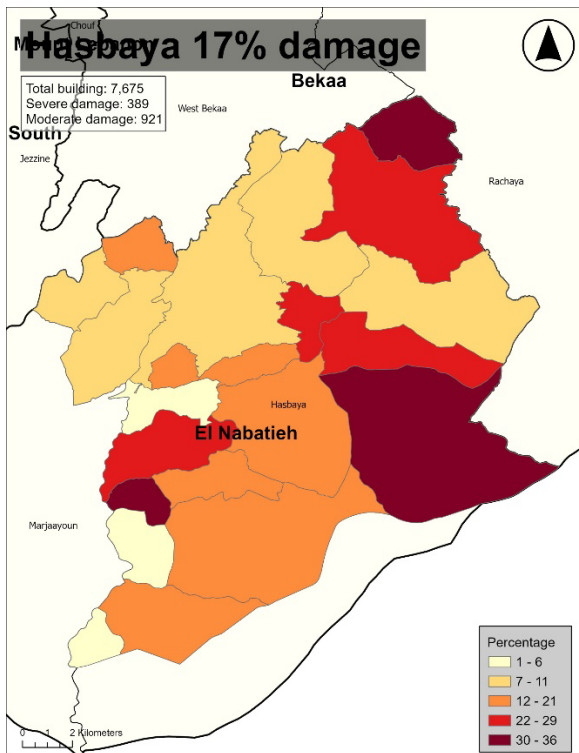


Figure 6: Building Damage in Hasbaya District

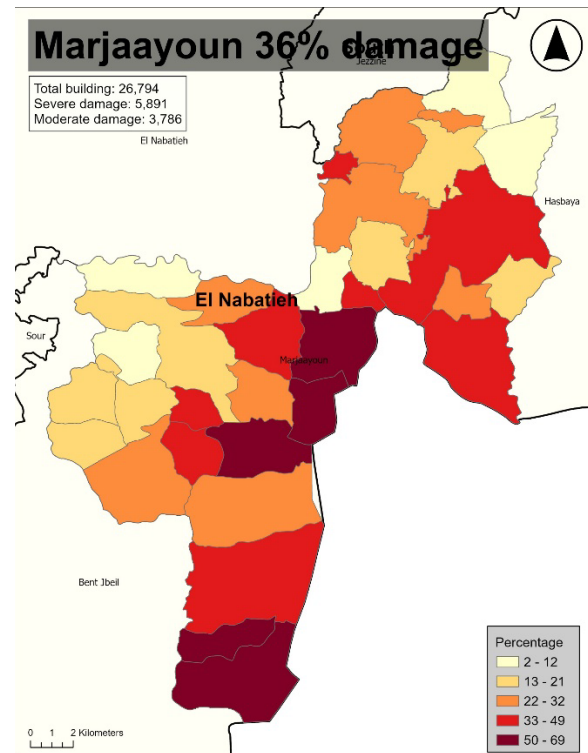


Figure 7: Building Damage in Marjaayoun District

### 3.2 South Governorate

The following section presents the building damage assessment across Lebanon's South Governorate's three districts, highlighting the particularly severe impact on Sour. Among the districts, Sour exhibits the highest level of damage, with 3,121 severely damaged buildings out of its total 54,814 structures.

Table 2: Building Damage Assessment in South Governorate Districts, Lebanon

	Total Bldg Nbr	No Damage	Moderate Damage	Severe Damage
Saida	53958	50502	1211	2245
Sour	54814	49144	2549	3121
Jezzine	11437	8563	2004	870

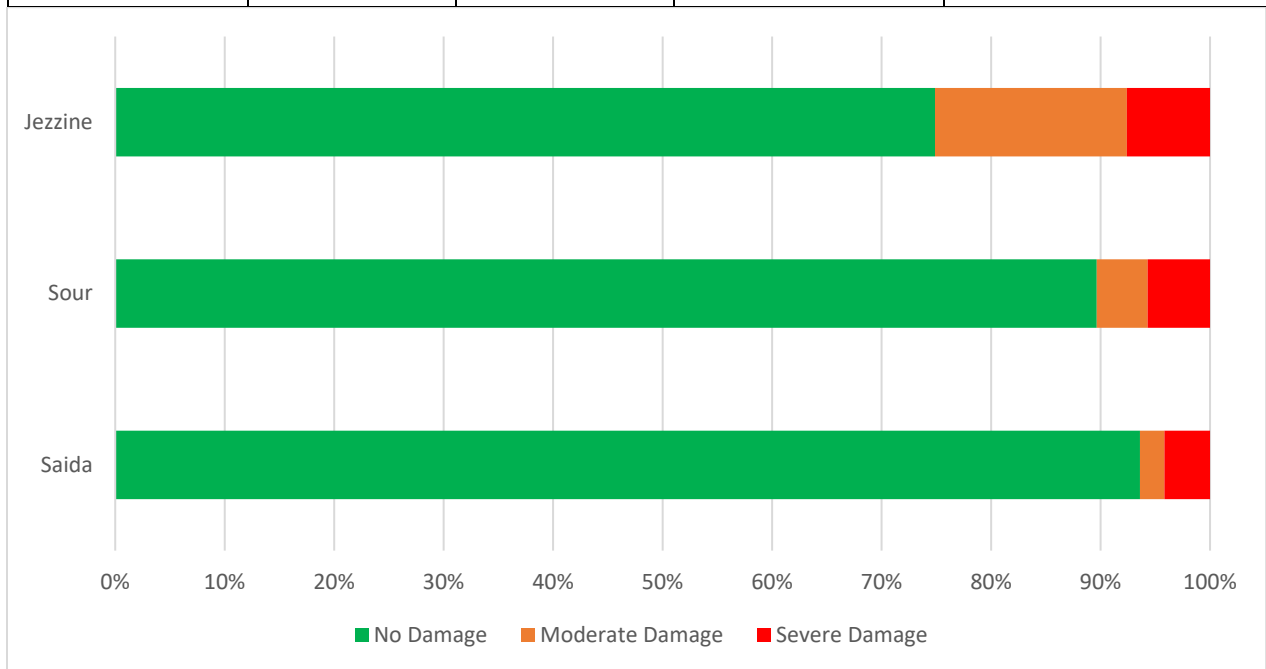


Figure 8: Distribution of Building Damage in South Governorate Districts

## 4. Limitations

While this damage assessment provides valuable insights, several important limitations should be noted. Despite cloud masking in Sentinel-2 imagery, residual haze or atmospheric effects may reduce data quality. The effectiveness of the maskCloudsS2 function depends on the reliability of the QA60 band. Thresholds may need calibration based on local conditions, land use, or specific types of disasters. Sentinel-1 backscatter values (VV and VH) are sensitive to

terrain, moisture, and vegetation structure but may not always directly indicate damage. The analysis results have been reviewed against available damage imagery manually, however inaccessibility limits ground-based verification data which is required to integrate and validate data. The methodology assumes that changes in NDBI, and backscatter are directly attributable to damage, which may not always be true.

## **5. Disclaimer**

The analysis presented is entirely based on publicly available remote sensing satellite data from Sentinel-1, providing an initial assessment solely of severely damaged and moderately damaged buildings.

Limitations in the quality of currently available data prevent meaningful analysis of limited or minor damage. The Miyamoto team's previous experience in remote damage analysis indicates total damage including limited or minor will be significantly higher.

This analysis is intended solely to provide a general overview of building damage distribution and concentration and should not be regarded as an exact or definitive representation of total numeric building damage. Accuracy may also vary across governorates.

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