The Role of Open-Source Data in Disaster Preparedness and Response. A Case Study on Flood Impact in Local Communities

Adeola Oyetunde [1], Gresa Neziri [2]

[1] Dept. of Surveying and Geoinformatics, Obafemi Awolowo University, Ile – Ife, Nigeria - aaoyetunde@student.oauife.edu.ng
[2] SpaceSyntaKs, Ganimete Terbeshi, 61, 10000 Prishtina, Kosovo - gresaneziri@spacesyntaks.org

Keywords: Open-Source Data, Disaster Preparedness, Flood Impact, OpenStreetMap, GIS Spatial Analysis, Volunteered Geographic Information.

ABSTRACT

Flooding remains one of the most destructive natural hazards globally, resulting in severe social, economic, and infrastructural impacts. This study investigates the role of open-source geospatial tools and community-contributed data in enhancing disaster preparedness and response, using the Jakande Housing Estate in Lagos, Nigeria as a case study. The methodology integrates multi-temporal analysis of high-resolution satellite imagery over a six-year period to detect land cover changes and assess flood risk dynamics. Initial analysis revealed significant data gaps within OpenStreetMap (OSM), prompting the initiation of a targeted mapping campaign via the Humanitarian OpenStreetMap Team (HOT) Tasking Manager. This initiative mobilized volunteers to update critical geographic features. To complement remote mapping efforts, in-situ data collection was carried out using the Open Data Kit (ODK), capturing real-time information on infrastructure conditions and displacement patterns. Spatial analyses, including change detection and overlay techniques in QGIS, revealed that over 40% of residential zones within the study area are located in high-risk flood-prone zones, with essential facilities, such as police stations and commercial clusters, also affected. The findings underscore the value of integrating remote sensing, open-source geospatial data, and participatory mapping approaches to enhance situational awareness and support evidence-based emergency response planning. Nonetheless, the study faced limitations due to variability in spatial resolution and restricted access to high-quality spectral data. Future research should explore the integration of higher-resolution imagery and predictive flood modeling to further improve impact assessments and inform long-term resilience strategies.

1. Introduction

1.1 Background of the Study

Flood-related losses continue to escalate globally due to rapid urban expansion, inadequate infrastructure, and the increasing impacts of climate change. According to the United Nations Office for Disaster Risk Reduction (UNDRR), over 90% of disaster-affected populations in recent decades have been impacted by water-related hazards, with floods representing a significant proportion of these events (UNDRR, 2021). In 2020 alone, floods accounted for 201 out of 389 recorded natural disasters, affecting approximately 98.4 million people and resulting in an estimated USD $171.3 billion in economic losses (Centre for Research on the Epidemiology of Disasters [CRED], 2021). The World Bank (2010) further estimates that over 800 million people are exposed to fluvial flood risk under a 1-in-100-year scenario.

As the most frequent and economically devastating natural hazard, floods cause widespread social and economic disruption, particularly in urban and peri-urban communities. Vulnerability is often amplified in areas where informal development and inadequate planning prevail (Tellman et al., 2021). Despite their impact, many high-risk zones remain under-mapped, with limited access to real-time, reliable geospatial data—presenting a serious challenge to effective preparedness and response efforts (Haworth et al., 2018; Sliuzas et al., 2016).

These challenges have prompted growing interest in alternative approaches that leverage open and participatory geospatial data. This study builds on that momentum by examining how community-mapped data and open-source tools can help address spatial data gaps and support inclusive, locally responsive flood preparedness strategies in high-risk environments.

1.2 Conceptual Framework

Traditional flood impact assessments have typically relied on historical hydrological records, government reports, and post-event field surveys. While foundational, these approaches often suffer from delayed availability, coarse spatial resolution, and insufficient representation of local perspectives (Nguyen et al., 2021; Fazeli et al., 2015). These constraints limit the speed and relevance of emergency decision-making and hinder long-term resilience planning.

In response, open-source geospatial platforms—most notably OpenStreetMap (OSM), have emerged as a powerful alternative. With over 10 million contributors and more than one billion edits, OSM has become a globally recognized source of Volunteered Geographic Information (VGI) (Herfort et al., 2021). Its capacity for real-time crowdsourced mapping makes it particularly useful in disaster scenarios, enabling rapid updates and supporting more adaptive emergency responses.

Engaging local communities in pre-disaster mapping activities enhances both the temporal availability and contextual relevance of geographic data. Community-driven contributions to OSM not only accelerate the production of local-scale spatial datasets but also foster participatory engagement in disaster preparedness and resilience planning. Training community members to map their surroundings, particularly in under-mapped and vulnerable urban areas, can significantly improve

https://doi.org/10.5194/isprs-archives-XLVIII-4-W13-2025-185-2025

disaster readiness and empower local actors (World Bank, 2017).

This study investigates the role of OSM in flood preparedness and response by illustrating how local communities in developing contexts can contribute to the generation of geographic information. Through a case study, the research demonstrates a practical methodology for validating and enhancing the accuracy of OSM data for disaster risk reduction. While the current focus is on flood mapping, the approach is broadly applicable and adaptable to a range of natural hazards and emergency response scenarios.

1.3 Objective of the study

The primary objective of this study is to demonstrate the value of open-source geospatial tools and community-mapped data in improving flood preparedness and response in data-scarce urban environments. Using the Jakande Housing Estate in Lagos, Nigeria, as a case study, the research aims to:

1. Assess existing gaps in publicly available spatial data, particularly OpenStreetMap coverage
2. Engage local contributors in the creation and validation of geographic features relevant to flood risk
3. Integrate remote sensing analysis to delineate flood extents and identify vulnerable zones
4. Apply spatial analysis to evaluate infrastructure exposure and population displacement and
5. Develop evidence-based recommendations for incorporating community mapping into municipal disaster planning frameworks.

By comparing pre- and post-intervention data completeness and risk visualization, the study aims to illustrate how participatory mapping workflows can enhance situational awareness and support proactive decision-making in flood-prone communities.

2. Study Area and Data Acquisition

2.1 Study Area

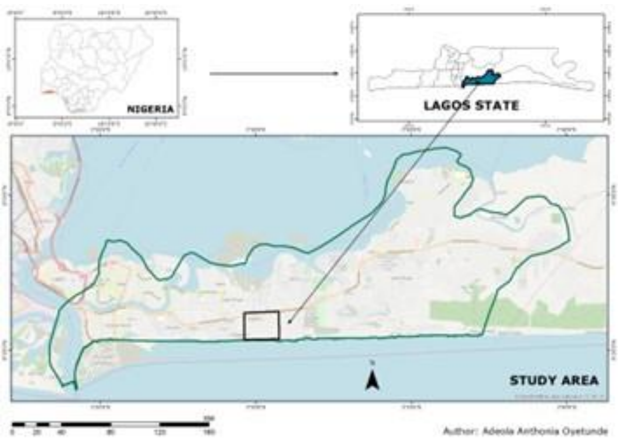

Figure 1. Location of the Jakande Housing Estate within Lagos State, Nigeria.

The study focuses on the Jakande Housing Estate, located in the Eti-Osa Local Government Area (LGA) of Lagos State, Nigeria. The estate lies within the jurisdiction of three Local Council Development Authorities (LCDAs): Ikoyi-Obalende, Iru-Victoria Island, and Eti-Osa East. It is geographically positioned at approximately latitude 6.432706° N and longitude 3.504796°E (equivalent to 6° 25' 57.74" N and 3° 30' 17.27" E).

Jakande Housing Estate, situated in a low-lying coastal zone, is highly susceptible to recurrent flooding, primarily driven by extreme rainfall events, obstructed drainage channels, and unregulated urban development. Recent assessments have reported that floodwaters in the area regularly displace thousands of residents and disrupt essential services including health, transport, and education (Yusuf, 2022; NEMA, 2023). Flood events in 2022 and 2023 caused significant structural damage to residential buildings and public infrastructure, prompting calls for improved environmental governance and flood mitigation strategies.

Beyond its geographic vulnerability, Jakande Housing Estate exemplifies the structural and spatial challenges faced by rapidly urbanizing coastal settlements across West Africa. The area remains underrepresented in national spatial databases and had minimal feature coverage in OpenStreetMap prior to this study. These data gaps, combined with high population density, infrastructure exposure, and historical flood impacts, make the estate a compelling site for investigating the use of open-source geospatial tools and community-driven mapping in disaster preparedness (Frontiers in Environmental Science, 2024).

2.2 Socioeconomic and Infrastructural Vulnerability Assessment

Recent flood events in the Jakande Housing Estate have revealed critical vulnerabilities in both the physical infrastructure and the socioeconomic fabric of the community. According to the National Emergency Management Agency (NEMA), numerous structures already compromised due to age and inadequate maintenance collapsed under the pressure of floodwaters, leaving many families homeless. Affected residents were forced to seek temporary shelter in overcrowded conditions, including makeshift tents and shared accommodations with friends and relatives within the estate (NEMA, 2023).

The flood also disrupted essential services by submerging key public infrastructure such as markets, schools, healthcare facilities, religious centers, and a local police station. This widespread infrastructural failure not only paralyzed daily life but also exposed systemic weaknesses in the estate's urban planning and risk management frameworks. Several of the collapsed buildings had been previously identified for demolition by state authorities, underscoring long-standing gaps in enforcement and preventative redevelopment.

The event reflects broader patterns observed in urban disaster studies, where low-income populations are disproportionately affected by infrastructure-related hazards. The reliance on informal shelter solutions and community networks further illustrates the socioeconomic vulnerability of residents and the insufficiency of existing institutional response mechanisms. Despite prior government warnings, the lack of proactive measures to mitigate these risks emphasizes the urgent need for integrated urban planning and disaster risk reduction strategies, as supported by previous research on Lagos' infrastructure challenges (Yusuf, 2022).

https://doi.org/10.5194/isprs-archives-XLVIII-4-W13-2025-185-2025 | © Author(s) 2025. CC BY 4.0 License.

3. Methodology

This study employed a multi-tiered methodological framework that integrates remote sensing, participatory community mapping, and ground-truth data collection to assess flood impacts and improve disaster preparedness in the Jakande Housing Estate, Lekki Peninsula II, Lagos State, Nigeria. The methodology was designed to address both spatial data gaps and the need for localized, community-informed assessments in flood-prone urban areas. The overall approach was divided into three sequential phases: Remote sensing and land cover analysis; Community mapping using OpenStreetMap (OSM); Ground-truth data collection using Open Data Kit (ODK).

3.1 Data Sources and Methods

3.1.1 Remote Sensing and Land Cover Analysis: High-resolution satellite imagery spanning a six-year period was acquired to perform temporal analysis of land cover changes and flood inundation patterns. Landsat-8 imagery was used for historical comparison, and was processed in QGIS for multi-temporal change detection. This analysis utilized the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) to delineate flooded areas and assess vegetation loss due to water logging. The classified maps served as baseline layers for subsequent geospatial analyses.

Figure 2. Jakande Estate, 2016.

Figure 3. Jakande Estate, 2020.

Figure 4. Jakande Estate, 2024.

3.1.2 Community Mapping with OpenStreetMap (OSM): A preliminary review of OpenStreetMap (OSM) coverage for the study area revealed substantial data gaps, particularly in the mapping of residential zones, healthcare facilities, drainage systems, and evacuation routes. In response, a dedicated mapping initiative was launched through the Humanitarian OpenStreetMap Team (HOT) Tasking Manager. This platform enabled the creation of a custom mapping task delineating Jakande Housing Estate within the Eti-Osa Local Government Area.

The primary goal of the campaign was to strengthen the local geospatial dataset for disaster risk management while promoting community engagement. Volunteer mappers, both local residents and remote contributors, digitized previously unmapped features, including buildings, road segments, drainage lines, and public service facilities. These contributions were enriched with attribute data to improve spatial precision and thematic relevance.

Local collaborators also supported the process by identifying key unmapped areas and validating the locations of critical infrastructure features. This collaborative effort provided context-specific insights, allowing local knowledge to enhance the mapping output and address existing spatial data gaps. The open-source nature of OSM ensured that all mapped data remained freely accessible for integration into planning tools and emergency response systems.

The contributor metrics generated during the task demonstrated strong engagement from the global mapping community, highlighting the scalability of participatory mapping efforts.

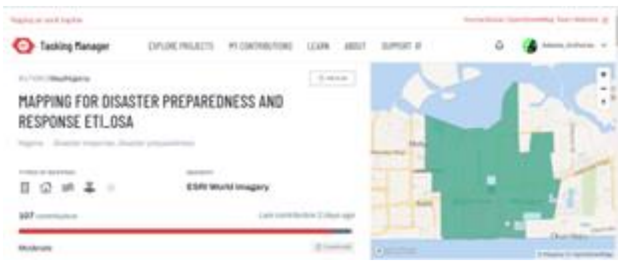

Figure 5. HOTOSM mapping task for Jakande Estate within Eti-Osa LGA.

https://doi.org/10.5194/isprs-archives-XLVIII-4-W13-2025-185-2025 |

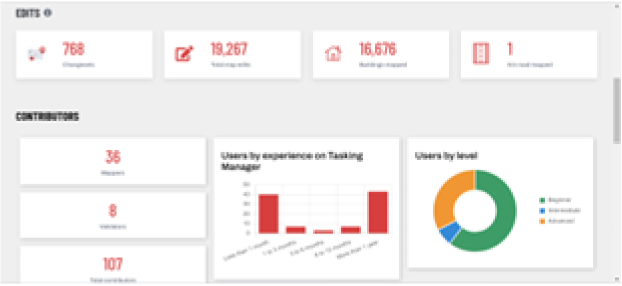

Figure 6. Contributor metrics showing user participation and edits on HOTOSM.

All spatial data produced through this campaign were prepared for integration with subsequent ground-truthing activities and processed using QGIS for advanced spatial analysis.

3.1.3 Ground Truth Data Collection using Open Data Kit (ODK): To validate the remote sensing and community mapping outputs, on-ground data collection was carried out using Open Data Kit (ODK). This phase focused on capturing real-time, location-specific information about infrastructure conditions, flood extents, and community vulnerabilities. The structured survey included the following data points:

1. Location Coordinates: GPS-tagged locations of surveyed infrastructures
2. Infrastructure Type and Condition: Categorization of structures as residential, commercial, or public, with notes on damage status (Good, Damaged, Destroyed)
3. Drainage and Accessibility Assessment: Inspection of drainage systems and road accessibility during flood events
4. Community Feedback and Evacuation Status: Documentation of local observations, evacuation measures, and relief needs
5. Photo Evidence: Geotagged images for visual verification of field observations.

Data collected through ODK was synchronized in real time to a centralized database. These field-based observations enabled cross-verification of remotely mapped features and filled contextual gaps not captured through satellite imagery or remote mapping. All validated data were then processed and visualized using QGIS, producing high-resolution maps that highlighted damage extent, accessibility barriers, and at-risk infrastructure zones.

This ground-truthing process not only enhanced the reliability of spatial datasets but also provided critical insight into the lived realities of affected communities, supporting more informed flood resilience planning.

3.2 Data Analysis Techniques

To assess flood extent and land cover change, this study employed Landsat 8 Operational Land Imager (OLI) data, focusing on pre-flood imagery from January to May 2024 and post-flood imagery from June to December 2024. This temporal segmentation enabled the detection of flood-induced surface changes during the 2024 flood events affecting the Jakande Housing Estate.

NDWI and NDVI were calculated in QGIS to delineate water bodies and assess vegetation stress or loss, respectively. The NDWI was derived using the green and near-infrared bands, while the NDVI used the red and near-infrared bands.

The respective formulas used were:

$$NDWI = (B3 - B5)/ (B3+B5), \quad (1)$$

where B3 = Band 3 - Green
B5 = Band 5 - Near infrared
NDWI = Normalized Difference Water Index

$$NDVI = (B5 - B4)/ (B5+B4), \quad (2)$$

where B4 = Band 3 - Red
B5 = Band 5 - Near infrared
NDWI = Normalized Difference Vegetative Index

To delineate flooded areas, the continuous NDWI raster values were converted into a binary classification using a threshold-based segmentation approach. A threshold was determined by sampling NDWI values from confirmed flooded zones, with all pixels exceeding this threshold classified as "flooded" and those below as "non-flooded."

Subsequently, a buffer analysis was applied to the flood polygons to generate zones of influence. These buffer zones facilitated proximity-based analysis of infrastructure and assets at risk. Buildings, roads, and other mapped features were intersected with buffer zones to quantify exposure and identify areas with elevated vulnerability. This spatial analysis directly informed the identification of flood risk hotspots and guided the formulation of response and mitigation strategies.

This analytical workflow followed geospatial modeling practices adapted from the UN-SPIDER Knowledge Portal's recommended flood mapping methodology (UN-SPIDER, 2024).

4. Results and Discussions

4.1 Results

This study's findings are organized into three primary areas: remote sensing and land cover analysis, community mapping outputs, and ground truth validation using Open Data Kit (ODK). These components collectively provide a comprehensive understanding of flood impacts, infrastructure vulnerabilities, and the efficacy of community-driven mapping in addressing data deficiencies.

4.1.1 Remote Sensing and Land Cover Analysis: Multi-temporal analysis of Landsat satellite imagery from 2018 to 2024 revealed notable changes in land cover patterns associated with recurring flood events. Using the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI), the study identified a 25% increase in waterlogged areas during peak flood periods in 2024 compared to baseline pre-flood conditions.

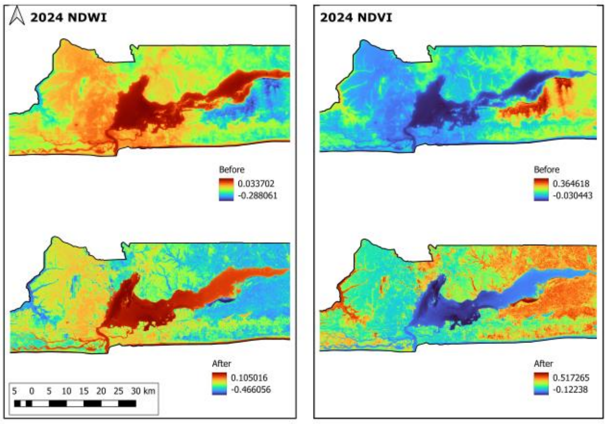

Figure 7. NDWI and NDVI outputs for part of Lagos State, based on Landsat 8 imagery.

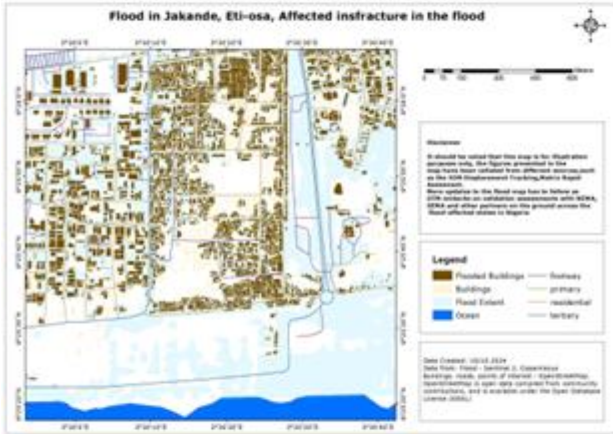

Figure 8. Map identifying infrastructure affected by flooding in Jakande Housing Estate.

The spatial expansion of inundated zones significantly encroached upon residential areas, particularly in low-lying and informally developed sectors of the estate. Areas with unpaved roadways and public-use infrastructure, such as community centers, were disproportionately impacted. Overlaying flood extent polygons with mapped infrastructure layers indicated that over 40% of residential buildings were situated within high-risk flood zones. Areas with unpaved roads and public-use buildings, such as schools and community centers, were among the most affected.

In addition to flood extent, temporal NDVI analysis over the 2018-2024 period revealed a progressive increase in impermeable surfaces, attributed largely to unregulated urban expansion. This transformation has reduced the area's natural drainage capacity and exacerbated flood risks. These findings confirm the critical role of geospatial tools in supporting real-time flood monitoring, vulnerability assessment, and early warning systems in high-risk urban environments.

4.1.2 Community Mapping Outputs: The participatory mapping campaign, coordinated via the Humanitarian OpenStreetMap Team (HOT) Tasking Manager, resulted in significant improvements in spatial data completeness for the study area. The initiative added more than 16,000 previously unmapped buildings, 30 road segments, and five community health centers to OpenStreetMap (OSM), substantially enhancing the geographic dataset available for disaster response.

Key infrastructure, including schools, clinics, police stations, and evacuation routes, was accurately digitized and attributed. Community mappers also identified obstructed drainage channels and inaccessible evacuation routes, which were geotagged and prioritized for intervention planning.

Beyond data enrichment, the process strengthened local capacity by equipping residents with practical mapping skills and raising awareness of flood vulnerability. This participatory approach demonstrated the dual benefits of enhancing both technical datasets and social preparedness.

4.1.3 Ground Truth Validation with ODK: Field validation using Open Data Kit (ODK) involved 150 structured surveys covering residential buildings, commercial properties, and public facilities. Survey results showed that 62% of residential structures in flood-prone areas sustained physical damage, while 45% of local businesses reported inventory losses due to floodwaters.

Flood depth measurements ranged from 0.5 to 1 meters, with floodwaters persisting for an average of two to four days in severely affected areas. Road accessibility assessments revealed that 70% of surveyed roads became impassable during peak flooding, limiting access to critical services such as hospitals and emergency shelters.

Qualitative feedback collected through community interviews highlighted issues including delayed evacuation procedures and the inadequacy of existing early warning systems. These insights point to significant gaps in real-time flood response and community preparedness.
The ground-truth data not only validated the findings derived from remote sensing and OSM but also added critical contextual detail. The integration of ODK-sourced data improved the robustness of the overall flood impact assessment, reinforcing the value of combining spatial and field-based methodologies in disaster risk analysis.

4.2 Discussion

This study demonstrated that combining remote sensing with participatory mapping and field-based validation improves the spatial and contextual precision of flood impact analysis in data-scarce urban environments. The use of multi-temporal satellite imagery allowed for accurate delineation of flood extents, while engagement through OpenStreetMap (OSM) helped address longstanding gaps in the spatial representation of informal settlements. Field validation using Open Data Kit (ODK) added reliability by capturing real-time, ground-level evidence of infrastructure damage and local vulnerabilities.

This integrated approach offered benefits in both technical performance and community participation. However, limitations emerged during implementation. The absence of Sentinel-2 imagery for critical time frames restricted spectral sensitivity and temporal resolution, while inconsistencies in contributor mapping, such as misaligned building geometries and incomplete feature attributes, required post-processing corrections. Physical access constraints during fieldwork also limited the comprehensiveness of the ODK survey coverage in certain zones.

These limitations suggest several directions for improvement. Future workflows could incorporate drone-based photogrammetry and higher-resolution satellite imagery to increase spatial granularity. The use of IoT-enabled water level sensors could enhance real-time flood monitoring, while predictive modeling based on historical rainfall and land use change could support early warning systems. These enhancements would further strengthen the methodology's applicability to high-risk, rapidly urbanizing areas.

4.3 Recommendation

Based on the findings of this study, the following actions are recommended for government agencies, urban planners, and disaster risk management authorities:

1. Enhance Drainage Infrastructure Upgrade and maintain stormwater drainage systems to reduce surface runoff and mitigate flooding
2. Enforce Land Use Regulations Implement and rigorously monitor compliance with zoning laws and building codes to prevent construction in flood-prone and unregulated areas
3. Improve Solid Waste Management Establish sustainable waste collection and disposal systems to prevent blockage of drainage channels and culverts
4. Establish Community-Based Early Warning Systems Deploy localized flood alert systems that combine satellite data, sensor networks, and SMS-based notifications to provide timely risk communication
5. Promote Public Awareness and Education Design continuous education and outreach programs to strengthen household-level flood preparedness and encourage proactive evacuation behavior
6. Integrate Nature-Based Solutions Apply climate-resilient urban design principles, including the preservation of wetlands, restoration of natural waterways, and installation of green infrastructure such as permeable pavements and bioswales.

5. Conclusion

This study highlights the potential of integrating open-source geospatial tools, participatory mapping, and ground-truth validation to improve flood risk assessment and preparedness in urban informal settlements. Using Jakande Housing Estate in Lagos as a case study, the research demonstrated how combining satellite-based analysis with community-sourced data can produce high-resolution, locally relevant insights into flood exposure and infrastructure vulnerability.

By bridging the gap between technical geospatial workflows and community engagement, the methodology addressed persistent challenges in data availability and spatial equity. The approach enabled the identification of risk hotspots, quantified exposure levels, and revealed institutional and social vulnerabilities.

Beyond the case study, this research offers a transferable model for urban resilience planning in other flood-prone regions of the Global South. Future work should explore enhanced remote sensing tools, real-time monitoring technologies, and predictive modeling to further support inclusive, adaptive disaster risk strategies in rapidly urbanizing environments.

References

Fazeli, H. R., Said, M. N., Amerudin, S., & Abd Rahman, M. Z., 2015. A study of volunteered geographic information (VGI) assessment methods for flood hazard mapping: A review. *Jurnal Teknologi*, 75(10).

Frontiers in Environmental Science., 2024. Vulnerability, resilience, and adaptation of Lagos coastal communities to flooding. *Frontiers in Environmental Science*, 12, Article 10087. doi/.org/10.3389/esss.2024.10087.

Goodchild, M. F., 2007. Citizens as sensors: The world of volunteered geography. *GeoJournal*, 69(4), 211–221.

GRASS Development Team., 2015. *Geographic Resources Analysis Support System (GRASS) Software, Version 6.4*. Open Source Geospatial Foundation. grass.osgeo.org (20 April 2025).

GRASS Development Team., 2017. *Geographic Resources Analysis Support System (GRASS) Software*. Open Source Geospatial Foundation. grass.osgeo.org (20 April 2025).

Grippa, T., Lennert, M., Georganos, S., & Vanhuysse, S., 2022. Leveraging open-source GIS for urban studies: A case study using QGIS and OpenStreetMap data. *Journal of Urban Technology*, 29(2), 81–99.

Haworth, B., & Bruce, E., 2015. A review of volunteered geographic information for disaster management. *Geography Compass*, 9(5), 237–250.

Haworth, B., Whittaker, J., & Bruce, E., 2018. Assessing the application and value of participatory mapping for community engagement in emergency management. *Applied Geography*, 96, 143–152. doi.org/10.1016/j.apgeog.2018.05.001.

Herfort, B., Eckle, M., de Albuquerque, J. P., & Zipf, A., 2021. Towards assessing the quality of volunteered geographic information from OpenStreetMap for disaster management. *ISPRS International Journal of Geo-Information*, 10(2), 51.

Herfort, B., Lautenbach, S., de Albuquerque, J. P., Anderson, J., & Zipf, A., 2021. The evolution of humanitarian mapping within the OpenStreetMap community. *Scientific Reports*, 11, 3037. doi.org/10.1038/s41598-021-82546-3.

Konapala, G., Kumar, S. V., & Ahmad, S. K., 2021. Exploring Sentinel-1 and Sentinel-2 diversity for flood inundation mapping using deep learning. *arXiv preprint* arXiv:2006.XXXX.

Krullikowski, C., Chow, C., Wieland, M., Martinis, S., Bauer-Marschallinger, B., Roth, F., Matgen, P., Chini, M., Hostache, R., Li, Y., & Salamon, P., 2023. Estimating ensemble likelihoods for the Sentinel-1 based Global Flood Monitoring product of the Copernicus Emergency Management Service. *arXiv preprint* arXiv:2304.12488.

Lennert, M., & GRASS Development Team., 2017. Addon i.segment.stats. In *Geographic Resources Analysis Support System (GRASS) Software, Version 7.2*. Open Source Geospatial

Foundation. grass.osgeo.org/grass7/manuals/addons/i.segment.stats (02 May 2025).

Le Cozannet, G., Salman, A. G., Rozenberg, J., Taranath, M., Licker, R., & Hallegatte, S., 2020. Can we project future exposure to urban flooding? *Nature Sustainability*, 3, 728–730. doi.org/10.1038/s41893-020-0539-0.

Misra, A., White, K., Nsutezo, S. F., Straka, W., & Lavista, J., 2024. Mapping global floods with 10 years of satellite radar data. *arXiv preprint* arXiv:2411.01411.

National Emergency Management Agency (NEMA)., 2023. *Assessment of flood incident at Jakande Estate, Lagos*. nema.gov.ng (02 May 2025).

Nguyen, T. H., Delmotte, A., Fatras, C., Kettig, P., Piacentini, A., & Ricci, S., 2021. Validation and improvement of data assimilation for flood hydrodynamic modelling using SAR imagery data. *arXiv preprint* arXiv:2109.07470.

Nielsen, O., Roberts, S., Gray, D., McPherson, A., & Hitchman, A., 2005. Hydrodynamic modelling of coastal inundation. In *MODSIM 2005 International Congress on Modelling and Simulation*.

Rajabifard, A., Mansourian, A., & Valadan Zoej, M. J., 2004. Developing spatial data infrastructures for disaster management. In *Proceedings of the 4th Global Spatial Data Infrastructure Conference*.

Sailaja Tripathy, S., Chaudhuri, S., Murtugudde, R., Mharte, V., Parmar, D., Pinto, M., Zope, P. E., Dixit, V., & Ghosh, S., 2023. Analysis of Mumbai floods in recent years with crowdsourced data. *arXiv preprint* arXiv:2306.09770.

Sliuzas, R., Flacke, J., & van Maarseveen, M., 2016. Modelling urban flood risk in developing countries: The case of Dar es Salaam. *Habitat International*, 53, 272–283. doi.org/10.1016/j.habitatint.2015.11.036.

Tarpanelli, A., Mondini, A. C., & Camici, S., 2022. Effectiveness of Sentinel-1 and Sentinel-2 for flood detection assessment in Europe. *Natural Hazards and Earth System Sciences*, 22, 2473–2489.

Tellman, B., Sullivan, J. A., Kuhn, C., Kettner, A. J., Doyle, C. S., Brakenridge, G. R., ... & Slayback, D. A., 2021. Satellite imaging reveals increased proportion of population exposed to floods. *Nature*, 596(7870), 80–86. doi.org/10.1038/s41586-021-03695-w.

Tripathy, Y. F., Brenner, C., & Sester, M., 2020. Flood severity mapping from volunteered geographic information by interpreting water level from images containing people: A case study of Hurricane Harvey. *arXiv preprint* arXiv:2006.11802.

UN-SPIDER., 2024. *Step-by-step flood mapping and damage assessment using Sentinel-2 data*. United Nations Office for Outer Space Affairs. un-spider.org (02 May 2025).

World Bank., 2010. *Natural hazards, unnatural disasters: The economics of effective prevention*. Washington, DC: World Bank. doi.org/10.1596/978-0-8213-8050-5.

World Bank., 2017. *Using participatory mapping for disaster preparedness in Jakarta*. Washington, DC: World Bank. documents.worldbank.org/en/publication/documents-reports/documentdetail/915261493797399464/using-participatory-mapping-for-disaster-preparedness-in-jakarta (10 May 2025).

Yusuf, A., 2022. Environmental security and governance challenges of flooding in Lagos State: A case study of Jakande Estate, Lekki. *LASU Journal of African Studies*, 12(2), 77–93. lasujournalofafricanstudies.org.ng/storage/publications/yusuf-1679245339.pdf (10 May 2025).

Zhao, J., Xiong, Z., & Zhu, X. X., 2024. UrbanSARFloods: Sentinel-1 SLC-based benchmark dataset for urban and open-area flood mapping. *arXiv preprint* arXiv:2406.04111.