LIFELINES

GeoAI for Humanitarian Action
Supper Club Series

Disaster Response and Recovery

How is openly accessible GeoAI* being used across the lifecycle of a humanitarian crisis**, and what is the opportunity cost of not integrating GeoAI tools into these contexts?

Key Highlights and Considerations

- **When a disaster strikes, a timely response is critical.** Most operational emergency responses often target the first 72 hours as a viable response window to save the most lives. GeoAI can automate hazard footprinting, exposure mapping, and damage detection to deliver actionable intelligence within hours instead of weeks.
- **A growing ecosystem of actors is enabling operational adoption of GeoAI for humanitarian action.** Operational actors like UNOSAT/OCHA, Copernicus EMS, UNDP, and the World Bank, along with open-source communities, are co-developing open datasets, baseline layers, and rapid-mapping tools enabled by International satellite tasking charters and open licensing, accelerating access to critical data for crisis mapping.
- **Trust, bias, and transferability remain major barriers.** Humanitarian adoption is limited by domain shift, inadequate uncertainty quantification, and limited validation data. Without confidence layers and calibrated probabilities, humanitarian decision-makers hesitate to rely on GeoAI outputs for high-stakes decisions.
- **Ethical, sustainable, and field-ready design is essential.** Future GeoAI systems for disaster response and recovery must adopt "do-no-harm" principles — protecting sensitive information, respecting data rights in conflict-affected areas, and ensuring low-bandwidth, offline usability for last-mile responders.

*__GeoAI (Geospatial Artificial Intelligence)__ is the application of AI, machine learning, and deep learning methods to geospatial data, GIS, and spatial problems and is used to extract features, detect patterns, make predictions, and scale spatial analysis.

** The **lifecycle of a humanitarian crisis** is visualized in Figure 1. For these Supper Clubs, we will look at GeoAI in the response and recovery/rebuilding stages of the cycle.

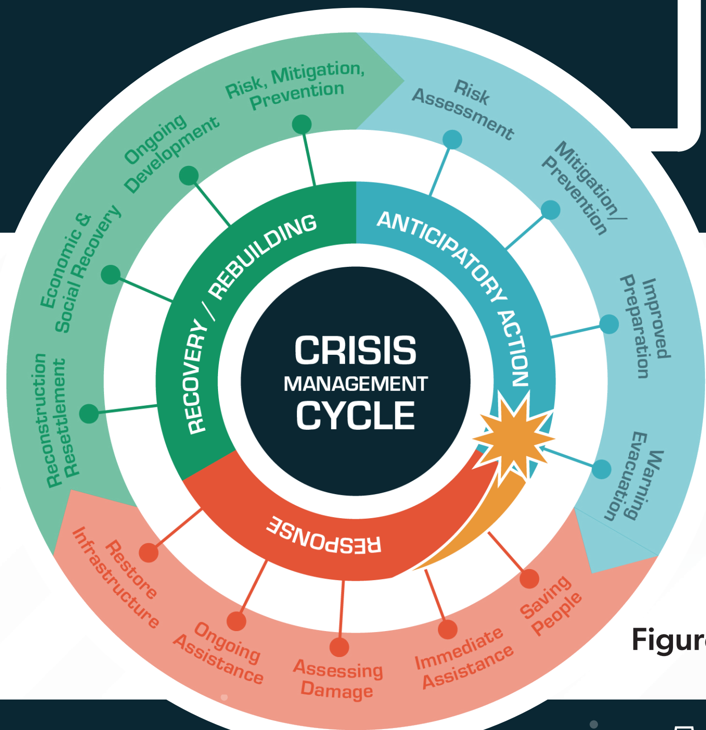


Figure 1

Guiding Questions for Discussion and Reflection

How are you seeing GeoAI being used for rapid emergency response or damage assessments?

- What are your hopes and fears for this technology?
- How have these hopes and fears been realized in your projects?
- What are the blind spots you are currently aware of in the use of this technology?

In an age of unprecedented scale of disaster, how does GeoAI help address the tension between data scarcity and data deluge in varying environments that experience crises?

- What opportunities exist or are currently being missed by the AI and EO community in conducting robust damage assessments for a data-scarce environment?
- Can GeoAI fill in the data gaps at an acceptable level of granularity, in particular with damage assessments often requiring very high-resolution images?
- What approaches/ guardrails are currently being embraced to develop training datasets that do not expose the affected community to further risks (for communities in conflict-affected areas)

How can the GeoAI community develop humanitarian action-friendly interfaces that elicit trust, transparency, and rapid adoption in the humanitarian context?

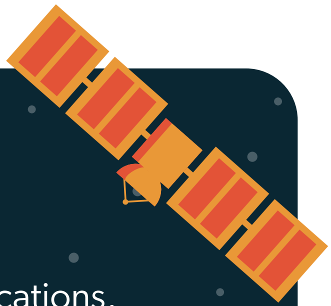
- What are the risks and ethical considerations involved in the use of AI for damage assessment and post-disaster needs assessment?
- How can we elicit trust in the discriminative maps produced by these GeoAI systems? In particular, for structural damage assessment where an aerial view from satellite might be insufficient to reach a comprehensive assessment.
- Are there any values in integrating Explainable AI approaches to Damage Assessment frameworks?
- How to ascertain when the damage is too little or too much to assess with GeoAI? How do we approach issues of false positives and false negatives in GeoAI predictions?

What developments around algorithms, data systems, computational overheads, social factors, etc, can further drive the adoption of GeoAI in the humanitarian context?

- What efforts are currently in place to address the computational needs in constrained and fragile environments?

Is GeoAI being effectively designed to meet the information needs of the humanitarian community for needs assessments for response, recovery, and reconstruction? Is GeoAI enough? When are classical approaches sufficient?

Background



Motivation

Disasters often have a far-reaching impact on public and private communications, transportation, and utility structures. This inadvertently disrupts housing, public health, migration, and education, often escalating in areas with ongoing conflicts. For disaster response and recovery, humanitarians need reliable, current information that fits into their workflows and is accurate enough to inform decision-making. The continued advancement in Geo-AI provides a remarkable opportunity to offer fit-for-purpose tools for rapid assessments and provide timely insights to response teams and humanitarian decision makers. This research brief discusses the prospects of using Geo-AI for disaster response and recovery within the humanitarian context.

Response, Relief and Reconstruction

Some examples of response, relief, and reconstruction efforts within the disaster management cycle include, but are not limited to:

1.) Rapid Emergency Response and Needs Assessment

2.) Damage Assessment

3.) Post-Disaster Economic Assessments

Rapid emergency response involves actions taken during or immediately after a disaster to save lives, reduce damage, and restore essential services. This typically includes activities like evacuation, search and rescue, medical relief, and food provision within the first 72 hours after the start of a disaster. This also involves a preliminary needs assessment by a response team or local disaster management organization.

Damage assessment involves the estimation of the degree and distribution of destruction in the aftermath of a disaster. This typically captures the hazard footprints, exposed or affected elements (infrastructure, agriculture, people), and their corresponding economic costs **(Figure 2).**

Post-disaster economic Assessments are often used during large-scale disasters for coordinated assessments of sectoral and economic post-disaster damages, losses, and recovery needs. For example, the Post Disaster Needs Assessments (PDNAs), Damage and Loss Assessments (DaLAs), and the Global Rapid Post-Disaster Damage Estimation (GRADE) are used for high-impact government-led damage assessment, particularly in developing countries. These approaches are known to effectively provide well-calibrated estimates of the direct economic damages to residential buildings, non-residential buildings, infrastructure, agriculture, and others. They are a vital component of Disaster Financing and Recovery Planning that takes place over a longer timeframe.

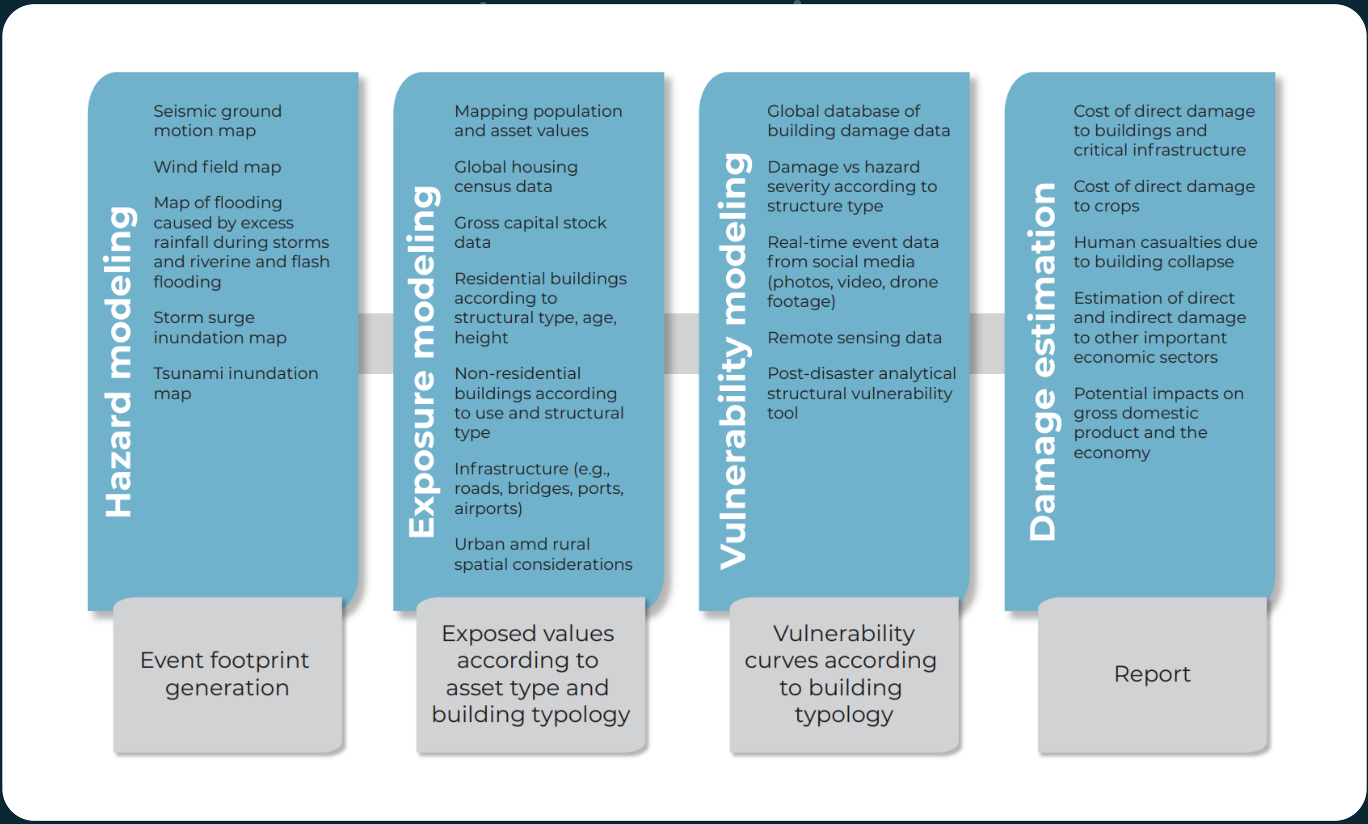


Figure 2: Global Rapid Post-Disaster Damage Estimation (GRADE) Methodology. Source

Applications of GeoAI in Disaster Response and Recovery

Geospatial technologies, field intel, and artificial intelligence can be leveraged to quickly assess who and what is affected, what is urgently needed (shelter, water, power, medical supplies), and where to focus efforts, particularly in conflict-affected contexts. More specifically, Geo-AI can enhance:

- **Rapid Emergency Response** by providing models for faster and more scalable extraction of disaster footprints, hazard exposure, and at-risk elements, as well as identifying accessibility constraints such as road blockages, debris zones, and safe routes to shelters and care centers. In parallel, these models can support rapid needs assessments by integrating and cross-checking information from field reports and operational response teams to better understand human movement, accessibility, shelter capacity, WASH facilities, and optimal dispatch routes for delivering aid. An often-unspoken expectation for these models is their ability to function as dynamic platforms that map impacts quickly and can be continuously verified in the field. This ensures that early outputs not only guide immediate action but can also be rapidly refined to improve on-the-ground accuracy.

- **Damage Assessment** by providing faster, scalable, and precise models and datasets for change detection, including assessing the structural damage to buildings and infrastructure, and extracting damage proxy maps.

- **Recovery and Reconstruction** by providing frameworks that enable the seamless translation of damage assessments into sectors, while identifying the relative degree of confidence (uncertainty), loss ranges, and assessment of recovery progress. Providing future projections of hazard risk exposures and potential damage from varying hazard scenarios can also inform long-term programming efforts.

Currently, established actors in the GeoAI and humanitarian action ecosystem provide tools, operational maps, open datasets, and models for disaster response and recovery. For example, UN organizations like the UNOSAT/ OCHA, UN IOM, UNDP, The World Bank (GRADE), and the Copernicus Emergency Management Service (EMS) provide operational mapping of varying types of disasters, footprints, and damage. The open-source communities contribute open models, datasets, and tools for developing more precise damage assessment AI models and benchmarking them with the state-of-the-art performance. International Charters enables the provision of expedited satellite tasking and open data mechanisms from public and private organizations with medium to high-resolution datasets for more precise mapping of hazards. Together with well-established open licensing, several foundational geospatial layers, such as building footprints, road networks, hospital and clinic locations, population grids, and other critical facilities, are being made openly available, enabling the development of these tools.

Additionally, these data foundations are supported by an active ecosystem of volunteers from the Humanitarian OpenStreetMap Team (HOTOSM), MapAction, Missing Maps, and others. These platforms and communities, collectively called Volunteered Geographic Information (VGI), supply rapid spatial data layers and analysis of infrastructural damage during disasters, particularly in areas where authoritative datasets are outdated, incomplete, or non-existent. These efforts often provide essential spatial layers such as building footprints, road networks, bridges, schools, and health facilities that can aid the development of rapid disaster assessment, exposure analysis, and response coordination. In sum, VGI provides a dual function:

1.) it provides the training and validation data for developing machine learning models

2.) it acts as an operational data source for situational awareness during crises

More so, the community also provides practical examples of how to develop GeoAI tools for meeting humanitarian needs, with similar constraints on the lack of open very high resolution (VHR) data. For example, HOT is leading efforts for using fAIR, an AI-assisted mapping tool, and localizing open-source AI models like RAMP in partnership with local communities and volunteer mappers. Complementary tools such as MapWithAI, an OSM-friendly platform for evaluating AI-generated road predictions against satellite imagery, further exemplify how to use AI to meet the humanitarian need for scale and speed while embracing key quality control ethos.

Spotlight: fAIr is an open AI-assisted mapping service developed by the Humanitarian OpenStreetMap Team (HOT) that aims to improve the efficiency and accuracy of mapping efforts for humanitarian purposes. The service uses AI models, specifically computer vision techniques, to detect objects in satellite and UAV imagery.

Challenges and Opportunities for Improvement

Despite this growing body of work within the ecosystem, the use of Geo-AI for humanitarian actions still faces many bottlenecks that limit its adoption and wide-scale use. Some of these are well-known challenges with developing vision models for geospatial datasets, while others are unique to the humanitarian response community.

Geo-AI tools and platforms, while powerful, are often plagued with bias, transferability, and scalability challenges with many humanitarian implications. These issues stem not only from domain shifts in sensors, seasonality, geographies, and building typologies, but also from systemic issues like **limited availability of open data for training and inadequate incentives for data sharing.** Because most open datasets are heavily represented in the Global North, models frequently struggle to generalize to local contexts in the Global South, where disasters and humanitarian crises are most acute. This leads to **common misclassifications such as underdetecting damage in low-rise or non-engineered structures, misidentifying informal settlements, or overlooking context-specific features like unpaved roads or vernacular housing.** Over time, these biases reinforce a cycle in which regions most in need of GeoAI-enabled insights remain the least represented in the datasets and models designed to support them.

Investments in open data initiatives, context-aware model adaptation, and inclusive partnerships that enable capacity building and equitable participation from researchers, institutions, and volunteers in the Global South can help bridge this gap. **Equally important is the integration of reliable uncertainty quantification metrics, such as calibrated probabilities and confidence layers at different scales of maps or data aggregation, to transparently communicate the limits of model predictions.** Without this kind of design approach for Geo-AI development, the trust in using Geo-AI for humanitarian response can be eroded, particularly in the context where a good balance of scalable assessment and acceptable precision is critical for high-stakes decision making.

More so, GeoAI for Humanitarian Action is equally challenged by the need for ethical tools that can safeguard people in fragile and conflict-affected zones. These include **designing tools that adopt a do-no-harm framework by redacting sensitive features, deploying tools that respect the data rights and privacy of hazard-affected communities.** These frameworks are not often at the forefront of open-source Geo-AI development. These challenges also make the need for scalable validation difficult in this context, where providing reliable ground truth is equally subject to access and safety constraints. Additionally, maintaining open models, tools, and datasets often requires concerted efforts and funding to continuously expand, validate, and release the most up-to-date and representative datasets, benchmarks, and models. Finally, reaching last-mile responders in low-resource settings in fragile contexts often requires a significant design for resource efficiency, which is often not central to many Geo-AI deployment approaches. **Without these considerations, GeoAI risks widening existing divides rather than closing them.**