AI-Assisted Community Mapping for Post-Conflict Housing Recovery: A Pilot in Harasta, Rural Damascus

(Ghada RIFAI, Hussein BACHIR, and Prof.Dr. Salah HAJISMAIL, Syria)

Keywords: Post-war reconstruction, AI-assisted damage assessment, Syria

1. SUMMARY

This paper presents an ongoing pilot project that applies AI-assisted community mapping to support post-conflict housing recovery in Harasta, Rural Damascus, Syria. To ensure feasibility and replication within local institutional constraints, the methodology relies primarily on municipality-produced damage assessment plans, complemented by freely available low-resolution satellite imagery and structured community-led validation. The project develops a building-level geospatial identification system using a hybrid referencing approach (municipal identifiers, grid-based indexing, and GPS coordinates). It selects a pilot area characterized by varied damage levels, mixed land uses, and tunnel locations.

A participatory data infrastructure is being established through a mobile GIS tool (QField) and staged training of community volunteers and municipal staff to collect standardized building condition data and georeferenced photographs. These data will form the labelled dataset for subsequent AI model training and integration into a spatial database. Initial mapping outputs indicate spatial variation in damage severity and land use, providing an early basis for assessing habitability and informing recovery prioritization. However, population estimates and infrastructure rehabilitation projections remain provisional and will be refined through ongoing fieldwork, iterative validation, and model development.

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Figure 1 war-damaged residential buildings in Harasta, eastern Ghouta, Syria. Source: International Committee of the Red Cross (ICRC), ICRC Visual Archive (n.d.)

2. INTRODUCTION

Over the past fourteen years, the war in Syria has caused severe destruction to cities and towns, especially in areas that were under prolonged siege and military control. Many places experienced heavy bombardment, large-scale displacement, and extensive damage to housing and infrastructure. One of the most affected areas is Harasta, located in Eastern Ghouta near Damascus. Before 2018, Harasta was under the control of armed opposition groups, during which a vast network of tunnels was constructed beneath residential buildings, streets, and public spaces. These tunnels were used for movement, shelter, and military purposes.
Harasta was under siege for nearly five years, starting in 2013. During this period, the city was exposed to continuous airstrikes, artillery attacks, and severe shortages of food and medical supplies. In the final months before the reconciliation agreement in May 2018, the town faced intense military escalation that caused massive destruction. Following the

reconciliation, a significant portion of the population was forcibly displaced. Many residents were required to leave their homes and were transferred to northern Syria, while only limited numbers were later allowed to return. As a result, Harasta was left with vast areas of destroyed housing, damaged schools and services, and a deeply fragmented urban and social fabric.

For several years after 2018, returns were minimal, and reconstruction did not occur in a real or organized manner. Many buildings remained in ruins, and large areas remained empty. This situation continued until 8 December 2024, when the Assad regime fell. After this moment, a new phase began. People gradually returned to Harasta, trying to check their homes, repair what they could, and rebuild their lives after years of forced absence. This return is still fragile and uneven, but it has created an urgent need to understand the city's current condition and to think about post-war reconstruction priorities.

In this context, there is a strong need to understand where damage is concentrated, how it relates to past military practices, such as tunnel networks, and how reconstruction can be planned in a fair and effective manner. A proposed project for AI-assisted community mapping, which builds on and utilizes Geographic Information Systems (GIS), builds on existing grassroots reconstruction initiatives, reinforcing inclusive, locally rooted surveying and informed decision-making structures through

1. Develop an AI-assisted system for damage classification and geospatial building identification by analyzing pre- and post-conflict data collected on damage assessment, integrating GPS-based spatial referencing, and validating results through structured community-led data collection.
2. Assess and map building habitability and neighborhood-level damage severity by combining AI-generated damage typologies with population density estimates to inform evidence-based prioritization for recovery interventions.
3. Produce data-driven projections for social and utility infrastructure rehabilitation needs, while fostering municipal collaboration and supporting inclusive, community-informed reconstruction planning.

2.1 Why AI-Assisted Community Mapping & What This Study Does

The proposed project pilots a community-embedded approach to post-conflict damage assessment and reconstruction planning in Harasta, a war-affected city in Rural Damascus. It integrates artificial intelligence (AI) techniques with participatory data collection and geospatial analysis to support more inclusive, evidence-based strategies for managing land and infrastructure recovery.

The project builds on ongoing grassroots efforts by returning residents rehabilitating their homes with support from local community members and donors. Despite these efforts and the municipality's ongoing attempts to assess damage and define reconstruction priorities, challenges remain. There remains a lack of coordinated planning, limited community participation, and insufficient structured tools to align municipal assessments with local initiatives. Consequently, housing conditions cannot be systematically evaluated, needs remain unprioritized, and reconstruction is not effectively guided by community-informed planning.

To address these gaps, the project develops an AI-assisted system to classify structural damage and assess habitability using the municipality's ArcGIS maps. This system has been

trained on a hybrid dataset that combines satellite-derived features with community-collected data, such as georeferenced photographs and condition surveys, ensuring that outputs are technically robust and locally grounded.
Additionally, creates a geospatial building identification framework that uses grid referencing and GPS coordinates to locate each structure in Harasta, linking buildings to visual documentation and assigning identifiers in accordance with the municipality's existing cadastral naming and numbering system.
These records form the basis of a spatial database for urban-scale analysis. At the neighborhood level, combining damage assessments with pre- and post-conflict population density estimates to identify and rank priority areas for recovery. The project also generates data-driven projections for infrastructure rehabilitation needs, including water, electricity, and sanitation services, as well as key elements of social infrastructure such as schools and public parks, providing a foundation for sustainable returns and integrated reconstruction planning.
Implemented in close collaboration with the Municipality of Harasta and local volunteer networks, training and mobilizing at least 30 community and municipality members to support data collection and validation. This participatory structure enhances the credibility of the findings, fosters local ownership, strengthens governance, and builds long-term recovery capacity.
Ultimately, the project offers a replicable model for AI-supported land damage assessment and reconstruction planning in post-conflict urban settings, bridging technology with lived experience and data with dignity.

3. LITERATURE REVIEW

Existing literature shows that urban destruction in Syria has been widespread, uneven, and closely linked to patterns of military control, siege, and prolonged violence. Satellite-based damage assessments conducted by REACH and other technical agencies confirm that Eastern Ghouta, including Harasta, experienced extremely high levels of destruction, with residential buildings, schools, and basic infrastructure among the most affected elements (REACH Initiative, 2019). Similar findings are reported in broader damage assessments, which document large-scale housing losses and infrastructure damage across Syrian cities resulting from sustained conflict (UNRWA, 2014; World Bank, 2025). These studies demonstrate that destruction was not random but followed clear spatial patterns shaped by airstrikes, ground fighting, and underground military activities. The long-term impacts of this damage continue to affect housing conditions, access to services, and residents' ability to return safely and stably.
At the national level, country profiles and displacement-focused reports emphasize that return and recovery in Syria are influenced not only by physical destruction but also by security conditions, access to livelihoods, and the availability of basic services such as education, healthcare, and transportation (UAAE, 2025; UN-HABITAT, 2022). Even in areas where active fighting has stopped, return remains fragile due to destroyed infrastructure, weak institutional capacity, and limited planning frameworks. These challenges have been further exacerbated by recent shocks, including earthquakes, which intensified existing vulnerabilities in cities such as Aleppo, Latakia, and Homs (UNRWA, 2023). This context is particularly relevant for towns like Harasta, where large segments of the population were forcibly displaced after reconciliation processes and only began to return years later.

From an urban planning perspective, research on post-war cities stresses that reconstruction is not only a technical process of rebuilding damaged structures, but also a political and social process that reshapes land use, mobility, housing, and urban identity (Ludwig, 2024). Studies focusing on Syria highlight how war has transformed patterns of control, surveillance, and everyday life in urban space, and how reconstruction can become a new field of power and inequality rather than a neutral recovery effort (Jadaliyya, 2018). Without inclusive and socially informed planning, reconstruction risks reproducing pre-war inequalities and creating new forms of spatial exclusion.

Recent literature also highlights the growing role of spatial methodologies and GIS in post-war contexts. Early work by Barakat, Car, and Halls (2007) emphasizes the importance of spatial analysis for linking damage, infrastructure, and policy decisions in post-conflict recovery. Subsequent studies demonstrate how GIS can support post-war reconstruction by mapping damage, identifying service gaps, and guiding phased interventions (Halls, 2014). In the Syrian context, GIS has been widely utilized to document destruction, estimate housing losses, and analyze connectivity to roads, schools, and services at both city and regional scales (REACH Initiative, 2019; World Bank, 2025). However, much of this work remains focused on aggregate or citywide analysis, while fewer studies examine neighborhood-level spatial relationships in detail.

Together, this body of literature demonstrates that post-war reconstruction in Syria must be understood as a multidimensional process, encompassing spatial, social, political, and technical dimensions, rather than merely as physical rebuilding. It also highlights the value of GIS as a tool for connecting damage patterns, infrastructure, land use, and recovery needs. Building on these studies, this paper applies GIS to analyze war damage, tunnel networks, and proximity to social infrastructure in Harasta, to support more just, targeted, and evidence-based post-war reconstruction priorities.

4. RESEARCH METHODOLOGY

The paper uses a narrative qualitative presentation and analysis of the project phases and steps. defining the tools and methods used, auto-analyzing and rectifying the implementation to achieve the project objectives.

The project itself is planned in five major actions and phases as follows:

1. Municipality's existing damage assessment plans Analysis

Municipalities' damage assessment plans are analyzed as a primary methodological tool to assess the structural impact of conflict on the built environment. This approach enables the classification of building structures based on observed damage levels, categorizing them as destroyed, partially damaged, or intact. The resulting damage assessments will be critical for broader spatial analyses and post-conflict reconstruction planning.

2. Building an Identification System and defining the pilot area of the project

The project develops a building identification framework that integrates geospatial techniques with locally adaptable coding schemes, enabling precise and consistent referencing of individual structures without a formal address system. Building footprints will be digitized using open-source GIS software, serving as the foundation for spatial indexing.

Each building is assigned a unique identifier derived from the municipality's damage assessment maps, as well as a hybrid system that combines spatial grid referencing and geolocation coordinates (e.g., GridID + GPS). The pilot area is defined by the following criteria: varied damage levels (suitable for training and comparison), diverse land-use categories, and the inclusion of tunnel locations. Additionally, temporal overlays of satellite imagery will be employed to monitor structural changes over time, supporting damage classification and the community validation process. Each building record will also be linked to satellite, derived, and community-collected photographic evidence to facilitate visual verification and traceability within the integrated geodatabase.

3. Community Engagement

Mobilizing Local volunteer networks to collect georeferenced photographic documentation and complete standardized digital form developed using Qfield application to complement data collection and validate it. Training the Community members in ethical, safe, and methodologically robust data collection and validation practices, ensuring the reliability and integrity of field inputs. Using these locally sourced data to conduct community-led ground truthing will train AI to generate community-based findings, contributing to a more accurate and contextually informed damage assessment process.

4. AI-Based damage classification

The project integrates machine learning techniques into the analytical workflow to enhance the accuracy and scalability of damage assessment derived from community data collection and municipal maps. Convolutional Neural Networks (CNNs) will be employed for the visual classification of buildings based on discernible structural features visible in collected pictures of the damaged buildings. For more granular analysis, segmentation, and object recognition, advanced deep learning architectures such as U-Net and Mask R-CNN will be used, which are well-suited for delineating damaged structures from their surroundings.

Training these on a curated, labelled dataset composed of annotated, collected pictures of the various damage levels of the building, collected through community participation. This hybrid training dataset ensures that the models are context-sensitive and can distinguish among multiple typologies and damage severities. Once validated, the trained models will be deployed to automate the classification process across the pilot area, generating standardized damage categories that feed directly into the spatial database and inform downstream decision-making in recovery planning.

5. Spatial Analysis for Recovery Planning

Following the classification of individual building damage, aggregating the spatial data to the study area level enables area-based analysis and prioritization. This aggregation supports the identification of spatial patterns in destruction and facilitates strategic planning at a community scale. Ranking the Neighborhoods using a composite index that combines structural damage scores with estimated population density. Deriving Population estimates from pre-conflict numbers of inhabited houses and community-provided inputs regarding household return rates. This integrative approach ensures a nuanced understanding of both physical and demographic vulnerability.

Based on the spatial distribution of damage and projected population needs, the study will also estimate requirements for essential infrastructure services, including water supply, electricity networks, and sanitation systems. These projections will inform targeted reconstruction planning and resource allocation across Harasta's most affected zones.

5. STUDY'S PHASES AND WORK PLAN

The project runs over 8 months between Aug 2025 and April 2026, divided into the following phases:

PHASE 1: Preparation and Municipal Coordination
(August – November 2025)

- Initiate and formalize coordination with the Municipality of Harasta and the Area Directorate (approvals, liaison, workspace).
- Collect and review municipal datasets and damage assessment plans as the baseline reference.
- Define the pilot study area and develop the building identification system (municipal codes + GridID/GPS).
- Draft and agree on protocols, data protection measures, and a code of ethics for fieldwork.

PHASE 2: Tool Development, Piloting, and Volunteer Mobilization
(November 2025 – January 2026)

- Develop the QField digital form (general building information, damage assessment, photos) and prepare field guidance.
- Test the tool with municipality and Kafaat team members, integrate feedback, and finalize the pilot version.
- Conduct a pilot survey in the designated test area to validate workflow, quality control, and coordination mechanisms.
- Mobilize and train volunteer teams through staged sessions at the municipality (ethics, photo protocol, survey practice).
- Use the pilot to support outreach and engage additional community members for the full survey.

PHASE 3: Field Data Collection and Validation
(January – February 2026)

- Implement community-led field data collection across the selected study area.
- Validate collected records through a structured review process involving municipal staff and the technical team.
- Link field data to municipal maps and satellite imagery to strengthen ground truthing and dataset reliability.
- Complete the final verified dataset required for AI training and spatial analysis.

PHASE 4: AI Analysis, Spatial Integration, and Final Outputs
(February – May 2026)

- Train and validate AI models (CNN / U-Net / Mask R-CNN) using the labelled dataset generated through the field survey.
- Integrate AI results into the GIS database linked to each building identifier and generate standardized damage outputs.
- Conduct spatial analysis and prioritization (damage patterns, estimated population needs, and infrastructure/service needs).
- Finalize maps, dashboards, and reports, and disseminate results through local stakeholder engagement and knowledge sharing.

6. RESULTS BY PROJECT OBJECTIVES

These initial findings are based on the analysis of municipal damage assessment plans, satellite imagery, and the preliminary GIS maps developed for the selected study area in Harasta. The project is still under implementation, and the findings presented here are indicative and subject to refinement as field data collection, AI model training, and validation continue.

1: Develop an AI-assisted system for damage classification and geospatial building identification

Initial analysis indicates that municipality-produced damage assessment maps can serve as a reliable primary data source for building-level identification and damage classification, eliminating the need for high-cost, high-resolution satellite imagery. The project deliberately prioritizes municipal datasets and openly available, low-resolution satellite imagery to ensure the methodology remains feasible, replicable, and scalable with local institutional resources.

The mapping work completed to date has enabled the delineation of individual building footprints and the assignment of unique spatial identifiers, linking each structure to its corresponding municipal damage categories. The selected pilot area—characterized by varied damage levels, diverse land-use types, and tunnel locations—has proven suitable for testing this integrated system.

At this stage, damage classification is based on municipal assessments and visual interpretation, supported by spatial referencing rather than automated AI outputs. The AI-assisted component remains under development and will be trained using community-collected photographic data during the next phase. This step is expected to enhance accuracy while maintaining the project's low cost and locally replicable design.

The following map illustrates building-level damage categories derived from municipal damage assessment plans, overlaid on freely available satellite imagery. Buildings are classified as no damage (green), partial damage (yellow), or severe damage (red), with tunnel locations highlighted to indicate areas of heightened structural risk. Areas marked as 'not assessed' or 'unclassified' reflect data gaps that will be addressed through ongoing community-led field surveys and validation. The map represents an initial output of the project and will be refined as field data collection and AI-assisted classification progress.

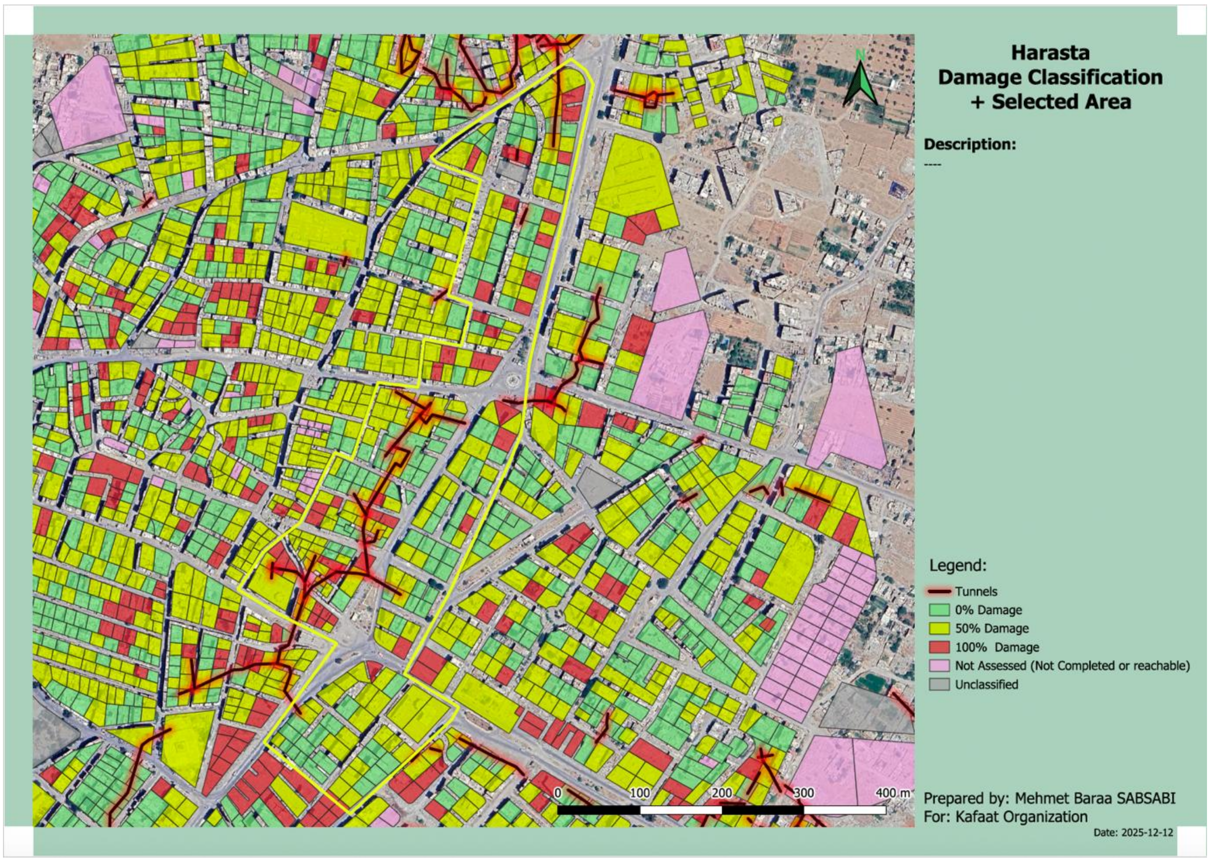

Figure 2 damage classification for the selected pilot area in Harasta, based on municipal assessment maps, with tunnel locations and remaining unassessed areas highlighted

Additionally, the following map illustrates the buildings' land use based on municipal land-use data. Buildings are categorized by their primary function, including residential, commercial, mixed-use, public services, religious facilities, and open spaces, with tunnel locations overlaid to highlight areas of structural and planning sensitivity. The map provides an initial understanding of how urban functions are distributed across the study area and serves as a preliminary input for assessing recovery priorities.

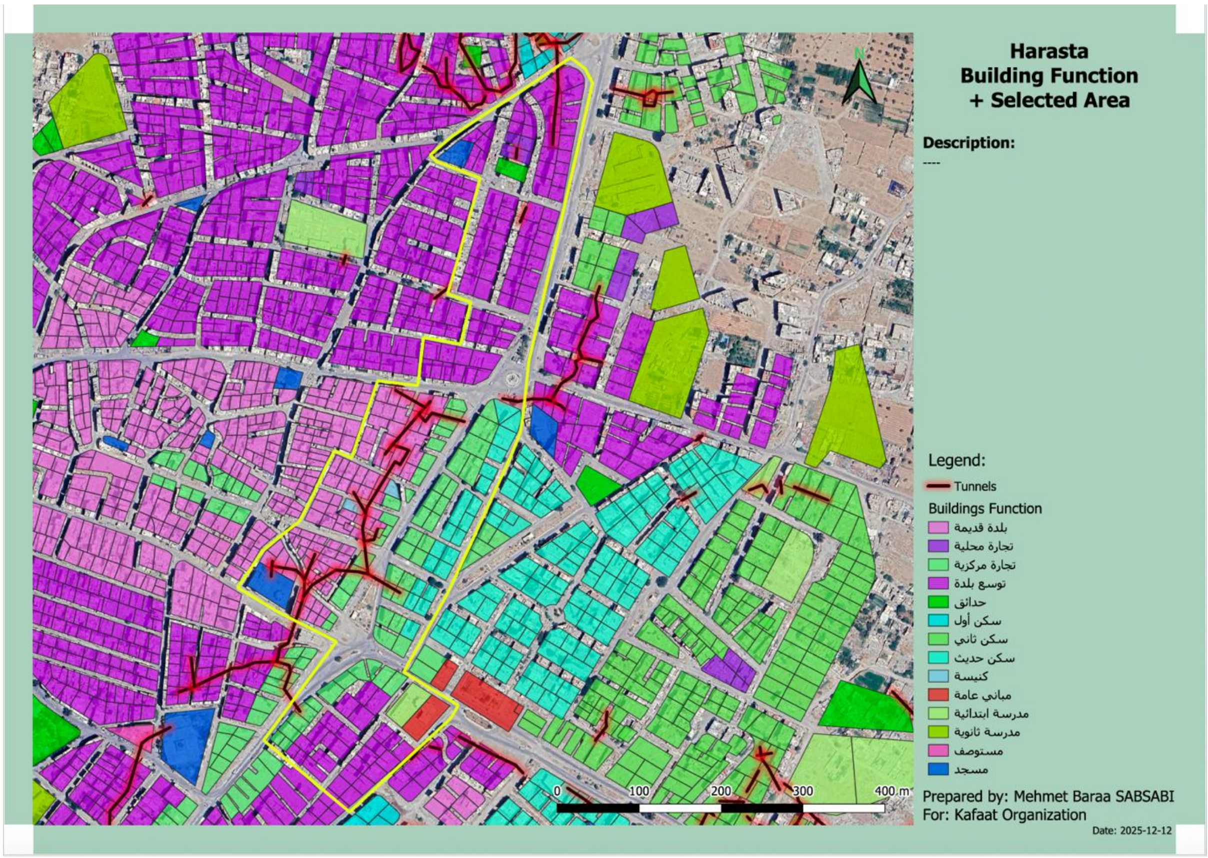

Figure 3 land-use classification for Harasta, showing residential, commercial, public, and mixed-use areas, with tunnel locations highlighted.

2: ASSESS AND MAP BUILDING HABITABILITY AND NEIGHBORHOOD-LEVEL DAMAGE SEVERITY

Preliminary damage and land-use maps reveal clear spatial differentiation in damage severity across the study area. Initial patterns suggest that areas with mixed residential and commercial uses exhibit more complex damage conditions, while some predominantly residential blocks show more consistent levels of partial damage.

These early results provide a preliminary assessment of building habitability, highlighting zones where structures may be repairable with limited intervention versus those likely to require more extensive rehabilitation. When combined with land-use mapping and the tunnel locations, the analysis begins to illustrate how damage intersects with everyday urban functions.

However, population density estimates and habitability assessments remain provisional, relying on pre-conflict data and assumptions regarding return and occupancy. Ongoing community-led field surveys and validation activities are essential to refining these findings and grounding them in current, on-the-ground conditions.

3: PRODUCE DATA-DRIVEN PROJECTIONS FOR SOCIAL AND UTILITY INFRASTRUCTURE REHABILITATION NEEDS

The initial spatial analysis suggests strong potential for the approach to inform infrastructure and service recovery planning, utilizing data that municipalities already possess or can realistically maintain. Early overlays of damage classification and land-use data identify areas where rehabilitation of utilities, such as water, electricity, and sanitation, may be most urgent, particularly in zones with a combination of residential concentration and moderate-to-high damage.

The close collaboration with the municipality during this phase has already contributed to institutional ownership of the data and methods. By building on municipal maps rather than external or proprietary datasets, the project reinforces local capacity and supports longer-term integration of the methodology into municipal planning processes. In addition, the development and use of the QFIELD application, can later be used to facilitate data entry for building permits.

At this stage, infrastructure projections are indicative rather than definitive. More robust projections will emerge as AI-assisted classification, validated field data, and improved population estimates are incorporated. As the project advances, these outputs are expected to support inclusive, community-informed recovery planning that aligns technical analysis with municipal priorities and local knowledge.

7. CONCLUSION

This pilot project demonstrates the feasibility of developing an AI-assisted, building-level damage assessment system that utilizes primarily municipal resources and community participation, without relying on costly high-resolution satellite imagery. By grounding the methodology in municipality-produced damage assessment maps and freely available satellite imagery, the project prioritizes replicability, institutional ownership, and long-term sustainability within local governance structures.

The initial mapping and spatial analysis indicate that meaningful differentiation in damage severity and land-use patterns can be achieved even at this early stage. The selection of a pilot area with varied damage levels, mixed land uses, and tunnel-affected locations has proven appropriate for testing both the technical workflow and the coordination mechanisms between the municipality, technical experts, and community volunteers.

While the AI component is still under development, the preparatory phases have highlighted the importance of community-led field validation in improving data reliability and contextual understanding. The integration of local knowledge through structured data collection is expected to play a crucial role in training AI models that reflect on-the-ground realities rather than relying solely on remote observations.

At this point, conclusions regarding building habitability, population presence, and infrastructure rehabilitation needs remain indicative. These findings will require further refinement through the collection of full-field data, training of AI models, and iterative validation cycles. However, early results suggest that combining municipal datasets with community-generated evidence can support more inclusive, evidence-based recovery planning.

Overall, the initial phase of the project confirms that a low-cost, locally anchored, and scalable approach to post-conflict damage assessment is viable. As implementation continues, the project is expected to generate more robust analytical outputs that can directly inform municipal decision-making and contribute to inclusive reconstruction strategies in Harasta and, potentially, in other Syrian cities.

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Funding note:
This work is supported by the Aubrey Barker Fund – FIG Foundation Research Grant (2025–2026), under the theme "AI Applications in Surveying and Land Management," and is implemented by Kafaat for Reconstruction in collaboration with the Municipality of Harasta

BIOGRAPHICAL NOTES

Ghada Rifai is an urban planner and researcher specializing in post-conflict reconstruction, participatory planning, and community-based urban recovery in Syria. She is the co-founder of Kafaat for Reconstruction and Mobaderoon, "Syrian peacebuilding network," where she leads applied research and pilot projects linking municipal planning, community engagement, and spatial analysis. Her work focuses on developing locally grounded tools for damage assessment, housing recovery, and inclusive reconstruction processes. She is now pursuing her PhD in Global Urban Studies at Rutgers University in the U.S. Ghada has over 20 years of professional experience working with local authorities, civil society organizations, and international partners on urban recovery and governance-related initiatives. Her research interests include post-war cities, participatory GIS, and the role of urban planning in social and institutional recovery.

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Prof. Dr. Salah Hajismail was born in Aleppo, Syria, an Architect since 2002, a master's in Architecture in 2004, a master's in civil engineering in 2006, Phd in Cultural Heritage from Politecnico di Torino, Italy, in 2011. Worked as an architect/ Engineer in different countries, designed and constructed many buildings in Syria and outside, winning design competitions.
Academically, worked at Aleppo University, Faculty of Architecture from 2011-2015, published many research papers, books, and chapters in Arabic, English, and Italian languages. Forced to leave his country, worked at Universidad de Cantabria- Santander – Spain, Sapienza University of Rome- Italy, before moving to work as a full professor at Ankara Yildirim Beyazit University, architecture and fine arts faculty- Turkey.
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