International Cartographic Association
Association Cartographique Internationale

Disruptive Innovation: The Lasting Outcomes of Participatory Mapping and Volunteered Geographic Information in Nepal's Post-Earthquake Recovery

Theresa Dearden [a,*], Jon Corbett [a], Mohammad Abubakar Metcho [b], Logan Cochrane [b], Ayla De Grandpré [a], Nama Budhathoki [c]

[a] *University of British Columbia Okanagan*
[b] *Hamad Bin Khalifa University*
[c] *Humanitarian OpenStreetMap Team*

* Corresponding author – tdearden@mail.ubc.ca

Abstract: Volunteered Geographic Information (VGI) is spatial data collected through digital participatory mapping, where non-expert volunteers create and share spatial knowledge. Despite claims of empowerment and improved decision-making, the long-term outcomes of participatory mapping remain under-evaluated. In humanitarian emergency response, VGI production enables the creation of updated real-time post-crisis maps, thus improving response effectiveness. This paper examines the lasting socio-economic outcomes of VGI production in humanitarian assistance, beyond the immediate crisis period, with a focus on the 2015 Nepal earthquake response. VGI production led to the creation of the first freely available and comprehensive digital basemap for Nepal, which catalyzed the development of new spatial services and platforms. Beyond disaster relief, the mapping data provided a foundation for new business and educational opportunities, including Baato Maps, a culturally relevant, low-cost navigation tool. The adoption of these tools has fostered a competitive ecosystem for spatial services like ride-sharing, e-commerce, and delivery, fostering economic resilience. This paper demonstrates how participatory mapping, when purposefully integrated, can drive disruptive innovation and create socio-economic benefits which support the transition from emergency response to long-term development. It highlights the importance of incorporating community generated VGI into future humanitarian planning and evaluation to support sustainable, community-driven innovation and enhance long-term resilience.

Keywords: Participatory Mapping, Volunteer Geographic Information, Humanitarian, Crisis Response, Nepal

1. Introduction

In the aftermath of a natural disaster, diverse actors including civil society, humanitarian organizations, and government agencies must collaborate and coordinate response actions to meet critical life-saving needs in affected areas. Access to timely and accurate data, especially spatial data, plays a crucial role in optimizing the allocation of resources for relief efforts, including financial, technical, and logistical support (Poiani et al., 2016). Inadequate information management and coordination between government, civil society, and international humanitarian organizations hinders effective emergency response and planning (Alesani & Missoni, 2023; Cinnamon, 2020; Moore et al., 2016).

With the rise of accessible technologies, a new phenomenon has emerged which allows for large-scale digital participation by volunteers to support humanitarian emergency assistance. This is known as 'digital humanitarianism', where volunteers, including those on the ground impacted by the crisis and far away that offer labour and technical skills, enhance coordination and accelerate response by providing critical and rapidly updated information which is made freely available to formal responders (Cinnamon, 2020; Givoni, 2016). This Volunteered Geographic Information (VGI), created through participatory mapping processes, has become a core component of digital humanitarianism, especially in situations where limited pre-existing spatial data exists and numerous actors are involved. The term Volunteered Geographic Information, introduced in 2007, describes spatial data collected by remote volunteers to meet shared goals, often facilitated by intermediaries such as academic researchers, government planners, and civil society organizations (Goodchild, 2007; Kamptner & Kessler, 2019). If local communities and individuals are integrated into the process of VGI production, the data can also capture critical place-based insights that might otherwise be overlooked by short-term temporary international responders (Givoni, 2016; Herfort et al., 2021).

Participatory mapping, which originated in the 1970s as part of Participatory Rural Appraisal (PLA) and Participatory Learning and Action (PLA) methods in the Global South, rethought the process of map production by engaging local communities and non-experts in mapping their knowledge (Chambers, 2006; Corbett et al., 2016; Rambaldi et al., 2006). The rise of participative web,

Advances in Cartography and GIScience of the International Cartographic Association, 5, 11, 2025.
32nd International Cartographic Conference (ICC 2025), 17–22 August 2025, Vancouver, Canada. This contribution underwent double-blind peer review based on the full paper. https://doi.org/10.5194/ica-adv-5-11-2025 | © Author(s) 2025. CC BY 4.0 License

which reflects the evolution of internet technologies towards more user-centric, participatory, and socially-oriented experiences, and the Geoweb have transformed participatory mapping, enabling broader digital participation and fostering the development of platforms like OpenStreetMap (OSM) (Albuquerque et al., 2016; Polous, 2023). OSM allows users to collaboratively create, edit, and share VGI features such as roads, buildings, and landmarks in real-time, creating the potential for frequently updated, freely available, and globally accessible maps which can capture personal knowledge such as toponymy (Mahmud et al., 2022). OSM has made a major contribution to the parallel fields of VGI, citizen science and Public Participation GIS (Fagerholm et al., 2021). Participatory mapping is reported to enhance decision-making and management by empowering communities to communicate their unique understandings of place (Corbett et al., 2016; Rambaldi et al., 2006). Despite its enduring popularity, claims of long-term benefits and effectiveness of participatory mapping research and practice remain largely unsubstantiated (Corbett et al., 2016). Similarly, little is known about the outcomes arising from the adoption and use of participatory mapping outputs - including if and how VGI data produced during humanitarian emergency response is used after responders depart (Givoni, 2016).

The first successful application of VGI in crisis response occurred after the 2010 Haiti earthquake, when volunteers from around the world contributed to mapping affected areas using OSM (Hunt, 2023). Since 2010, despite improvements, including the establishment of dedicated humanitarian VGI coordination organizations including the Humanitarian OpenStreetMap Team (HOT), the adoption and integration of VGI data into crisis response processes has varied widely (Hunt & Specht, 2019). Success has been linked to several factors, including perceptions of legitimacy and data accuracy, the relationships between responders and VGI intermediaries, and pre-existing technical and human capacity (Soden & Palen, 2016; Thapa et al., 2017).

While much research has focused on the use of VGI datasets in specific disaster response efforts (Hunt, 2023; Soden & Palen, 2016), the sustained impacts of participatory mapping and data creation both during and after humanitarian emergency response remain underexplored (Givoni, 2016; Yan et al., 2020). Much of the existing evaluation has focused on process-based metrics—such as points on a map or number of users—rather than the broader outcomes often realized in the long-term recovery process (Cochrane & Corbett, 2020; Haworth et al., 2018; Yan et al., 2020). This gap in understanding limits the ability to capture the true potential of VGI. Global case studies have linked creating access to high-quality, open spatial data to a range of benefits, such as fostering new business opportunities (Hansen & Schrøder, 2019), improving community resilience to future disasters (Parajuli et al., 2023), and enabling better decision-making (Cochrane & Corbett, 2020).

This article examines the sustained socio-economic benefits of VGI production during humanitarian emergencies. Using the 2015 Nepal earthquake response as a case study, we investigate the acceleration of disruptive innovation linked to the participatory mapping process and the VGI produced for emergency response. A decade has passed since the earthquake, allowing sufficient time to assess the longer-term impacts of actions taken in the response. The local non-profit Kathmandu Living Labs (KLL) played a pivotal role in facilitating the production and use of VGI by local individuals and humanitarian response organizations. This process created innovative access to mapping and open spatial data, inspiring local communities, institutions, and businesses to continue mapping Nepal and build new services and opportunities that were previously unavailable, including ridesharing and food delivery. We specifically highlight Baato Maps, a culturally relevant, low-cost mapping solution, as a key example of how VGI integration can accelerate innovation and deliver lasting socio-economic benefits.

2. Background

2.1 Challenges of Evaluating Impact

The dynamic and often chaotic nature of crisis response complicates the evaluation of VGI use in humanitarian settings and understanding the deeper, more sustained changes in communities affected by disasters as a result of VGI production (Alesani & Missoni, 2023; Cinnamon, 2020). Supporting the transition of impacted populations from post-crisis to long-term sustainable recovery and resilience-building is a key aim of humanitarian assistance (Alesani & Missoni, 2023). However, lasting socio-economic benefits that accelerate this transition are often indirect and may not emerge until long after the formal response phase concludes, making them difficult to measure within the traditional evaluation frameworks (Herfort et al., 2021). Whilst proponents of VGI point to its open-source and decentralized nature as a benefit (Parr, 2015), this complicates efforts to track, verify and evaluate the impact of this data including use by responders and government agencies (Hunt & Specht, 2019; Polous, 2023). Measuring and defining these impacts would require a shift of evaluative attention from outputs to outcomes, focusing on evaluating long-term changes in social and economic dynamics that emerge from the integration of open data and community-driven innovation long after a humanitarian intervention ends.

2.2 Disruptive Innovation and the Rise of Digital Humanitarianism

Innovation in participatory mapping has evolved significantly with the advent of cheaper and more accessible digital technologies. In the context of humanitarian and international development work, "disruptive innovation" refers to new technologies or practices that challenge existing systems and power structures (S. Brown, 2020; Fejerskov & Fetterer, 2021). Digital humanitarianism, driven by the integration of local

and global participants, has introduced new ways to engage citizens in humanitarian response through decentralized, open-source platforms like OSM (Cinnamon, 2020; Mulder et al., 2016). This has created a new paradigm of innovation which disrupts traditional humanitarian response systems, not only through the use of new technologies but also through the demand for increasingly transparent approaches to crisis response for governments, civil society, responders, and people affected by crisis who can put needs on the map (Fejerskov & Fetterer, 2021; Givoni, 2016; Mulder et al., 2016). However, for such innovations to have lasting effects, they must be integrated into formal systems as standard practice, allowing them to evolve beyond their initial applications (S. Brown, 2020; Soden & Palen, 2016).

Participatory mapping uptake and adoption has the potential to subvert entrenched power dynamics in cartography and humanitarian assistance by allowing local communities and non-experts to directly participate in knowledge production (Cinnamon, 2020; Cochrane & Corbett, 2020; Haworth et al., 2018). These contributions help increase accountability by democratising access to the production and outputs of spatial information used for decision-making, empowering local actors to shape their recovery and future resilience (Corbett et al., 2016; Givoni, 2016). In situations which purposefully leverage local expertise, VGI production increases the capacity for local actors to utilize VGI for their own benefit for immediate disaster response and longer-term recovery (Haworth et al., 2018; Yan et al., 2020).

Contributors to VGI tasks can be non-experts; however, data are often verified by other volunteers to ensure data quality (Albuquerque et al., 2016; Parr, 2015). This has not only expanded opportunities for citizens to participate in mapping their environment, but has also enabled the creation of custom applications that utilize the OSM infrastructure to address specific and locally-relevant user needs (Neis & Zielstra, 2014). However, concerns about data privacy and digital inequality persist, and issues with volunteer engagement and motivations affect the coverage and quality of spatial data (Kamptner & Kessler, 2019; Khanal et al., 2019).

Despite the initial success of crisis mapping using OSM to improve the efficiency of response efforts, challenges arose in data accuracy and communication between responders (Soden & Palen, 2016). This highlighted the need for better coordination between VGI creators and formal humanitarian responders, a critical element for ensuring the uptake of VGI. The non-profit Humanitarian OpenStreetMap Team (HOT) formed as a key intermediary to coordinate VGI efforts, creating a customized OSM platform which mobilizes remote volunteers to collect and update spatial data during and after crises (Scholz et al., 2018). Over the past 15 years, HOT has significantly contributed to participatory mapping using VGI, with 514,000 mappers creating over 165 million building edits and mapping 3.7 million kilometers of roads around the world. HOT is also dedicated to long-term anticipatory action, including the 'Missing Maps' project which seeks to create data in vulnerable areas that lack high-quality spatial information (Albuquerque et al., 2016; Scholz et al., 2018).

Yet, despite its proven success, HOT as an organization and VGI as a data type have not been systematically integrated into the operational frameworks of humanitarian response frameworks including the UN Inter-Agency Standing Committee's Humanitarian Programming Cycle (HPC) (IASC, 2015). Whilst individual response organizations including World Food Programme, Medecins Sans Frontiers and British Red Cross have incorporated VGI into their operations, there are significant challenges in the systemic adoption of VGI to support collaboration between responders (Cinnamon, 2020). In a meta-analysis of 51 humanitarian VGI deployments between 2010 and 2016, Hunt & Specht (2019) found that VGI data are often the first to be dismissed by formal responders due to lack of capacity to use or verify data created by third-parties. Without formal systems and clear metrics for success to evaluate its contribution, VGI's potential for sustained impact remains underutilized by the international community, limiting its broader adoption and integration into future humanitarian efforts.

2.3 From Crisis to Innovation: VGI's Impact on Nepal's Earthquake Recovery

The 2015 Nepal earthquake response provides a clear example of how VGI production can accelerate humanitarian response and lead to lasting innovations which accelerate socio-economic benefits. On April 25, 2015, a 7.8 magnitude earthquake struck near Kathmandu, killing nearly 9,000 people, injuring 22,300, leaving 2.5 million people homeless and impacting an estimated one-third of Nepal's population (Government of Nepal, 2015; McMurren et al., 2017). With over 450 humanitarian organizations and 34 country teams physically mobilized to support relief efforts, the need for rapid, accurate mapping was urgent (Government of Nepal, 2015). The limited national disaster management infrastructure, outdated pre-existing data, and remote locations of affected areas hampered initial response efforts, creating challenges for both national and international responders (Paudel & Soden, 2023).

Prior to the earthquake, Nepal had minimal accurate and freely available digital infrastructure for mapping and route-finding, with government data largely unavailable for public use, outdated, and incomplete (McMurren et al., 2017). As homes in Nepal are not typically addressed, navigation relied on traditional and informal methods, using landmarks and local descriptions (S. Bhattrai, personal communication, Dec 2023). Participatory mapping and the production of VGI played a critical role in overcoming this gap. Over 5,000 online volunteers contributed to the HOT platform to support the earthquake response, producing more than 1,000,000 edits to the map of the affected area (Andersen, 2015; Parr, 2015). These edits included classifying roads, identifying damage, and providing detailed geographical data that allowed

responders to navigate remote areas (Thapa et al., 2017; McMurren et al., 2017). Kathmandu Living Labs (KLL), a local organization established by OSM scholar and champion Dr. Nama Budhathoki, had been mapping facilities in the Kathmandu Valley on OSM since 2013. Dr. Budhathoki's technical skills and network played a central role in elevating KLL's capacity to lead mapping efforts, coordinating between the global HOT and OSM volunteers, local volunteers, and humanitarian responders (McMurren et al., 2017; Poiani et al., 2016).

KLL's pre-existing organizational technical capacity, local knowledge, and community engagement enabled the rapid scaling of VGI during the response (Hunt, 2023; Poiani et al., 2016). This included the addition of 40 Nepali volunteers, who came to the KLL 'situation room' to offer support and included students, employees at technology firms, some of whom had never mapped before (Kathmandu Living Labs, 2016; Thapa et al., 2017; N. Budhathoki, personal communication, Dec 2023). These volunteers were quickly trained to become data collectors and verifiers, ensuring culturally-relevant review of incoming data from VGI volunteers (N. Budhathoki, personal communication, Dec 2023).

One of the most significant innovations to support the response was KLL's development of QuakeMap, a mobile application deployed within 24 hours of the earthquake, which allowed affected communities to report damages and needs directly (McMurren et al., 2017). These reports helped prioritize relief efforts, informed strategic decision-making on the ground, and allowed participating responders to see when reports had been addressed in real-time (Hunt, 2023). While the initial skepticism from government agencies and humanitarian organizations about data quality created challenges for KLL's efforts to integrate VGI, legitimacy was enhanced through widespread participation and media coverage from national and international media outlets and volunteers, ultimately leading to broader adoption by government and formal humanitarian responders (Thapa et al., 2017). In contrast to prior similar emergency responses, the OSM basemap became the most commonly used source of GIS data by teams working in the response (Soden & Palen, 2016). QuakeMap was adopted as an official tool for coordinating relief efforts by the Nepal Army and the National Information Technology Center (Hunt, 2023; McMurren et al., 2017). The widespread adoption of VGI by international, government, and local actors in this case study is cited as a turning point which lead to open-data practices becoming more commonly used by a wide range of humanitarian actors (Herfort et al., 2021; Hunt & Specht, 2019).

3. Methods

This study is part of a broader research initiative funded by the Social Sciences and Humanities Research Council of Canada, examining the unintended impacts of participatory mapping. Cases were selected based on expert recommendations, with the HOT and KLL project in Nepal chosen as a key example. A research ethics review was approved by the University of British Columbia, and data collection in Nepal occurred in December 2023.

The study employs a case study approach, informed by a variety of research methodologies, including an academic literature review, and interviews with key informants from HOT and Baato Maps. Prior to in-country data collection, the research team held regular meetings with the lead of HOT Asia-Pacific and KLL for six months, gathering contextual data and coordinating meetings with relevant stakeholders. In-country data collection involved individual interviews and focus group discussions (FGDs) with project staff, academics, NGO personnel, government officials, and users of participatory mapping tools. All interviews and FGDs were audio recorded with participant consent. This allowed for an ecosystem approach to understanding the unintended societal impacts of participatory mapping, using a decade-long perspective since the initial mapping efforts in Nepal post-2015 earthquake.These conversations provided a diverse set of insights into the ongoing use of VGI, though it is acknowledged that several important stakeholders were not reached due to the study's scope and timeframe.

The study's data collection period was limited to two weeks, which, while allowing for daily meetings with multiple stakeholders, restricted the number of participants. Additionally, all interviews and reviewed literature were conducted in English, which excluded certain regional resources in Nepali. While this study draws on the perspectives of experts and key informants, it is recognized that the perspectives of other stakeholders were not fully captured. Understanding the complex, multifaceted nature of participatory mapping and innovation, the research acknowledges the challenges of establishing clear cause-and-effect relationships, particularly given the uncertainties of timeframes, the limited availability of tools, and the absence of attention to indirect impacts (Corbett et al., 2016; Grandpré et al., 2023. A more nuanced, deeper understanding of these multidimensional impacts would enhance future efforts to assess the effectiveness of participatory mapping and VGI, and arguably provide the ability to drive sustainable change within the humanitarian OSM landscape.

4. Findings

In the wake of the 2015 Nepal earthquake, the VGI that was produced has played a key role in shaping long-term socio-economic benefits, extending far beyond immediate disaster relief. Continued leadership and contributions from civil society organizations including KLL has led to the production of a comprehensive and freely available map on OSM (Paudel & Soden, 2023). This has provided significant contributions towards accurate navigation services within Nepal, leading to new norms for smartphone users who can now easily map driving directions or order food delivery (Pandey, 2023; Yan et al., 2020). Prior to the earthquake, Nepal's route-finding and navigation capabilities were severely limited due to poor data quality and the absence of a national addressing

system (S. Bhattrai, personal communication, December 2023; Khadka, 2023). Global services like Google Maps were inadequate, failing to distinguish between vehicle-accessible roads and footpaths (S. Bhattrai, personal communication, December 2023). Local businesses which wished to expand or improve their offerings by including GIS navigation services, for example to deliver goods to homes, were hindered by the high cost and inaccuracy of global providers (B. Pokherel, personal communication, December 2023). Relying on land-mark based directions that varied by individual perception created a significant challenge for effective service delivery and innovation.

Following the production of VGI in the earthquake response, mapping of more features throughout Nepal continued, helping to address these challenges. While Kathmandu Living Labs (KLL) had initiated open mapping efforts prior to the disaster, the speed and quality of coverage was limited by their funding and staff capacity. Contributions from local and digital mappers following the earthquake expanded these efforts and continued long after the immediate relief efforts, creating a comprehensive and freely accessible basemap for Nepal on OSM (N. Budhathoki, personal communication, December 2023; HeiGIT, 2020; Kamptner & Kessler, 2019). For example, the road network coverage in Nepal on OSM increased by 15% directly after the disaster and by 2020 had increased by 30% (HeiGIT, 2020). Local interest in mapping was sparked, and multiple organizations and programs have emerged which aim to build local OSM mapping skills to support projects in topics including climate change, disaster risk reduction, entrepreneurship, youth engagement, and agriculture (OpenStreetMap, 2024). KLL developed a digital internship and leadership program for Nepali youth, which sought to empower participants to map rural and data-poor regions of Nepal on OSM (Khanal et al., 2019). 19 interns created over 1,200,000 map changes over a period of 3 months, not only creating critical data for under-mapping localities, but also enhancing the capacity of youth to use spatial data to improve existing practices and create new socio-economic opportunities (Khanal et al., 2019). These edits suggest increasing interest and engagement in participatory mapping and its applications.

The output of this participatory mapping on OSM is a widely used and freely available basemap of Nepal. Coupled with a shift toward open data practices, the production of this VGI has inspired local businesses and communities to leverage the data and infrastructure to create long-term socio-economic benefits. For example, OSM road data was used instead of government data for local flood evacuation planning in Nepal, highlighting how VGI integration can address gaps in local data, enhance decision-making, and increase resilience to disasters (Parajuli et al., 2023). A key economic benefit has been the ability for a local GIS-based economy to emerge which utilizes locally-made data, either freely or through Nepali service providers at a fraction of the cost of international commercial providers.

Baato Maps is one example of a culturally-relevant mapping solution in which the speed of development was enabled by the post-earthquake surge of VGI data, and a desire to add value to OSM data (S. Bhattrai, personal communication, December 2023). The freely available Baato Maps mobile application utilizes a disruptive innovation approach to navigation by using landmark-based guidance, addressing the limitations of formal street addressing and enabling users to navigate Nepal's complex terrain in Nepali using familiar methods (Pandey, 2023). The application's offline capabilities further enhance its utility in remote areas with limited internet access. Beyond navigation, Baato Maps also offers API services to local businesses, making affordable spatial data services available for various sectors, including e-commerce, ridesharing, food delivery, and logistics (Baato Maps, 2025). The API has initiated the development of several apps which use Baato Maps, as well as the development of a competitive ecosystem of spatial service delivery for Nepali businesses which address market gaps (B. Pokherel, personal communication, December 2023). This entrepreneurship has created economic opportunities for business owners and employees, as well as a wide network of service providers. For example, the launch of Galli Maps in 2022, a delivery-focused navigation service, improved door-to-door delivery for e-commerce, groceries, and medical supplies (Khadka, 2023; Pandey, 2023). This type of service provision not only fosters economic benefits but can also increase resilience to shocks, for example by providing essential services for vulnerable citizens during the COVID-19 pandemic.

The creation of new spatial services can be seen as part of a broader trend where the availability of open spatial data has enabled entrepreneurial opportunities, though the exact causal relationship remains complex. Similar studies have demonstrated that open spatial data can lead to the development of new business sectors, providing support to local economies (Hansen & Schrøder, 2019; Haworth et al., 2018). In Nepal, the new ecosystem of services derived from open spatial data have created economic opportunities for business owners and employees, as well as a wide network of individual service providers. Access to creating and participating in mapping has facilitated better communication between citizens and governments, and the development of educational initiatives aimed at building local leadership. These developments underscore the long-term socio-economic impacts that arise from participatory mapping and VGI-accelerated innovation, with increased access to critical services—such as navigation, delivery, and connectivity—enhancing not just crisis recovery but also creating a more resilient socio-economic infrastructure in Nepal.

5. Discussion

The case study of the 2015 Nepal earthquake response illustrates the often-overlooked potential of participatory mapping to generate long-term and often unexpected socio-economic benefits. While participatory mapping has long been touted for its ability to empower marginalized

groups and facilitate decision-making (Cochrane & Corbett, 2020; Fagerholm et al., 2021; Rambaldi et al., 2006), its lasting outcomes—especially those initiated because of a humanitarian emergency —remain underexplored. In Nepal, participatory mapping did not only enable a more rapid and efficient humanitarian response; it also accelerated innovations such as Baato Maps, which provides previously unavailable services tailored to the specific needs of Nepali users. The empowerment of both the user and the service provider to utilize and create open spatial data has created a new paradigm of civic participation which is increasingly accessible, transparent and accountable (Givoni, 2016; Haworth et al., 2018). VGI production to the scale necessary to create these socio-economic impacts may not have been realized without the influx of volunteers and resources in the aftermath of a disaster.

Yet, as with many participatory mapping projects, the challenges of evaluating its impact beyond the immediate outputs persist. The open structure of VGI data, particularly in platforms like OpenStreetMap (OSM), makes it difficult to track the long-term use and impacts of the data, as these are often not integrated into formal decision-making processes (Scholz et al., 2018). Without clear systems for monitoring and verifying how VGI data is used post-crisis, it becomes challenging to assess its full socio-economic value, leaving organizations like HOT and KLL vulnerable when competing for donor funding.

Improving socio-economic outcomes for communities in the Global South remains a key goal of sustainable development projects, many of which are financed by the same donors who fund humanitarian assistance. And yet, the potential for VGI production and uptake to support emergency response and transitions to recovery and long-term socio-economic improvements has been overlooked in multi-sector evaluations of humanitarian assistance. Given the potential for resource optimization and the promotion of success stories which enhance donor popularity, why has the contribution of VGI been undervalued?

A key challenge is coordination and information sharing between actors within and between sectors. Although humanitarian assistance and international development actors often operate in the same locations, differing timescales and types of interventions lead to coordination being reliant on chance and personal connections (Hunt & Specht, 2019; Soden & Palen, 2016). Whilst there are growing calls to ‘disrupt development’ from actors working in the humanitarian and development fields (Fejerskov & Fetterer, 2021), there is also growing recognition of the need for organizations within the system to enhance coordination between nodes of the ‘complex system’ (Moore et al., 2016).

Evaluations of humanitarian response are sparse, largely limited to recording deviations from standard operating procedures, and rarely used as an opportunity to create new ways of doing things (Alesani & Missoni, 2023; Ramalingam, 2016). This limits learning and accountability to a “single-loop” approach, which seeks to improve existing processes or systems but does not challenge underlying assumptions or foster innovation (Fejerskov & Fetterer, 2021). While this approach can lead to incremental improvements, it does not fully capture the potential for systemic change and innovation that participatory mapping can catalyze. A "double-loop" approach, which questions the underlying assumptions about how humanitarian response systems operate, is crucial for identifying the broader, long-term impacts of VGI (Ramalingam, 2016). Such an approach could lead to a more comprehensive understanding of VGI's role in fostering long-term innovation, community empowerment, and economic development.

The example of Baato Maps demonstrates how VGI can spark lasting socio-economic changes by enabling new services and business models. However, to maximize VGI's potential in future humanitarian efforts, there must be a concerted effort to integrate VGI data into long-term recovery and sustainable development planning. This requires an evaluation framework that not only considers short-term crisis response outcomes but also tracks how innovations introduced during emergencies can contribute to sustainable development and future crisis management. In doing so, the humanitarian sector can better harness the power of participatory mapping to create sustainable, long-term benefits for affected communities. However, the challenge remains to ensure that such innovations are sustained and expanded, requiring a systemic shift in how humanitarian actors perceive VGI.

Given the evidence from the Nepal case study, future research should focus on developing more robust frameworks for evaluating the long-term impacts of participatory mapping and VGI production after humanitarian emergency response. A deeper understanding of if and how VGI shifts power dynamics in humanitarian settings is also essential. While VGI democratizes spatial information, further investigation is needed to understand how this empowerment is perceived and utilized by local communities, individuals, and civil society. By exploring these areas, future research can provide a more comprehensive understanding of VGI’s potential to drive innovation, foster economic development, and enhance resilience, both in humanitarian response and in long-term sustainable development efforts. This will not only help improve the effectiveness of future humanitarian interventions but also underscore the value of participatory mapping as a tool for sustainable development.

6. Conclusion

This paper has highlighted the potential for digital participatory mapping to lead to disruptive innovation and lasting socio-economic benefits in crisis-affected communities after humanitarian emergency response has concluded. The Nepal case study underscores the value of VGI production and integration in complex humanitarian response, which, with appropriate evaluation and planning frameworks, can be optimized to contribute to long-term sustainable recovery and resilience-building. The success

of Baato Maps, a culturally relevant navigation tool developed using OSM data, illustrates how localized crowdsourcing of digital spatial data can lead to unexpected and understudied outcomes that might be realized well after immediate intervention timeframes that are typically used to evaluate impacts. By adopting a collaborative "double-loop" approach that evaluates the potential of VGI production to accelerate innovation and catalyze sustainable development, the humanitarian sector can more effectively harness the power of participatory mapping to drive lasting change. This shift will ensure participatory mapping, when implemented appropriately, is recognized as a valuable tool for crisis response and lasting benefits, enabling digital humanitarianism to fulfil its potential.

References

Albuquerque, J., Herfort, B., & Eckle, M. (2016). The Tasks of the Crowd: A Typology of Tasks in Geographic Information Crowdsourcing and a Case Study in Humanitarian Mapping. Remote Sensing, 8(10), 859. https://doi.org/10.3390/rs8100859

Alesani, D., & Missoni, E. (2023). Coordination in humanitarian response and the nexus with development. In E. Missoni & D. Alesani, Management of International Institutions and NGOs (2nd ed., pp. 201–223). Routledge. https://doi.org/10.4324/9781003289852-9

Andersen, J. (2015). OpenStreetMap response to the April 25 Earthquake in Nepal [Blog]. Results of Various OpenStreetMap Analyses. https://osm.jenningsanderson.com/nepal/

Baato Maps. (2025). Baato—Maps for Nepal. Baato. https://baato.io/

Brown, S. (2020). The Rise and Fall of the Aid Effectiveness Norm. The European Journal of Development Research, 32(4), 1230–1248. https://doi.org/10.1057/s41287-020-00272-1

Chambers, R. (2006). Participatory Mapping and Geographic Information Systems: Whose Map? Who is Empowered and Who Disempowered? Who Gains and Who Loses? The Electronic Journal of Information Systems in Developing Countries, 25(1), 1–11. https://doi.org/10/ggsccd

Cinnamon, J. (2020). Humanitarian Mapping. In International Encyclopedia of Human Geography (pp. 121–128). Elsevier. https://doi.org/10.1016/B978-0-08-102295-5.10559-1

Cochrane, L., & Corbett, J. (2020). Participatory Mapping. In J. Servaes (Ed.), Handbook of Communication for Development and Social Change (pp. 705–713). Springer Singapore. https://doi.org/10.1007/978-981-15-2014-3_6

Corbett, J., Cochrane, L., & Gill, M. (2016). Powering Up: Revisiting Participatory GIS and Empowerment. The Cartographic Journal, 53(4), 335–340. https://doi.org/10.1080/00087041.2016.1209624

Fagerholm, N., Raymond, C. M., Olafsson, A. S., Brown, G., Rinne, T., Hasanzadeh, K., Broberg, A., & Kyttä, M. (2021). A methodological framework for analysis of participatory mapping data in research, planning, and management. International Journal of Geographical Information Science, 35(9), 1848–1875. https://doi.org/10.1080/13658816.2020.1869747

Fejerskov, A. M., & Fetterer, D. (2021). Disrupting Development? A Situated Perspective on Technology and Innovation in Global Development. Progress in Development Studies, 21(3), 231–243. https://doi.org/10.1177/14649934211018399

Givoni, M. (2016). Between micro mappers and missing maps: Digital humanitarianism and the politics of material participation in disaster response. Environment and Planning D: Society and Space, 34(6), 1025–1043. https://doi.org/10.1177/0263775816652899

Goodchild, M. F. (2007). Citizens as sensors: The world of volunteered geography. GeoJournal, 69(4), 211–221. https://doi.org/10.1007/s10708-007-9111-y

Government of Nepal. (2015). Nepal 2015 Earthquake Post Disaster Needs Assessment (No. Volume B).

Grandpré, A., Corbett, J., Cochrane, L., & Butterfield, M. (2023). “Siloing” Impact: Exploring academic and practitioner perspectives on impact in digital participatory mapping. Spatial Knowledge and Information Canada 2023. https://doi.org/10.17605/OSF.IO/N6DU5

Hansen, H. S., & Schrøder, L. (2019). The Societal Benefits of Open Government Data with Particular Emphasis on Geospatial Information. In A. Kő, E. Francesconi, G. Anderst-Kotsis, A. M. Tjoa, & I. Khalil (Eds.), Electronic Government and the Information Systems Perspective (Vol. 11709, pp. 31–44). Springer International Publishing. https://doi.org/10.1007/978-3-030-27523-5_3

Haworth, B. T., Bruce, E., Whittaker, J., & Read, R. (2018). The Good, the Bad, and the Uncertain: Contributions of Volunteered Geographic Information to Community Disaster Resilience. Frontiers in Earth Science, 6, 183. https://doi.org/10.3389/feart.2018.00183

HeiGIT. (2020). Exploring Localness of OSM Data – An Analysis using the OSHDB and ohsome api [Academic]. Heidelberg Institute for Geoinformation Technology. https://heigit.org/exploring-localness-of-osm-data-an-analysis-using-the-oshdb-and-ohsome-api/

Herfort, B., Lautenbach, S., Porto De Albuquerque, J., Anderson, J., & Zipf, A. (2021). The evolution of humanitarian mapping within the OpenStreetMap community. Scientific Reports, 11(1), 3037. https://doi.org/10.1038/s41598-021-82404-z

Hunt, A. (2023). Crisis and Hazard Mapping. In The Routledge Handbook of Geospatial Technologies and Society (1st ed.). Routledge. https://doi.org/10.4324/9780367855765

Hunt, A., & Specht, D. (2019). Crowdsourced mapping in crisis zones: Collaboration, organisation and impact. Journal of International Humanitarian Action, 4(1), 1. https://doi.org/10.1186/s41018-018-0048-1

Kamptner, E., & Kessler, F. (2019). Small-scale crisis response mapping: Comparing user contributions to events in OpenStreetMap. GeoJournal, 84(5), 1165–1185. https://doi.org/10.1007/s10708-018-9912-1

Kathmandu Living Labs. (2016). Kathmandu Living Labs: Six-Months of Earthquake Response [Blog]. https://kathmandulivinglabs.github.io/timeline-sixmonths/

Khadka, P. (2023). Finding your way in Nepal. Nepali Times. The Nepali Times. https://nepalitimes.com/opinion/comment/finding-your-way-in-nepal

Khanal, K., Budhathoki, N. R., & Erbstein, N. (2019). Filling OpenStreetMap data gaps in rural Nepal: A digital youth internship and leadership Programme. Open Geospatial Data, Software and Standards, 4(1), 1–10. https://doi.org/10.1186/s40965-019-0071-1

Mahmud, Z., Chauhan, A., Sarkar, D., & Soden, R. (2022). Revisiting Engagement in Humanitarian Mapping: An Updated Analysis of Contributor Retention in OpenStreetMap. CHI Conference on Human Factors in Computing Systems Extended Abstracts, 1–6. https://doi.org/10.1145/3491101.3519728

McMurren, J., Bista, S., Young, A., & Verhulst, S. (2017). Nepal: Open Data to Improve Disaster Relief (Open Data for Developing Economies Case Studies). Open Data Impact. https://odimpact.org/files/case-nepal.pdf

Moore, R., Bhide, N., & Verity, A. (2016). Humanitarian Information Management Failures: Survey Report. United Nations Office for the Coordination of Humanitarian Affairs.

Mulder, F., Ferguson, J., Groenewegen, P., Boersma, K., & Wolbers, J. (2016). Questioning Big Data: Crowdsourcing crisis data towards an inclusive humanitarian response. Big Data & Society, 3(2), 2053951716662054. https://doi.org/10.1177/2053951716662054

OpenStreetMap. (2024). WikiProject Nepal [Wiki]. OpenStreetMap. https://wiki.openstreetmap.org/wiki/WikiProject_Nepal

Pandey, P. (2023). Nepali-made location apps gaining credence for their greater accuracy. The Kathmandu Post. https://kathmandupost.com/money/2023/03/06/nepali-made-location-apps-gain-credence-for-their-greater-accuracy

Parajuli, G., Neupane, S., Kunwar, S., Adhikari, R., & Acharya, T. D. (2023). A GIS-Based Evacuation Route Planning in Flood-Susceptible Area of Siraha Municipality, Nepal. ISPRS International Journal of Geo-Information, 12(7), 286. https://doi.org/10.3390/ijgi12070286

Parr, D. A. (2015). Crisis Mapping and the Nepal Earthquake: The Impact of New Contributors. KN - Journal of Cartography and Geographic Information, 65(3), 151–155. https://doi.org/10.1007/BF03545120

Paudel, S., & Soden, R. (2023). Reimagining Open Data during Disaster Response: Applying a Feminist Lens to Three Open Data Projects in Post-Earthquake Nepal. Proceedings of the ACM on Human-Computer Interaction, 7(CSCW1), 1–25. https://doi.org/10.1145/3579519

Poiani, T. H., Dos Santos Rocha, R., Degrossi, L. C., & Porto De Albuquerque, J. (2016). Potential of Collaborative Mapping for Disaster Relief: A Case Study of OpenStreetMap in the Nepal Earthquake 2015. 2016 49th Hawaii International Conference on System Sciences (HICSS), 188–197. https://doi.org/10.1109/HICSS.2016.31

Polous, N. (2023). A Holistic View on Volunteered Geographic Information. Proceedings of the ICA, 5(Journal Article), 1–8. https://doi.org/10.5194/ica-proc-5-17-2023

Ramalingam, B. (2016). Innovations in the Nepal earthquake response: Ten lessons from the DEC response review. In Nepal earthquake appeal response review. Disasters Emergency Committee.

Rambaldi, G., Kyem, P. A. K., McCall, M., & Weiner, D. (2006). Participatory Spatial Information Management and Communication in Developing Countries. THE ELECTRONIC JOURNAL OF INFORMATION SYSTEMS IN DEVELOPING COUNTRIES, 25(1), 1–9. https://doi.org/10.1002/j.1681-4835.2006.tb00162.x

Scholz, S., Knight, P., Eckle, M., Marx, S., & Zipf, A. (2018). Volunteered Geographic Information for Disaster Risk Reduction—The Missing Maps Approach and Its Potential within the Red Cross and Red Crescent Movement. Remote Sensing (Basel, Switzerland), 10(8), 1239. https://doi.org/10.3390/rs10081239

Soden, R., & Palen, L. (2016). Infrastructure in the Wild: What Mapping in Post-Earthquake Nepal Reveals about Infrastructural Emergence. Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, 2796–2807. https://doi.org/10.1145/2858036.2858545

Thapa, D., Budhathoki, N., & Munkvold, B. E. (2017). Analyzing Crisis Response through Actor-Network Theory: The Case of Kathmandu Living Labs. Communications of the Association for Information Systems, 41, 414–428. https://doi.org/10.17705/1CAIS.04119

Yan, Y., Feng, C.-C., Huang, W., Fan, H., Wang, Y.-C., & Zipf, A. (2020). Volunteered geographic information research in the first decade: A narrative review of selected journal articles in GIScience. International Journal of Geographical Information Science, 34(9), 1765–1791. https://doi.org/10.1080/13658816.2020.1730848