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Rerearch Article

Open and collaborative tools for disaster management and risk reduction

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Abstract: In recent years geo-information technologies have significant increase in various domain implementations. Such methodologies and applications are gathering more interest in aspects such as data collection, processing, analyses, and dissemination. Covering the full processing cycle, these technologies are impacting many fields, even those where traditionally there were no or few geospatial specialists. A relevant example can be the domain of Disaster Management and Risk Reduction (DMRR), where geo-information is providing powerful tools for effective management in the prevention, preparedness, response and recovery processes, which are of high interest to authorities and stakeholders. However, in certain cases, an important aspect is still under-considered - the "power of the crowd", which can bring vital knowledge and strength. Recently, also hazard specialists started to elicit the participation of citizens and to promote collaborative approaches in their mitigation strategies, whether it is for data collection (local or remotely), or to reduce the time a certain task is done, or simply to further disseminate knowledge and practices. As it is becoming a multi-field and multi-application domain, with our contribution we want to present the state of the art of the open and collaborative tools that are applied in DMRR, regardless of the hazard type, of the used platform (mobile, desktop) and the approach (remote, onsite). In addition, tools currently applied in other domains, but that can be fruitfully used also in DMMR will be included in our speech.

Keywords: Disaster Management; Risk Reduction; Hazards; Collaborative; Open; VGI.

1. Introduction

Natural and man-made hazards are often turning into hard to mitigate or control disasters which, in recent years, are with increased intensities and frequencies. As such stakeholders, local authorities and first responders usually are working together to adopt and implement the most suitable mitigation measures according to different scenarios and hazards. In reality, developing proper mitigation strategies and disaster management, as a whole, are far from being a straightforward problem. Usually, it is taken as a multi-fold problem since most of the hazard events are occurring suddenly with fast evolvement in time and changing local

conditions derailing the planned actions and making the first responders also vulnerable and not fully efficient. In other cases, problems during the preparation and response phases are mainly due to a lack of local knowledge, i.e., having complete and exhaustive knowledge of the local environment and hazard related factors.

As such lack of understanding can be considered as a drawback, in the last decade scholars are actively advocating and adopting contributions from citizens that are able to provide information and knowledge from the perspective of locals [1–2]. In fact, [1] adopted the term Volunteered Geographic Information (VGI) by which is meant the involvement of citizens (professionals and non) to contribute on volunteering basis with information (having also a spatial attribute). In the literature can be noted several suggestions where citizens can actively contribute also in the disaster domain, simply starting from data collection but also to higher level tasks as helping to identify what are the actual problems and how they can be analysed and resolved [3–4]. In specific hazard domains, can be highlighted several adoptions of the VGI, namely, for earthquakes [5–6], floods [7]. Where it is interesting to that the mentioned worked are utilizing the developments in mobile phones and Web 2.0 in the form of social networks. Fewer works can be found where citizens are contributing directly to early warning systems [8–9], building resilience [10], yet many examples of projects for crisis mapping can be found [11–12]. On the other hand, the tools that can actually be utilized by single volunteers or in a collaborative manner in the disaster domain are scarce. In the rest of this paper, we would like to discuss and present the tools that are either focused on a specific hazard or in general, but also such that are not developed for the disaster domain, yet still can be useful. Firstly, will be presented few desktop solutions, followed by mobile tools.

2. Desktop collaborative tools

2.1. OpenStreetMap

OpenStreetMap (OSM) is probably one of the most extensive and effective crowdsourced projects [13] in the geospatial domain. OSM is bringing a street-level spatial data globally and it is mainly relying on volunteers for providing up-to-date and accurate information (~≈8.3 mil registered users by the beginning of 2022 [14]). Single features are mapped through nodes, while linear and areal features are in contained as a list of nodes, named ways. More than just adding map elements users can also add attribute information to them using key = value predefined schema, for example, highway = motorway defines major divided road equivalent to freeway or autobahn.

Even though, OSM was not established as a disaster management project it finds great applicability mainly due to the fact that can be used as a two-way hub for providing valuable spatial information. One way could be defined only as data exploitation, meaning that everyone can access, browse and obtain the already available data, therefore, not just to look at it but also to import it in their environment for processing and analysing spatial data. Where the second way, is actually giving the possibility to the user for contributing to the global map with the matic-specific data, usually organized in collaborative campaigns. Below will be presented tools that can be used in the disaster domain in both data exploitation also in data contribution manner.

2.2. InaSAFE

InaSAFE is a software that allows the users to combine datasets from different sources like scientists, local governments and communities to produce hazard scenarios that can be used for planning, preparedness and response activities. It is developed as a Free and Open Source Software (FOSS) plugin for QGIS [15]. In such way the licensing allows the user not only to use it for free but also to contribute to its improvement and to adapt it according to the needs.

At its core, InaSAFE relies on the information available at OSM, in case it is not provided addition from the user. However, it is required to provide minimum specific information

according to the type of hazard under consideration. For example, if the case is to estimate the numbers of building exposed to a certain flooding event it is needed to input a flood depth layer after the inundation and the building can be directly downloaded from OSM (if mapped). A similar example can be seen on Figure 1 where is reported a possible affected population for the Bengawan Solo flood.

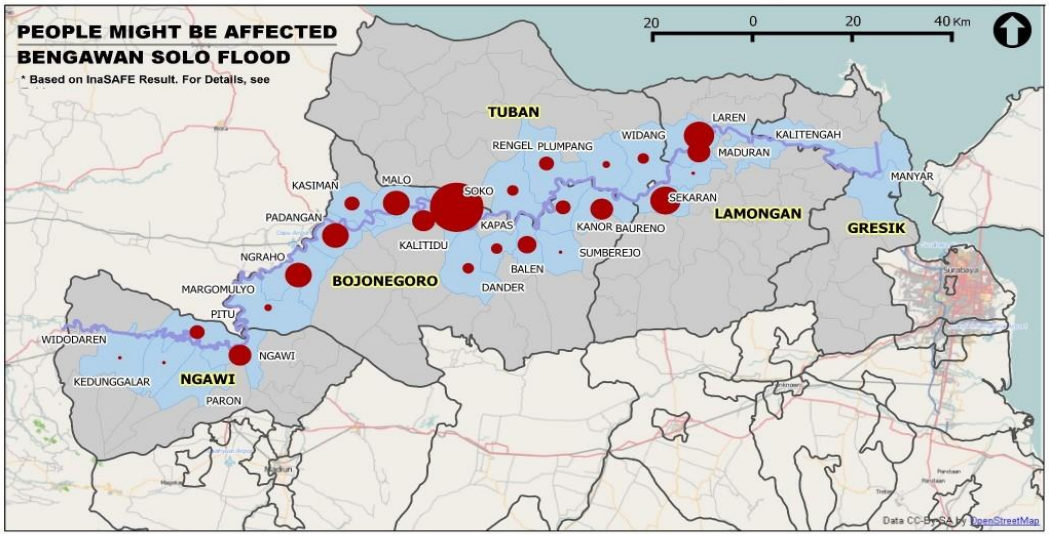

Figure 1. InaSAFE for Bengawan solo flood contingency plan, Institution: BPBD Jawa Timur (via inasafe.org).

2.3. Humanitarian OSM Team

The HOT is not a tool in the scope of this work, however their work is closely related to developing FOSS tools for supporting disaster management, therefore will be briefly introduced. The work of the team is entirely based on the collaborative principle, as their work is focused on open mapping for humanitarian actions and community development. The HOT actions are based on the work of international volunteers which are contributing either remotely or in the field with spatial data and information pre- and post-events. Their main tool of use is the OSM, however, they are dedicated also into developing FOSS tools. Two of the tools will be discussed below.

2.4. Tasking Manager

The role of the Tasking Manager is to breakdown larger mapping projects into small and feasible tasks that can be completed in a collaborative manner in a short time. The goal of the task (e.g., map buildings) is predefined and each user can contribute depending on the own level of expertise. Subdividing into smaller projects allows easier managing and monitoring of the overall aim.

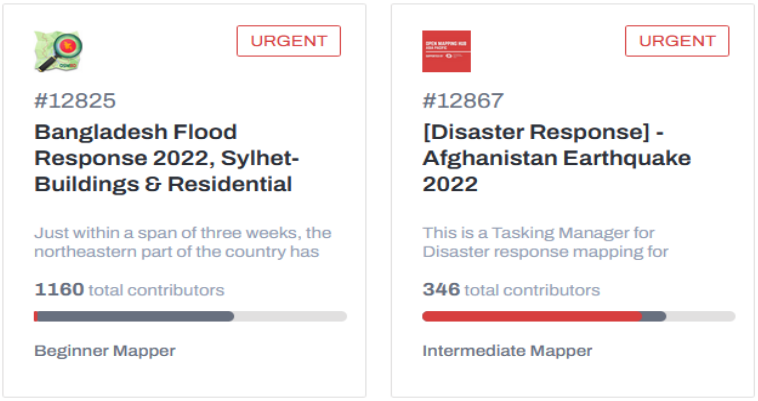

Figure 2. Example of mapping task with different expertise levels.

2.5. OpenAerialMap

OpenAerialMap is another tool developed by HOT which serves as a platform to host aerial imagery (from satellites or unmanned aerial vehicles) where every user can obtain or contribute freely. The general goal is to be a hub for high-resolution imagery that can be useful during disaster preparedness and response. Currently (at the time of writing), the platform collects more than 11,000 images from almost 1,000 contributors, and the spatial resolution of the images can vary from a few centimetres to a bit more than 10 cm.

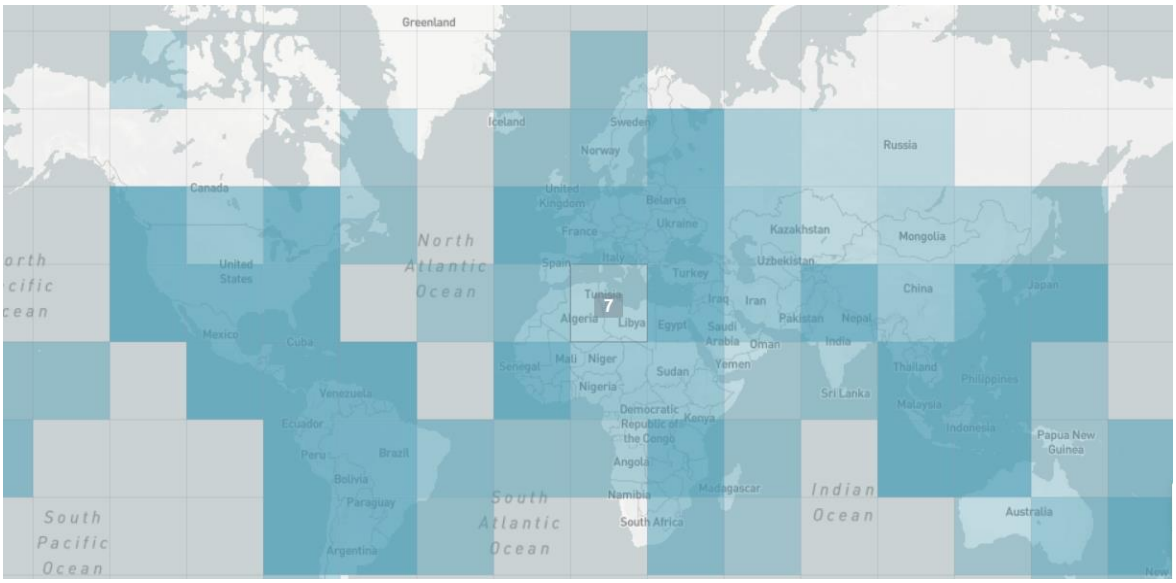

Figure 1. Global map of aerial collections. Colour tiles represent the number of images in it (dark blue means more collections).

3. Mobile tools

Nowadays smartphones and tablets are used by millions of people and with their expansions scholars and practitioners adopted another aspect for VGI contribution - by the means of portable devices, citizen can now be used as “sensors”, i.e., actively or passively to provide valuable geospatial information [16]. The “active” contribution is when the citizen knowingly is providing information using a dedicated application, on the other hand, “passive” is referred when the citizen is sharing an information (e.g., social media publication) but it has an added value to a specific field. Below will be discussed two mobile applications, where the first one is for generic data collection, still can be used for risk reduction actions, while the second is a hazard specific.

3.1. QField

QField is a data collection app also built under the FOSS license. Users are allowed to manage the data by adding and editing spatial and non-spatial data. One of the main advantages of the application is that it hides in itself all the potential of QGIS by using the same QGIS libraries, but it is developed for Android and allows portability. In fact, QField can sync with QGIS and transfer pre-configured projects. The application utilizes the built-in GPS module for positioning the user and can be easily integrated with WebGIS developing system. The data collection form can be created according to the needs of the survey and can be implemented for a variety of case studies (e.g., river monitoring, geological mapping, infrastructure assessment, etc.).

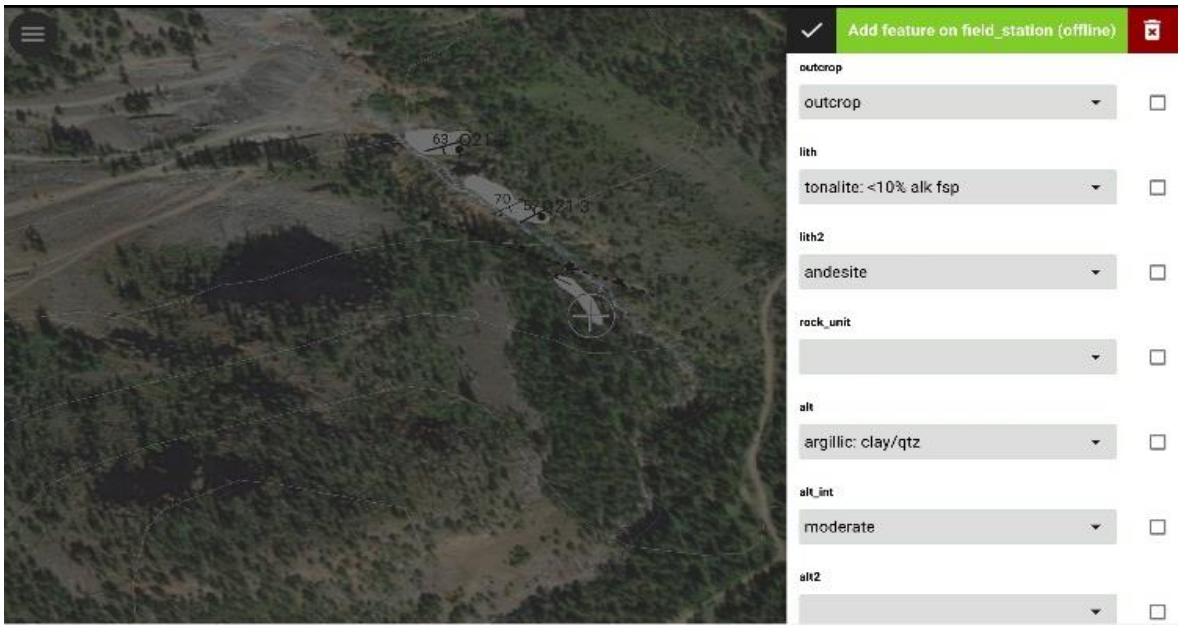

Figure 2. Example of form for geological mapping (via qfield.org).

3.2. Landslide Survey

LandslideSurvey mobile application was developed for thematic data collection, i.e., collection of the location and related information for landslides. The main goal of it is to provide the tool for easy and multi-source landslide inventory compiling. In fact, by design choice the mobile application does not show the mapped records from other users, this was made following the assumption that redundant data can help in validating entries, but also can contribute with additional information. The application is designed according to the proficiency level of the user into the topic (professional and non). Accordingly, the user interface guides through the compiling process of each entry, following a standard geological questionnaire. At a minimum the user should provide the type of the landslide and a photo of it, the application stores the location of the phone through a built-in positioning module. Once the record is saved, the application syncs with the server and in cases the smartphone is not connected to internet service, it syncs once online.

As a complementary to the app has been developed a LandslideSurvey plugin for QGIS, which allows the user to download locally the information from the server (including location and related information). A simple LandslideSurvey WebApp was also developed which allows the user to browse online the landslide records and explore simple statistics related to them.

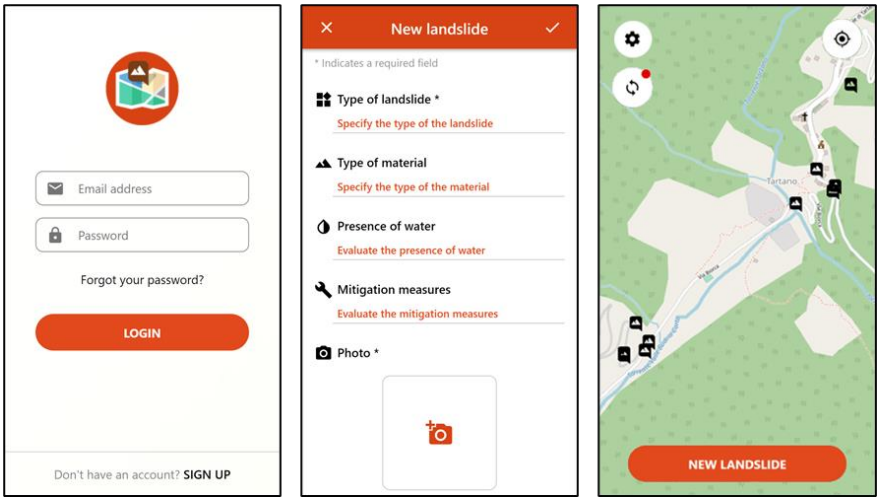

Figure 3. Screenshots from the LandslideSurvey Mobile App.

4. Conclusions

In this work, we have discussed some of the tools that can be used in Disaster Management and Risk Reduction actions in an open and collaborative manner. As it can be noted most of the tools are actually relying on OpenStreetMap which is perhaps the best example of open and collaborative effort in the geospatial domain. Based on its success is possible to derive additional tools and products that are specifically applicable for better development of hazard preparedness and response plans. Throughout the research phase for this contribution were noted other tools in the scientific literature. Mostly those tools could not be actually found or tested, which highlighted a problem related to the lack of maintenance of a product after the project end. However, during a full cycle for DMRR actions the volunteering contribution of citizens is always adding value with insights and information which, with certainty, will lead to more and new tools, applications that will be able to improve the activities related to planning, preparedness and response to hazards.

Author contribution statement:

Conceived and designed: V.Y., M.A.B., T.T.T.P.; Analyzed and interpret the data: V.Y., T.D.K.; Manuscript editing add: V.Y., M.A.B., X.Q.T.; Wrote the draft: V.Y., M.A.B.; Reviewer and edit: V.Y., M.A.B.

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References

1. Goodchild, M.F. Citizens as sensors: the world of volunteered geography. *GeoJournal* **2007**, *69*, 211–221. https://doi.org/10.1007/s10708-007-9111-y.
2. Glantz, M.H.; Ramírez, I.J. Improvisation in the time of disaster. *Environ.: Sci. Policy Sustainable Dev.* **2018**, *60*, 4–17. https://doi.org/10.1080/00139157.2018.1495496.
3. Haklay, M. Citizen science and volunteered geographic information: Overview and typology of participation. In: Sui D., Elwood S., Goodchild M. (eds) Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice. Springer Netherlands, Dordrecht, **2013**, pp. 105–122.
4. Kocaman, S.; Gokceoglu, C. Possible contributions of citizen science for landslide hazard assessment. *Int. Arch. Photogramm Remote Sens. Spatial Inf. Sci.* **2018**, *XLII-3/W4*, 295–300. https://doi.org/10.5194/isprs-archives-XLII-3-W4-295-2018.
5. Earle, P. Earthquake Twitter. *Nat. Geosci.* **2010**, *3*, 221–222. https://doi.org/10.1038/ngeo832.
6. Shan, W.; Feng, J.; Chang, J.; Yang, F.; Li, Z. Collecting earthquake disaster area information using smart phone. Proceeding of the 2012 International Conference on System Science and Engineering (ICSSE), **2012**, pp. 310–314. https://doi.org/10.1109/ICSSE.2012.6257197.
7. Kouadio, S.; Douvinet, J. A smartphone application to help alert in case of flash floods. Proceeding of the 2015 2nd International Conference on Information and Communication Technologies for Disaster Management (ICT - DM), **2015**, pp. 252–257.
8. Marchezini, V.; Trajber, R.; Olivato D.; Muñoz, V.A.; de Oliveira Pereira, F.; Luz, A.E.O. Participatory early warning systems: Youth, citizen science and Intergenerational dialogues on disaster risk reduction in Brazil. *Int. J. Disaster Risk*

Sci. **2017**, *8*, 390–401. https://doi.org/10.1007/s13753-017-0150-9.
9. Marchezini, V.; Horita, F.E.A.; Matsuo, P.M.; Trajber, R.; Trẹo-Rangel, M.A.; Olivato, D. A review of studies on participatory early warning systems (P-EWS): Pathways to support citizen science initiatives. *Front Earth Sci*. **2018**, *6*, 184. https://doi.org/10.3389/feart.2018.00184.
10. Cieslik, K.; Shakya, P.; Uprety, M.; Dewulf, A.; Russell, C.; Clark, J.; Dhital, M.R.; Dhakal, A. Building resilience to chronic landslide hazard through citizen science. *Front Earth Sci* **2019**, *7*, 278. https://doi.org/10.3389/feart.2019.00278.
11. Norheim-Hagtun, I.; Meier, P. Crowdsourcing for crisis mapping in Haiti. *Innovations: Technol. Governance Globalization* **2010**, *5(4)*, 81–89, https://doi.org/10.1162/INOV_a_00046.
12. Humanitarian open street map team. Online available: https://www.hotosm.org/. (Accessed 15-July-2022).
13. Haklay, M.; Weber, P. Open street map: User-generated street maps. *IEEE Pervasive Comput.* **2008**, *7*, 12–18. https://doi.org/10.1109/MPRV.2008.80.
14. Stats - Open street map Wiki. Online available: https://wiki.openstreetmap.org/wiki/Stats. (Accessed 15-July-2022).
15. QGIS development team. QGIS Geographic Information System. Open source geospatial foundation Project, 2020. http://qgis.osgeo.org. Qgisorg.
16. Yordanov, V.; Biagi, L.; Truong X.Q.; Tran, V.A.; Brovelli, M.A. An overview of geoinformatics state-of-the-art techniques for landslide monitoring and mapping. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.* **2021**, *XLVI-4/W2-2021*, 205–212.