Citizen science disaster risk geo-mapping methodology

Citizen Science for Disaster Risk Preparedness Policy Development in Kakanj, Bosnia and Herzegovina

I. Scopes and objectives of the project

The Citizen Science for Disaster Risk Preparedness Policy Development in Kakanj project aims to transform disaster risk preparedness in the municipality of Kakanj through an inclusive, data-driven citizen science approach. Over seven months, the initiative will train and engage over 100 citizen scientists—citizens from all local neighbourhoods, but primarily youth, rural residents, and members of the Roma community—in mapping disaster risks using geo-mapping tools and participatory research methods. These volunteers will work in partnership with disaster experts, researchers, local NGOs, and municipal authorities.

Together, they will co-design a risk mapping methodology, collect and analyze data on natural hazards such as flooding, landslides, industrial pollution, and earthquake vulnerability, but also man-made threats and develop an open-access risk dataset. The findings will inform policy recommendations for a local disaster risk reduction strategy, which will be formally presented to the Municipality of Kakanj. In parallel, the project will produce a scientific paper, technical mapping guidelines, and advocacy materials, all shared through EU open science platforms.

Beyond its scientific and policy contributions, the project prioritizes social impact. It fosters environmental awareness, strengthens youth leadership, and supports inclusive community participation in disaster governance. With a strong sustainability plan, it aims to evolve into a long-term platform for grassroots risk monitoring and environmental transformation in Kakanj—setting a precedent for participatory resilience planning in other municipalities.

The project is built on the citizen science approach centering on inclusive, participatory research that empowers local communities to actively contribute to disaster risk mapping and policy development in Kakanj. Rather than treating citizens as passive data providers, the project engages them as co-researchers in all phases: from co-designing the methodology and collecting geo-mapped risk data, to interpreting findings and advocating for policy change. By integrating local knowledge with scientific expertise and using open-source mapping tools, the approach fosters mutual learning, builds trust among stakeholders, and ensures that the resulting data and policies are grounded in the lived experiences of those most vulnerable to disaster risks.

II. Conceptual framework

The conceptual foundation of this project is built at the intersection of citizen science, disaster risk reduction (DRR), and participatory mapping, which together create a novel approach to strengthening local resilience in the municipality of Kakanj. Citizen science emphasizes the active involvement of non-professional scientists—citizens, communities, and youth—in knowledge production. By mobilizing residents as citizen scientists, the project democratizes the generation of disaster-related data and strengthens the legitimacy and inclusiveness of disaster preparedness strategies. This approach aligns with international DRR frameworks such as the Sendai Framework for Disaster Risk Reduction, which stresses the importance of community engagement, local knowledge, and bottom-up approaches in risk governance. In parallel, participatory mapping enables the visualization and localization of risks in ways that are accessible, empowering citizens to document hazards and vulnerabilities in their own environments. The integration of participatory methods with scientific expertise ensures that disaster risk assessments capture both technical and experiential dimensions of resilience.

The project is also directly aligned with the EU's open science principles and the IMPETUS challenge on disaster resilience. By making data, methodology, and findings openly accessible, the project fosters transparency, replicability, and knowledge sharing across Europe. Open science practices are embedded in every stage, from open-access datasets and reports to the publication of research outputs in open scientific journals. This ensures that local contributions extend beyond Kakanj, feeding into European-level resilience strategies and reinforcing a collective approach to disaster preparedness. The participatory and open-access model also empowers underrepresented groups—including youth, women, and minority populations—to shape the research agenda and influence policy outcomes.

Key concepts:

Citizen scientists are defined here as non-professional contributors—primarily youth and rural community members—who engage in data collection, observation, and analysis under a participatory and scientifically guided framework.

Disaster risk is understood as the potential loss of life, injury, or destruction of property and environment resulting from hazards combined with conditions of exposure and vulnerability.

Natural disaster risk refers to the potential for loss of life, injury, property damage, and social or economic disruption caused by natural hazards.

Man-made disaster risks refer to potential hazards resulting from human activities, negligence, or errors that can cause significant harm to people, property, or the environment.

Resilience refers to the capacity of individuals, communities, and systems to anticipate, absorb, adapt to, and recover from the impacts of hazards in a timely and efficient manner.

Vulnerability encompasses the social, economic, physical, and environmental factors that increase the susceptibility of people and assets to harm.

Categories and types of natural hazards:

1. Geological (Geophysical)

- Earthquakes
- Volcanic eruptions
- Tsunamis
- Landslides and rockfalls
- Avalanches

2. Hydrological

- Floods (river, flash, coastal, urban)
- Glacial lake outburst floods (GLOFs)
- Storm surges
- Erosion (riverbank, coastal)

3. Meteorological

- Storms (windstorms, thunderstorms, tropical cyclones, hurricanes, typhoons)
- Extreme temperature events (heatwaves, cold waves, frost)
- Hailstorms
- Lightning strikes

4. Climatological

- Droughts
- Wildfires / forest fires
- Desertification
- Long-term climate variability (e.g., El Niño, La Niña impacts)

5. Biological (natural in origin)

- Epidemics and pandemics (e.g., influenza, COVID-19)
- Vector-borne diseases (malaria, dengue, West Nile virus)
- Locust swarms and other pest infestations
- Animal and plant disease outbreaks

6. Extraterrestrial

- Meteorite impacts
- Solar flares / geomagnetic storms
- Cosmic radiation

Categories and types of man-made hazards:

1. Technological / Industrial

A. Nuclear and radiological accidents

- Nuclear power plant accidents (e.g., Chernobyl, Fukushima)
- Radiological contamination (lost radioactive sources)

B. Chemical

- Industrial chemical spills and leaks
- Toxic gas releases
- Pesticide and fertilizer accidents

C. Biological (man-made origin)

- Laboratory accidents (pathogen leaks)
- Bioterrorism (anthrax, engineered viruses)

D. Transportation accidents

- Air crashes
- Train derailments
- Maritime disasters (oil tanker spills)
- Road accidents involving hazardous materials

E. Structural failures

- Building collapses
- Dam failures
- Mining accidents

2. Environmental Degradation & Resource

- Deforestation and land degradation
- Industrial pollution (air, water, soil)
- Oil spills
- Overexploitation of natural resources (water, fisheries, minerals)
- Desertification induced by unsustainable human practices

3. Socio-Political

A. War and armed conflicts

- Conventional warfare
- Use of weapons of mass destruction (chemical, biological, nuclear)
- Insurgencies and terrorism

B. Terrorism and violent extremism

- Bombings, shootings, cyber-terrorism

C. Civil unrest

- Riots, strikes, violent protests
- Political instability leading to violence

4. Economic & Systemic

- Financial crises and economic collapse
- Food insecurity caused by market disruptions
- Energy crises (fuel shortages, blackouts)
- Supply chain disruptions

5. Cyber and Information

- Cyberattacks (hacking, ransomware, denial of service)
- Critical infrastructure disruption (power grids, hospitals, water systems)
- Disinformation and information warfare

6. Public Health & Safety (human-induced)

- Pandemics of human origin (lab leaks, poor biosafety, inadequate health systems)
- Industrial-scale food contamination
- Unsafe urbanization (slums, lack of sanitation, fire hazards)

III. Project design and approach

The project employs a participatory action research (PAR) design combined with mixed methods to ensure both scientific rigor and community ownership. Citizen scientists will be engaged in data collection using geo-mapping applications, structured surveys, participatory workshops, and visual documentation. Their insights will be complemented by scientific expertise in disaster risk management, geography, and environmental policy to produce an integrated dataset that captures both technical risk indicators and lived community experiences. Qualitative methods (focus groups, interviews, and community mapping sessions) will contextualize the spatial data, while quantitative analysis using GIS tools will allow the identification of risk zones and vulnerabilities. This methodological triangulation strengthens the reliability of the findings and ensures that they are actionable for local policy development.

Purpose of the methodology and research design

The purpose of this methodology is to establish a scientifically robust, participatory, and replicable approach for identifying, mapping, and analysing disaster and pollution risks at the municipal level through citizen science. The methodology is designed to address the absence of fine-grained, locally grounded disaster risk data in Kakanj and to bridge the gap between institutional risk assessments and citizens' lived experiences.

The research follows a participatory action research (PAR) and mixed-methods design, integrating geospatial data, qualitative community knowledge, and expert validation. Citizens are engaged not merely as data collectors, but as co-researchers involved in risk identification, documentation, validation, and interpretation. The methodology aligns with disaster risk reduction (DRR) principles, the Sendai Framework, and EU open science and FAIR data standards, ensuring both policy relevance and scientific credibility.

IV. Data sources

The methodology integrates four primary data source categories to ensure triangulation and reliability:

1 Community-generated primary data
Data collected through in-person meetings, focus groups, and site visits with residents and representatives of local neighbourhood councils (mjesne zajednice) in: Novo Naselje Bare, Plandište, Obre, Kakanj I, Kakanj II, Doboj, Vukanovići, Donji Kakanj, Mramor, and Kraljeva Sutjeska. These communities represent urban, semi-urban, and rural areas, as well as locations predominantly affected by natural hazards or industrial pollution.

2 Civil society and citizen initiative data
Data and documentation provided by organised citizen groups and activists, including Kakanj ustaje and the Foundation Atelier for Social Change (ACT), complemented by systematic mapping of publicly shared online materials related to disaster and pollution risks.

3 Youth-generated data
Geo-mapped data collected by a trained youth group from Gymnasium "Muhsin Rizvić," who subsequently trained peers and coordinated additional youth participation.

3 Secondary and reference data
Publicly available environmental information, historical records, and expert inputs from disaster risk specialists used for contextualisation and validation.

V Data collection processes

1 Participatory community mapping
In-person meetings were held with citizens, typically including presidents and members of local neighbourhood councils. These meetings combined structured discussions with on-site visits to identified risk locations. Disaster and pollution risks were visually documented through photographs and videos, supplemented by descriptive field notes and historical accounts provided by residents.

2 Civil society and activist mapping
Meetings with organised citizen groups and activists were conducted to identify priority risks and integrate previously collected documentation. Additionally, the online presence of these groups was systematically reviewed to extract relevant, verifiable risk data.

3 Youth-led geo-mapping
A group of six high-school students received training in geo-mapping and disaster risk identification. They subsequently delivered peer-to-peer training and coordinated youth data collection activities, contributing both spatial data and contextual insights.

4 Open citizen participation via digital channels

To maximise accessibility, citizens not directly involved in meetings were invited to submit geo-referenced photos, videos, and descriptions via WhatsApp, Viber, and Instagram. This multi-channel approach reduced technical barriers and expanded participation.

5 Digital data management

After assessing multiple tools, KoboToolbox was selected as the primary geo-mapping platform due to its open-source nature, mobile compatibility, and suitability for citizen-generated data. All collected data—regardless of entry channel—were standardised and entered into a central KoboToolbox database.

6 Pilot testing and refinement

The methodology was piloted through a focused mapping exercise in Novo Naselje Bare. Feedback from participants informed refinements to data categories, instructions, and submission channels before finalisation.

VI Data analysis procedures

1 Data cleaning and validation

All entries were reviewed for completeness, consistency, and spatial accuracy. Visual materials were cross-checked against location data, and duplicate or unclear entries were resolved through follow-up with contributors where possible.

2 Spatial analysis

Geo-referenced data were analysed using GIS tools to identify spatial patterns, clusters of risk, and areas of overlapping hazards. Risk layers were generated to visualise flood zones, landslide-prone areas, pollution hotspots, and infrastructure vulnerabilities.

3 Qualitative analysis and contextualisation

Qualitative inputs from focus groups, community discussions, and activist documentation were thematically analysed to contextualise spatial findings, capture historical trends, and identify locally specific vulnerability factors.

4 Triangulation and expert review

Findings were triangulated across community data, civil society inputs, youth-generated data, and expert knowledge. Disaster risk experts reviewed classifications and interpretations to ensure scientific robustness.

5 Validation and evaluation

A post-process evaluation survey confirmed a 95% stakeholder satisfaction rate, validating both the methodological approach and its outputs. Results informed final adjustments and confirmed readiness for wider application.