Mapping Community Resources For Disaster Preparedness

Humanitarian data capability and automated futures

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ADM+S

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ACKNOWLEDGEMENT OF COUNTRY

In the spirit of reconciliation, we acknowledge the Traditional Custodians of Country throughout Australia and their connections to land, sea and community. We pay our respects to their Elders past and present and extend that respect to all Aboriginal and Torres Strait Islander peoples today.

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CONTENTS

PROJECT BRIEF

Context. This report details the rationale, background research and design for a platform to help local communities map resources for disaster preparedness. It sets out a first step in improving community data capability through resource mapping to enhance humanitarian action before disaster events occur.

The project is a collaboration between the Swinburne node of the ARC Centre of Excellence for Automated Decision-Making and Society (ADM+S) and Australian Red Cross. It contributes to the ADM+S Centre's workstream on reconfiguring data practices for responsible, ethical and inclusive ADM and data futures. For humanitarian organisations, this work offers the chance to consider tools for improving data-driven decision-making as a process of community-oriented disaster preparedness.

The problem. The project seeks to enable local community disaster preparedness and thus build community resilience by improving the quality of data about community strengths, resources and assets.

Proposition. Disaster preparedness can be enhanced through improved data practices targeting community *resources* and rural and remote communities at risk of natural disasters such as bushfires, floods, heatwaves and severe storms. The work will complement the predominant focus on mapping risks, hazards, vulnerabilities and impact zones, following IFRC initiatives in enabling community resilience. And it aims to generate new ways of volunteering and acting locally toward disaster preparedness.

Knowledge and practice review. In this report, we define a gap in existing humanitarian mapping and the use of open, public and social media data in humanitarian contexts. We survey current knowledge and present a selection of case studies delivering data and humanitarian mapping in local communities.

Drawing on this knowledge and practice review and stakeholder workshops throughout 2021, we define a method and toolkit for the effective use of community assets data.

Design. Embedded in a 'resilient communities' framework and ethos, we introduce an open platform to enable **community resource mapping** for disaster preparedness. This approach shows how to build data capability through community-oriented collaborative data action and involves the following steps:

> **Step 1.** Identify useful datasets representing local community assets—people, groups, services, infrastructure, local knowledge, events and activities
>
> **Step 2.** Establish a pipeline for responsible, ethical and inclusive data preparation, analytics and visualisation
>
> **Step 3.** Explore and test the feasibility of an open platform and dashboard to assist community asset mapping
>
> **Step 4.** Conduct usability testing, e.g., within the project reference group and with community members

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DEFINING THE PROBLEM, FRAMING SOLUTIONS

DEFINING THE PROBLEM

Lack of data, poor data access and low-quality community-level data—particularly in emergency-prone rural and regional areas in Australia—continue to hamper emergency preparedness and response.

During scoping workshops for this project, we spoke with data professionals in Australian Red Cross, CSIRO and Seer Analytics, a community analytics organisation. It became clear that, while this problem is not new, only minor gains have been made for emergency preparedness after more than a decade of advances in humanitarian mapping and crisis data analytics. Local knowledge and community data used effectively to *respond* to emergencies are often through makeshift practices with simple technologies like shared spreadsheets and Facebook groups.

Informal, local sources of information and knowledge have been vital to emergency responses in rural and isolated small communities prone to bushfire, flooding, heat and storm damage. Their importance was evident in the response to bushfires across southern New South Wales and Victoria in 2019–2020 and during 2022 floods in Queensland and Lismore. In Lismore, residents took it upon themselves to identify social media posts from people pleading for help as waters rose with collated addresses made available through a public Google spreadsheet to coordinate local rescuers with boats.[1]

To date, these resources—people, expertise, equipment, spaces—have not been the focus of humanitarian mapping work to improve preparedness. Despite this, since mobile and social media have changed how we communicate, the problem of activating and supporting the sharing of local knowledge and information in times of need has been the focus of much digital humanitarian innovation.[2] How to better enable communities before disaster remains an open question and opportunity.

Problems in data selection, gathering, sharing, analysis and communication are the focus of this project. After the devastating 2019–2020 fires in southern NSW and Victoria, the 2020–2021 *Royal Commission into National Natural Disaster Arrangements* report emphasised the need for stronger 'knowledge, data and information to be shared, consistent and up to date'.[3] The Commission emphasised that disaster management begins before the crisis phases of a disaster and continues well after.

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[1] Tim Swanston (2022) How a spreadsheet became a lifesaver in Lismore's flood crisis. ABC News, 6 March. Available at: https://www.abc.net.au/news/2022-03-06/nsw-floods-how-a-spreadsheet-became-lifesaver-in-lismore/100885054.

[2] McCosker, A., Kamstra, P., De Cotta, T., Farmer, J., Shaw, F., Teh, Z., & Soltani Panah, A. (2021). Social media for social good? A thematic, spatial and visual analysis of humanitarian action on Instagram. *Information, Communication & Society*, *24*(13), 1870-1890.

[3] Commonwealth of Australia. (2020). *Royal Commission into National Natural Disaster Arrangements*. https://naturaldisaster.royalcommission.gov.au/publications/royal-commission-national-natural-disaster-arrangements-report p. 111.

Similarly, the Federal Government's *Australian Data Strategy Action Plan*[4] highlights the Commission's recommendations for improved data sharing. In addition to planning a strategy for ensuring better data-sharing practices, the Plan acknowledges the work of the National Recovery and Resilience Agency and Emergency Management Australia in achieving these goals.

Disaster management authorities, agencies and aid organisations have a role to play here, but so do people in their local communities. Crowdsourcing, open data and open mapping have shown potential in emergency contexts. However, a review of the evolution of humanitarian mapping leader OpenStreetMap noted the ongoing 'need to address the stark data inequalities' that exist across countries, regions and areas of humanitarian need.[5] Humanitarian mapping has moved in two main directions:

- Open, crowdsourced and public data mapping has shown promise in disaster response scenarios and identifying risks but is restricted by lack of resourcing and uncertainty about data access and rights.
- Commercial mapping and analytics have developed to incorporate remote sensing and satellite imaging and increasingly deploy machine learning to offer sophisticated predictive capability, but at a cost, with restricted access and often a narrow focus on risk and predictive modelling.

Questions remain about how to better connect authorities and aid organisations with needs and resources on the ground in local communities and how to help those communities prepare rather than just respond to a disaster.

Our workshop discussions pointed out the lack of community-level data in areas most at risk, which mostly tend to be underserved by useful data analytics. Open data exchanges and disaster mapping have evolved to serve emergency services agencies well during or after events but are rarely designed to help communities prepare or build resilience.[6] The target needs to shift to enabling effective community preparedness through data action. The core challenges are:

1) **Identifying relevant resources and data** (e.g., people, groups, services, infrastructure, local knowledge, events and activities) that can help build resilient communities
2) **Processing resource data** (e.g., by sifting, classifying, taxonomising and visualising or mapping) in ways that can inform and improve community action for preparedness
3) **Building data capability** to better connect aid organisations and emergency service agencies with people and organisations in local communities.

[4] Department of Prime Minister and Cabinet (2021) Australian Data Strategy Action Plan, available at: https://ausdatastrategy.pmc.gov.au/
[5] 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), 1-15.
[6] Potts, L. (2013). *Social media in disaster response: How experience architects can build for participation*. Routledge.

FRAMING THE SOLUTION

This project aims to address the following three challenges:

1) **Challenge 1**. Identifying resources and data: we test a new approach to identifying, connecting and mapping community resources (e.g., people, groups, services, infrastructure, local knowledge, events and activities) to support disaster preparedness and community resilience.
2) **Challenge 2**. Processing community resources data: we establish and test key elements of a framework and platform for improving inclusive, open, collaborative and community-centric data practices.
3) **Challenge 3**. Building data capability: we propose a method of foregrounding and expanding local knowledge and information about community resources that can be undertaken with communities as preparedness and resilience-building processes.

We combine existing best practices and knowledge to establish a methodology that will identify data about local resources and data generated by communities. Their local knowledge and information about resources can help improve disaster preparedness. In this approach:

> **Local community data** is defined as (a) people, groups, services, infrastructure and (b) data produced by local people, groups and organisations (local knowledge, events and activities).

In other words, the solution to the problem of data scarcity in local communities is to enable community data capability and action. Community data action is any localised approach to gathering, processing and sharing data about local knowledge and resources that can inform preparedness work, generate community connection and contribute to building community resilience.

The International Federation of Red Cross and Red Crescent Societies (IFRC) has established a Road Map to Community Resilience to operationalise its Framework for Community Resilience (FCR). The Framework **defines community resilience** as:

> The ability of communities (and their members) exposed to disasters, crises and underlying vulnerabilities to anticipate, prepare for, reduce the impact of, cope with and recover from the effects of shocks and stresses without compromising their long-term prospects.[7]

As a strengths-based and proactive approach, the IFRC's FCR establishes new targets for generating and using data to address disaster preparedness. Filling data gaps through local community effort is about helping diverse community members to engage, understand their strengths and facilitate action.

This approach aligns with shifts in IFRC strategy in recent years. For humanitarian organisations like Australian Red Cross, the question of how to better connect with

[7] IFRC (2016). Road map to community resilience: Operationalizing the Framework for Community Resilience, Geneva, page 5. https://www.ifrc.org/sites/default/files/1310403-Road-Map-to-Community-Resilience-Final-Version_EN-08.pdf

local communities before and after disasters is increasingly bound up in data and information access issues with strong local participation.

Community involvement in disaster preparedness and response has been a consistent policy priority for addressing risks and emergencies, with numerous community resilience policies developed through local governments across Australia.

In a complicated digital media environment, new analytics capabilities can improve the role and effectiveness of aid organisations and agencies in building community resilience, expanding volunteer networks, building preparedness and ultimately informing rapid response.

A focus on preparedness[8]—as opposed to disaster management—necessitates the development of new and innovative tools and practices. This development requires involvement and meaningful participation from people in affected locations, with an approach to humanitarian technologies that is community-centric rather than data-centric.[9]

The following review of research and practice explores existing data-driven approaches to disaster response and preparedness, drawing insights from the research field and some useful case studies. The review identifies useful community-centred data and mapping strategies that can inform a new approach to resource mapping for disaster preparedness.

The final section, '**A Community Resource Mapping Platform'**, details the methods and practicalities for implementing this approach.

[8] Staupe-Delgado, R., & Kruke, B. I. (2018). Preparedness: Unpacking and clarifying the concept. *Journal of Contingencies and Crisis Management*, *26*(2), 212–224. https://doi.org/10.1111/1468-5973.12175

[9] Baudoin, M. A., Henly-Shepard, S., Fernando, N., Sitati, A., & Zommers, Z. (2016). From top-down to "community-centric" approaches to early warning systems: Exploring pathways to improve disaster risk reduction through community participation. *International Journal of Disaster Risk Science*, *7*(2), 163-174. Novak, J.M., Day, A.M., Sopory, P., Wilkins, L., Padgett, D., Eckert, S., Noyes, J., Allen, T., Alexander, N., Vanderford, M. and Gamhewage, G., 2019. Engaging communities in emergency risk and crisis communication: A systematic review and evidence synthesis. *Journal of International Crisis and Risk Communication Research*, *2*(1), pp.61-96. 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.

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HUMANITARIAN DATA: Knowledge and practice review

KNOWLEDGE AND PRACTICE REVIEW

Techniques and technologies for generating, curating and visualising or mapping digital data to aid humanitarian efforts have significantly improved in the last decade. To inform our project, we reviewed existing approaches to using data to improve disaster response and preparedness in international research and practice. This review forms a knowledge base to help shape new innovative approaches and understand the evolving role of data, automation and advanced analytics in improving community responses to disaster risks and events. It incorporates research and practical applications that have used digital data in disaster prediction, mitigation and preparedness.

Big data has brought opportunities to improve logistics in disaster relief[10] through data extracted from digital platforms and interaction with services, sensor data, drones and other automated machines and systems combined with new data analysis techniques. Although the research sector has proposed various technical developments in using big data,[11] it has not replicated or implemented them in local communities, especially to aid preparedness.

While much of the work to date has focused on predicting risk and assessing vulnerabilities, disaster management increasingly focuses on preparedness or 'anticipatory action'.[12] However, challenges remain in connecting data to communities and sharing data within communities. Moreover, communities vary in their ability to respond to a disaster at the community level,[13] with responses depending on the existence of local organisations that represent the needs of those impacted.[14]

When technologies and data-driven tools for disaster response are community-centred and inclusive, they are understood to yield greater community investment.[15] Working with community-level data also involves building trust, local knowledge and capability.[16]

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[10] Gupta, S., Altay, N., & Luo, Z. (2019). Big data in humanitarian supply chain management: A review and further research directions. *Annals of Operations Research*, *283*(1), 1153-1173. Sharma, P., & Joshi, A. (2019). Challenges of using big data for humanitarian relief: lessons from the literature. *Journal of Humanitarian Logistics and Supply Chain Management*.

[11] Fadiya, S. O., Saydam, S., & Zira, V. V. (2014). Advancing big data for humanitarian needs. *Procedia Engineering*, *78*, 88-95. Akter, S., & Wamba, S. F. (2019). Big data and disaster management: a systematic review and agenda for future research. *Annals of Operations Research*, *283*(1), 939-959. Freeman, J.D., Blacker, B., Hatt, G., Tan, S., Ratcliff, J., Woolf, T.B., Tower, C. and Barnett, D.J., 2019. Use of big data and information and communications technology in disasters: an integrative review. *Disaster medicine and public health preparedness*, *13*(2), pp.353-367.

[12] Tozier de la Poterie, A., Clatworthy, Y., Easton-Calabria, E., Coughlan de Perez, E., Lux, S., & van Aalst, M. (2021). Managing multiple hazards: lessons from anticipatory humanitarian action for climate disasters during COVID-19. *Climate and Development*, 1-15.

[13] *Community Based Emergency Management*. (2016). Emergency Management Victoria. https://files.emv.vic.gov.au/2021-08/Community-Based-Emergency-Management-Overview.pdf

[14] Satterthwaite, D. (2011). Editorial: Why is community action needed for disaster risk reduction and climate change adaptation? *Environment and Urbanization*, *23*(2), 339–349. https://doi.org/10.1177/0956247811420009

[15] Kenney, C. M., & Phibbs, S. (2015). A Māori love story: Community-led disaster management in response to the Ōtautahi (Christchurch) earthquakes as a framework for action. International Journal of Disaster Risk Reduction, 14, 46-55.

[16] Kazansky, B. (2021). 'It depends on your threat model': the anticipatory dimensions of resistance to data-driven surveillance. *Big Data & Society*, 8(1), 2053951720985557.

Diverse public participation contributes to better addressing vulnerabilities to environmental hazards and disasters.[17]

We emphasise that local community connectedness and resilience initiatives can address vulnerabilities more effectively than situational awareness, based on crisis or forecast data extraction without community links, by focusing on existing resources and cooperation within local communities.

Below, we examine some broad themes of data for humanitarian action in existing research on disaster management. This review is interspersed with several practical data mapping and community response case study scenarios.

HUMANITARIAN DATA PORTALS, COMMONS AND EXCHANGES

- What are some of the exemplary, useful open-access portals for data to aid humanitarian action and response, and how are these data portals used?

Research on disaster risk often relies heavily on scientific data.[18] Although applications change with technological advances, Australia has well-developed datasets mapping hazards across the nation's diverse geographies, from local government levels[19] through to Australia's National Disaster Risk Reduction Framework (NDRRF), which was co-designed to support action across sectors at national, state and local levels, including the generation of data and analysis to aid risk assessment and reduction.

Emerging Australian initiatives to support the establishment and interoperability of disaster management datasets, such as the Bushfire Data Commons,[20] demonstrate domestic demand for integrating information and enabling greater usability. The Australian Research Data Commons (ARDC), an agency that provides Australian research infrastructure, is developing the Bushfire Data Commons with partners to map past fire paths and burn history, use remote sensing for information about bushfire fuel, build a platform for modelling fire behaviour and share data between agencies. Some social and community-led data could be structured in ways compatible with the commons as it is developed.

International commons initiatives exist for humanitarian data, most notably the UN-affiliated Humanitarian Data Exchange (humdata.org), but this is seldom used in the Australian context. A key aspect of managing and building effective data exchanges and

[17] Forino, G., von Meding, J., Brewer, G., & Van Niekerk, D. (2017). Climate change adaptation and disaster risk reduction integration: strategies, policies, and plans in three Australian local governments. *International journal of disaster risk reduction*, 24, 100-108.
[18] Li, G., Zhao, J., Murray, V., Song, C., & Zhang, L. (2019). Gap analysis on open data interconnectivity for disaster risk research. Geo-Spatial Information Science, 22(1), 45-58.
[19] Forino, G., von Meding, J., Brewer, G., & Van Niekerk, D. (2017). Climate change adaptation and disaster risk reduction integration: strategies, policies, and plans in three Australian local governments. *International journal of disaster risk reduction*, *24*, 100-108.
[20] https://ardc.edu.au/collaborations/strategic-activities/translational-research-data-challenges/bushfire-data-challenges/

portals is ensuring that datasets are privacy-protective, non-proprietary, structured and formatted for sharing and portability.

Where data portals have been deemed successful, they are built on key principles. These include 1) using open-source and standards-compliant software, 2) leveraging existing collaborative software initiatives, 3) ensuring flexibility in the system to allow for data from various sources, 4) ensuring tools are fast, intuitive and easy to use, and 5) using cloud-based software to ensure portability.[21]

Some have raised the important distinction between the proliferation of open data portals and exchanges that provide access to data and 'support for effective data use', hinting at some limitations in open humanitarian data projects. Further, datasets can present accessibility challenges. Some data may be buried in inaccessible document formats, such as PDFs, from which data must be extracted before use.

Localised social data are often omitted or considered unreliable for predictive or preparedness purposes due to this data being 'unstructured and not easy to use'.[22] Therefore, even when accessible to affected communities, risk mapping based on environmental and infrastructural data is rarely integrated with local sources of information or community-generated social data.

MAPPING CRISES, RISKS AND VULNERABILITIES

- How have open data and crisis mapping helped to involve communities in disaster preparedness?
- What are the strengths and limitations in how open and crowdsourced data and open mapping have been used to respond to disasters?

Going by various names—humanitarian mapping, open maps, crisis or disaster mapping—location-specific data has been gathered and aggregated for over a decade to enhance situational awareness,[23] monitor and predict crisis and disaster and map everyday humanitarian action.[24] Some of the earliest breakthroughs in digital humanitarian efforts came from open-source mapping tools.[25] Ushahidi.com and OpenStreetMap.org revolutionised disaster response, bringing local knowledge

[21] Dahlhaus, P., Murphy, A., MacLeod, A., Thompson, H., McKenna, K., & Ollerenshaw, A. (2016). Making the invisible visible: the impact of federating groundwater data in Victoria, Australia. Journal of Hydroinformatics, 18(2), 238-255.
[22] Li, G., Zhao, J., Murray, V., Song, C., & Zhang, L. (2019). Gap analysis on open data interconnectivity for disaster risk research. Geo-Spatial Information Science, 22(1), 45-58.
[23] Middleton, S. E., Middleton, L., & Modafferi, S. (2013). Real-time crisis mapping of natural disasters using social media. *IEEE Intelligent Systems*, *29*(2), 9-17. Herfort, B., Albuquerque, J. P. D., Schelhorn, S. J., & Zipf, A. (2014). Exploring the geographical relations between social media and flood phenomena to improve situational awareness. In *Connecting a digital Europe through location and place* (pp. 55-71). Springer.
[24] McCosker, A., Kamstra, P., De Cotta, T., Farmer, J., Shaw, F., Teh, Z., & Soltani Panah, A. (2021). Social media for social good? A thematic, spatial and visual analysis of humanitarian action on Instagram. *Information, Communication & Society*, *24*(13), 1870-1890.
[25] Gutiérrez, M. (2018). Crowdsourcing and Mapping Data for Humanitarianism. In M. Gutiérrez, *Data Activism and Social Change* (pp. 107–136). Springer International Publishing. https://doi.org/10.1007/978-3-319-78319-2_4

together on an open and accessible map in real time and triggering and facilitating on-the-ground practical action.[26]

Developments in the technologies and techniques have followed major collaborative work across many contexts. This approach continues to play a role in filling data gaps in areas affected by disaster risks.[27] Crisis mapping has sought to capitalise on geolocated, crowdsourced open information to aid humanitarian action. The value of the crisis map is its ability to 'connect the crowd to itself'.[28]

Many open-source mapping projects follow a 'citizen science' or crowdsourcing model of using local knowledge and interest for participation in data gathering and analysis.[29] When these approaches focus on informing preparedness, they can include important data capability development and learning processes.[30] Improving the ability of local communities to contribute to data collection and analysis adds another layer to the role open-source mapping can play in supporting community resilience.

In contrast to documenting local knowledge, the international Missing Maps project[31] involves remote volunteers updating OpenStreetMap by tracing or documenting observations from satellite imagery. It sometimes occurs at the acute phase of crises and sometimes as anticipatory action to update maps of impacted or vulnerable areas to support aid and response work. These processes help improve information during a disaster or before it is needed.

Such collaborative mapping is combined with other forms of expertise and data, such as water monitoring, to enhance situational awareness before and during disasters.[32] These are good examples of how self-organising informal volunteers can contribute to emergency response and community resilience initiatives.[33]

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[26] Pánek, J., Marek, L., Pászto, V., & Valůch, J. (2017). The Crisis Map of the Czech Republic: The nationwide deployment of an Ushahidi application for disasters. *Disasters*, *41*(4), 649-671. https://doi.org/10.1111/disa.12221

[27] 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

[28] Ziemke, J. (2012). Crisis Mapping: The Construction of a New Interdisciplinary Field? *Journal of Map & Geography Libraries*, *8*(2), 101–117. https://doi.org/10.1080/15420353.2012.662471

[29] Parajuli, B. P., Khadka, P., Baskota, P., Shakya, P., Liu, W., Pudasaini, U., ... & Vij, S. (2020). An open data and citizen science approach to building resilience to natural hazards in a data-scarce remote mountainous part of Nepal. *Sustainability*, *12*(22), 9448.

[30] Solís, P., Anderson, J., & Rajagopalan, S. (2021). Open geospatial tools for humanitarian data creation, analysis, and learning through the global lens of YouthMappers. *Journal of Geographical Systems*, *23*(4), 599-625.

[31] https://www.missingmaps.org/

[32] Lang, S., Füreder, P., Riedler, B., Wendt, L., Braun, A., Tiede, D., Schoepfer, E., Zeil, P., Spröhnle, K., Kulessa, K. and Rogenhofer, E. (2020). Earth observation tools and services to increase the effectiveness of humanitarian assistance. *European Journal of Remote Sensing*, *53*(sup2), 67-85.

[33] 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.

NationalMap

An online map-based tool, NationalMap allows easy access to spatial data from many Australian government agencies. It uses a fully open software architecture and allows users to access data on key areas like infrastructure, businesses, places of interest and communications coverage. The tool aims to support government, commercial and community innovation.

NationalMap is managed by Geoscience Australia (GA), with CSIRO's Data61 providing software development and data management support.

Users are also able to upload their own data to and overlay it to add detail not covered by existing public datasets. In the example provided in Figure 1, two purple dots show areas of poor mobile coverage within the urban areas of Lismore, NSW—areas where mobile phone users have self-reported inadequate coverage. The black dots represent 'areas of interest' as defined through the dataset. Recreational areas and natural resources, for example, can also be added through existing data filters.

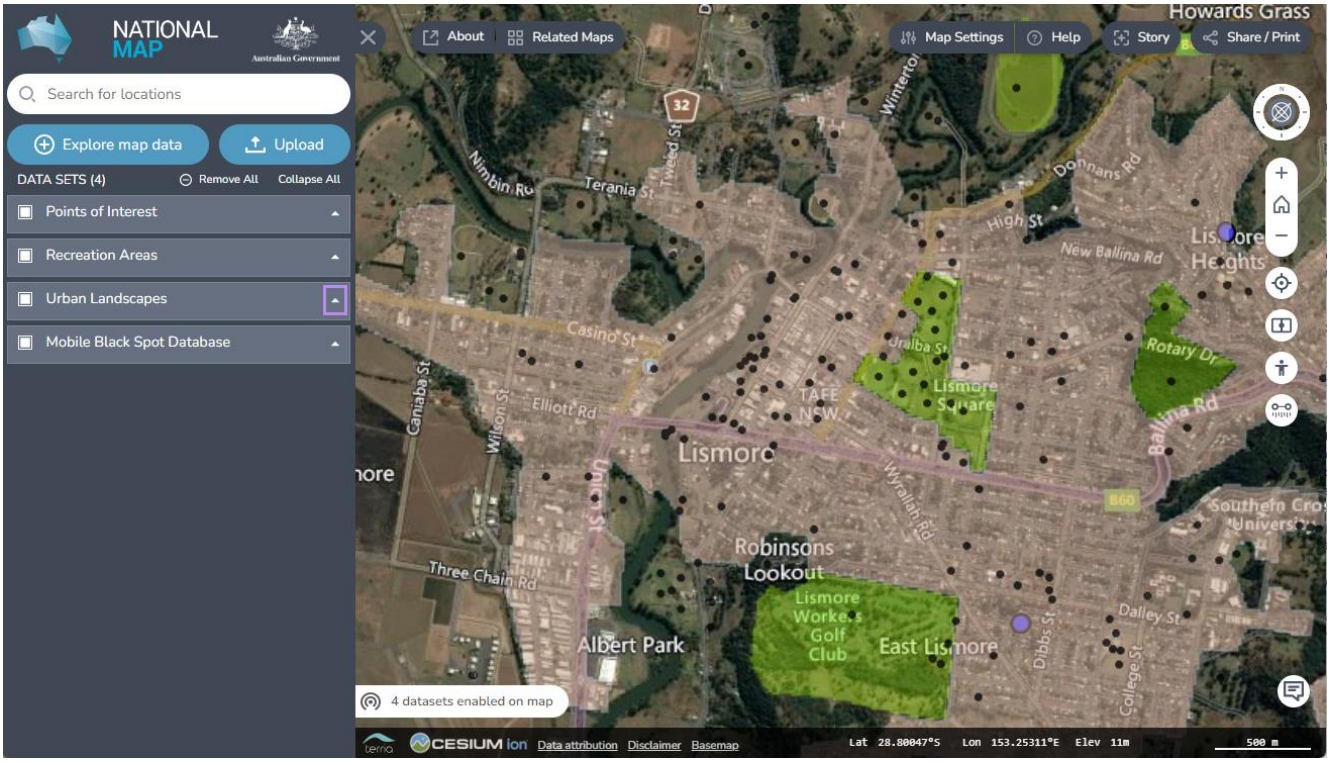

Figure 1. Example, National Map[34] of Lismore, with overlay of Points of Interest (black dots), Recreation Areas (green), Urban Landscapes (tan) and Mobile Black Spots (purple dots)

[34] https://nationalmap.gov.au/

Risk and vulnerability mapping have been a priority for agencies, drawing various available open data together to apply predictive modelling. Risk mapping typically sits higher on a hierarchy of evidence than social forms of knowledge, such as needs communicated by community members.[35]

Predicting risk and vulnerability or the pathways and trajectories of disaster events places an increasing focus on predictive modelling and advanced, algorithmic analytics. An example, supported in the development phase by Australian Red Cross, is the real-time flood modelling and prediction work of the FloodMapp initiative profiled below.[36] The CSIRO Data61 *Spark* project similarly models bushfire spread through simulation

FloodMapp

FloodMapp specialises in real-time flood intelligence for emergency managers, before, during and after flood events. With a mission to improve safety and prevent damage, FloodMapp provides highly accurate, real-time, property-level and dynamic flood inundation and depth insights.

The rapid flood model DASH is purpose built for impact-based flood forecasting and emergency management. It combines big data analytics, automation and machine learning techniques with novel hydrology and hydraulic models to achieve large-scale, rapid flood modelling. The proprietary technology reads in real-time and forecasted rainfall and river height data, which the models use to estimate predicted peak river heights and generate inundation mapping at scale.

Integration with any GIS platform (such as Waze and Esri) informs real time community monitoring of road hazards and aids traffic re-routing.

Working predominantly with government and critical infrastructure services, this kind of intelligence provides emergency managers with timely situational awareness and a common operating picture on the specific people, property and critical infrastructure at risk of impact, which can inform critical decision making before, during and after a flood event. This can enable targeted public messaging, risk mitigation and loss prevention, minimising business interruption and lost productivity, and mitigating risk for staff and assets.

[35] McLennan, B., Whittaker, J., & Handmer, J. (2016). The changing landscape of disaster volunteering: opportunities, responses and gaps in Australia. *Natural Hazards*, *84*(3), 2031-2048. Smith, E. C., Burkle, F. M., Aitken, P., & Leggatt, P. (2018). Seven decades of disasters: a systematic review of the literature. *Prehospital and disaster medicine*, *33*(4), 418-423.

[36] FloodMapp: https://www.floodmapp.com/. Bennett, T. (2022, March 8). How tech is helping manage a flood emergency. *Australian Financial Review*. https://www.afr.com/technology/how-tech-is-helping-manage-a-flood-emergency-20220303-p5a1el

and statistical prediction and provides data to assist in prevention, preparation and response.[37]

These initiatives do not tend to involve direct participation by local communities in design, data collection or analysis. Combining open datasets indicating needs, risks and vulnerabilities with local community-led knowledge, including data drawn from social media, can contribute to community buy-in and a more effective preparedness-focused approach to managing disaster risk while building community resilience.[38]

CROWDSOURCING LOCAL KNOWLEDGE: SOCIAL MEDIA DATA

- How has social media data been used to inform and coordinate disaster response?
- What role do social media and crowdsourcing platforms play in building connectedness, and what potential does it have for improving community resilience and preparedness?
- What are some of the data limitations that platforms have introduced?

Many Queenslanders and Victorians were reassured and informed by accessing Facebook during recent flood responses.[39] This data sharing was a success story, and most existing research tends to focus on people's use of social media for disaster response. Further, these forms of local knowledge and information sharing can also be *resources* that aid disaster preparedness.

Social media and the data generated through digital communications initiated much of the early enthusiasm and innovation in using big data to respond to a humanitarian emergency.[40] Social media data focusing on specific geographies can produce large datasets relevant to disaster response.

Useful knowledge can be drawn from the access to local insights and observations that social media enables. For example, researchers have used Twitter data to draw conclusions about floods in Queensland, observing how flood-affected people shared experiences, needs, emotional exchanges and negotiated roles while sense-making.[41] In the Asia-Pacific region, crowdsourced social media has been used to inform flood

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[37] Data61 SPARK https://data61.csiro.au/en/Our-Research/Our-Work/Safety-and-Security/Disaster-Management/Spark

[38] Baniya, S. (2022). Transnational Assemblages in Disaster Response: Networked Communities, Technologies, and Coalitional Actions During Global Disasters. *Technical Communication Quarterly*, 1-17.

[39] Bird, D., Ling, M., & Haynes, K. (2012). Flooding Facebook-the use of social media during the Queensland and Victorian floods. Australian Journal of Emergency Management, The, 27(1), 27-33.

[40] Lane, D. S., & Dal Cin, S. (2018). Sharing beyond Slacktivism: the effect of socially observable prosocial media sharing on subsequent offline helping behavior. *Information, Communication & Society*, *21*(11), 1523-1540. Palen, L., & Hughes, A. L. (2018). Social media in disaster communication. *Handbook of disaster research*, 497-518.

[41] Shaw, F., Burgess, J., Crawford, K., & Bruns, A. (2013). Sharing news, making sense, saying thanks: Patterns of talk on Twitter during the Queensland floods. *Australian Journal of Communication*, *40*(1), 23-39.

mapping in Jakarta[42] and Taipei.[43] Analysis methods are evolving, with sentiment analysis frequently adopted as an algorithmic approach to using social media in disaster response and recovery.[44]

Northern Rivers Floods

During and after the floods that occurred in the Northern Rivers region of New South Wales, local community members organised to develop data-sharing systems to coordinate recovery efforts. Use of Facebook Groups was widespread, with admins and others collating information for those seeking help and those able to offer it. Community groups also used Google Spreadsheets to update real-time information about the needs of community organisations in the recovery period.

Communities were also actively involved in state-sponsored data collection and mapping. Examples include the Flood Recovery 2022 Live Map created in partnership with Murwillumbah Volunteer Hub, Spangled Drongo Brewing, the Supply Centres—Urgent Needs Live List, and Flood Help Northern Rivers created by Resilient Lismore.

Such groups appeared out of necessity to supplement other news sources and information from emergency service agencies during the floods. While effective at coordinating recovery for those in existing social networks, such ad hoc service delivery was not always fit for purpose and relied on the intensive labour of group admins and other volunteers to coordinate and curate data. A disaster preparedness approach would see communities use and share data about needs and resources on an ongoing basis, with some automation as part of the process.

During the COVID-19 pandemic, social media sometimes fulfilled perceived shortfalls in information provided by official services. For example, in late December 2021, a Facebook group in Tasmania emerged in response to the move away from official listings of exposure sites, with participating community members crowdsourcing contact tracing. Such groups have been criticised for their potential to spread misinformation. However, crowdsourcing has been regarded as potentially valuable for

[42] Ogie, R. I., Clarke, R. J., Forehead, H., & Perez, P. (2019). Crowdsourced social media data for disaster management: Lessons from the PetaJakarta. org project. *Computers, Environment and Urban Systems*, *73*, 108-117.
[43] Lin, Y. T., Yang, M. D., Han, J. Y., Su, Y. F., & Jang, J. H. (2020). Quantifying flood water levels using image-based volunteered geographic information. Remote Sensing, 12(4), 706.
[44] Ragini, J. R., Anand, P. R., & Bhaskar, V. (2018). Big data analytics for disaster response and recovery through sentiment analysis. *International Journal of Information Management*, *42*, 13-24.

pandemic management. Due to a lack of resources, informal networks have responded to administrative failures[45] and helped to mobilise informal networks of support.[46]

Research suggests that crowdsourcing can contribute to disaster surveillance when other resources are unavailable. This practice shows that people turn to social media when other information sources are not meeting their needs.[47] In Northern Ireland in 2015–16, researchers found that people used Facebook to share information during the response stage of floods.[48] In 2015, during floods in Chennai, India, people found Facebook and WhatsApp useful in coordinating social activism regarding disaster management.[49]

Different forms of knowledge and insight can be derived from either official or community-based communication during disasters. One study covered the uses of social media for official communication during the Australian bushfires in the summer of 2019–2020[50]. Another detailed an informal Facebook group that responded to the 2011 bushfire disaster in Tasmania and generated a community response for recovery.[51] These sources of information reflect different facets of disaster scenarios. On the one hand, they show official directives and updates; on the other, they indicate help seeking and community-level action.[52]

While the focus has been on active disaster events or recovery, pre-disaster planning has also been a theme of research on social media engagement with an emergency management agency.[53] This work shows that people are interested in engaging with organisations as a form of preparedness but reflects calls for more efforts at pre-disaster stages.

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[45] Furtado, L. S., & Furtado, L. S. (2021). Urban Collectives and insurgency to fight COVID-19: An analysis of social media content. *Oculum Ensaios*, *18*. https://doi.org/10.24220/2318-0919v18e2021a5136

[46] Carlsen, H. B., Toubøl, J., & Brincker, B. (2021). On solidarity and volunteering during the COVID-19 crisis in Denmark: The impact of social networks and social media groups on the distribution of support. *European Societies*, *23*(sup1), S122–S140. https://doi.org/10.1080/14616696.2020.1818270

[47] Shklovski, I., Burke, M., Kiesler, S., & Kraut, R. (2010). Technology Adoption and Use in the Aftermath of Hurricane Katrina in New Orleans. *American Behavioral Scientist*, *53*(8), 1228–1246. https://doi.org/10.1177/0002764209356252

[48] Stephenson, J., Vaganay, M., Coon, D., Cameron, R., & Hewitt, N. (2018). The role of Facebook and Twitter as organisational communication platforms in relation to flood events in Northern Ireland: Role of Facebook and Twitter as organisational communication platforms. *Journal of Flood Risk Management*, *11*(3), 339–350. https://doi.org/10.1111/jfr3.12329

[49] Bhuvana, N., & Arul Aram, I. (2019). Facebook and Whatsapp as disaster management tools during the Chennai (India) floods of 2015. *International Journal of Disaster Risk Reduction*, *39*, 101135. https://doi.org/10.1016/j.ijdrr.2019.101135

[50] Atkinson, S., Kim, C., & Lee, J. Y. (2020). Facebook as an official communication channel in a crisis (p. 7). University of Canberra. https://search.informit.org/doi/epdf/10.3316/agispt.20210525047172

[51] Paton, D., & Irons, M. (2016). Communication, Sense of Community, and Disaster Recovery: A Facebook Case Study. *Frontiers in Communication*, *1*. https://doi.org/10.3389/fcomm.2016.00004

[52] Silver, A., & Matthews, L. (2017). The use of Facebook for information seeking, decision support, and self-organization following a significant disaster. *Information, Communication & Society*, *20*(11), 1680–1697. https://doi.org/10.1080/1369118X.2016.1253762

[53] Kurian, J. C., & John, B. M. (2017). User-generated content on the Facebook page of an emergency management agency: A thematic analysis. *Online Information Review*, *41*(4), 558–579. https://doi.org/10.1108/OIR-09-2015-0295

Research examining charitable giving and volunteering during the 2019–2020 Australian bushfires has demonstrated the value of social media (Twitter and Facebook) and crowdfunding sites (GoFundMe) to connect resources to where they are needed in local, disaster-affected communities.[54]

The actions identified and mapped in **Figure 2** represent the 'tip of an iceberg' in the exchange of information, resources and actions in response to the effects of fires. The platforms enabling these community-led initiatives (Google, GoFundMe, Facebook and Twitter) can be better leveraged to improve the mapping of local resources in response to disaster events and as an aid to preparedness.

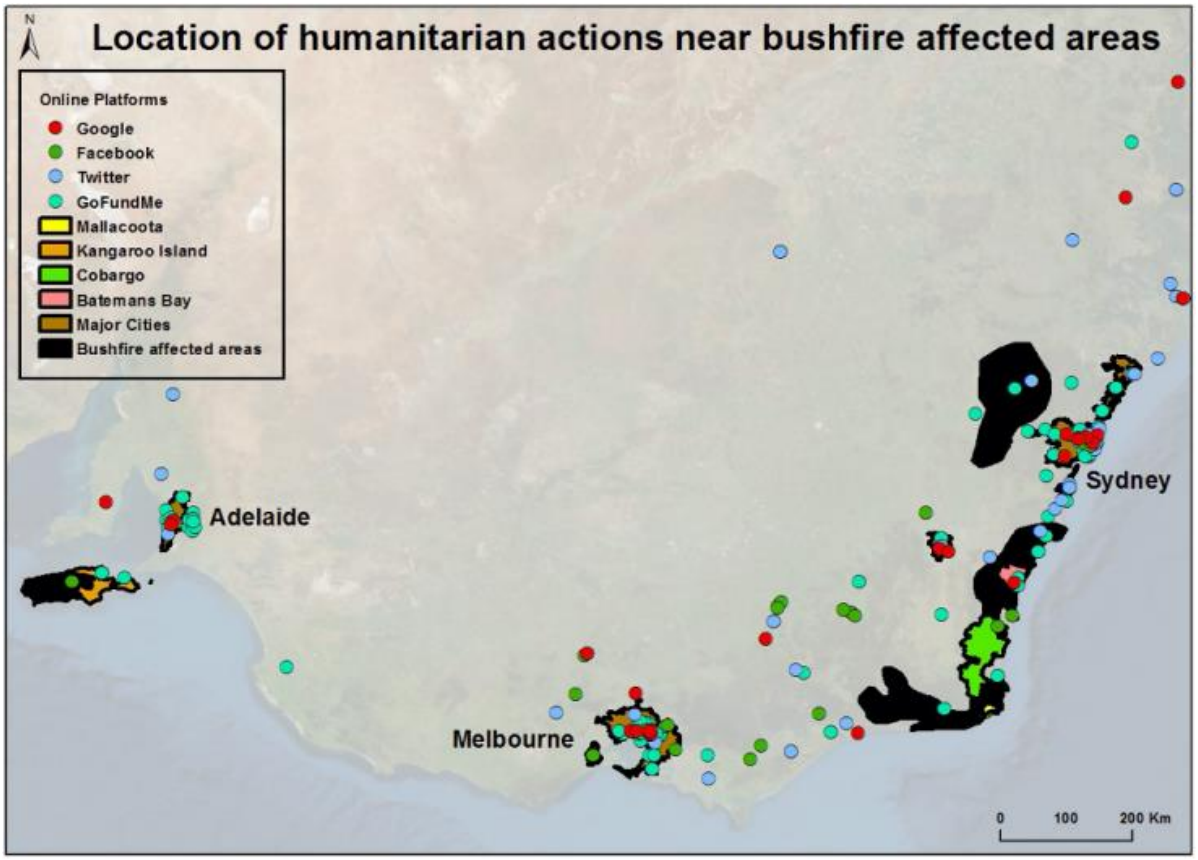

Figure 2. Locating humanitarian action through multiple public communication data sources concerning Australia's 2019–2022 bushfires[55]

[54] Wilson, S., Sivasubramaniam, D., Farmer, J., Aryani, A., De Cotta, T., Kampstra, P., Adler, V., & Knox, J. (2020). *Everyday humanitarianism during the 2019/2020 Australian bushfire crisis*. https://doi.org/10.25916/5EA784522F152

[55] Wilson, S., Sivasubramaniam, D., Farmer, J., Aryani, A., De Cotta, T., Kampstra, P., Adler, V., & Knox, J. (2020). *Everyday humanitarianism during the 2019/2020 Australian bushfire crisis*. https://doi.org/10.25916/5EA784522F152

Crowdfunding websites such as GoFundMe.com can help bridge social capital to provide disaster relief for individuals and their families.[56] It can support preparedness and disaster response; for example, the microfinance platform Kiva has been shown to support climate change resilience in Africa.[57]

Despite some of these gains, there are evolving challenges in using social media and crowdsourced data. Overviews of social media data also use document negatives, such as the risks of misinformation, misrepresentation, digital exclusion, unequal resourcing, information overload and potential lack of access due to power and telecommunications failures during disasters.[58] There are also ethical dilemmas in using social media data and important issues of addressing privacy through concepts such as 'contextual integrity'. This concept includes awareness of the purpose and privacy context of social media exchanges when looking to use them as data.[59]

Misinformation can also affect disaster management efforts and outcomes directly and indirectly.[60] Combating misleading uses of data has been described as a component of informational justice that can be done formally through content regulation and informally through community action. Studies show how local communities develop strategies to combat misinformation.[61]

There are limitations to the use of social media data in Australia. The population of social media users in major cities enables such work at scales beyond what is suited to regional or remote parts of Australia. Further, regulatory changes have affected social media's usability as a research site. Social media platforms have changed data access protocols, such as Instagram disabling its legacy API in 2020.[62] Despite these limitations, social media remains relevant and can potentially be a data source for preparedness.

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[56] Radu, M. B., & McManus, L. (2019). Bridging social capital through the techno-subsystem: A qualitative analysis of GoFundMe requests for hurricane relief. *Journal of Family Strengths*, *19*(1), 9. https://digitalcommons.library.tmc.edu/jfs/vol19/iss1/9/

[57] Chirambo, Dumisani. "Enhancing climate change resilience through microfinance: Redefining the climate finance paradigm to promote inclusive growth in Africa." *Journal of Developing Societies* 33.1 (2017): 150-173.

[58] Rajdev, M., & Lee, K. (2015, December). Fake and spam messages: Detecting misinformation during natural disasters on social media. In *2015 IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology (WI-IAT)* (Vol. 1, pp. 17-20). IEEE. Flores-Saviaga, C., & Savage, S. (2021). Fighting disaster misinformation in Latin America: the# 19S Mexican earthquake case study. *Personal and Ubiquitous Computing*, *25*(2), 353-373.

[59] Alexander, D. E. (2014). Social media in disaster risk reduction and crisis management. *Science and engineering ethics*, *20*(3), 717-733. P.727

[60] Hagley, Z. (2021). The Disaster of 'Alternative Facts': Misinformation and Disaster Management in Grenada. *Caribbean Studies*, *49*(1), 29-59. https://doi.org/10.1353/crb.2021.0011

[61] Flores-Saviaga, C., & Savage, S. (2021). Fighting disaster misinformation in Latin America: The #19S Mexican earthquake case study. *Personal and Ubiquitous Computing*, *25*(2), 353-373. https://doi.org/10.1007/s00779-020-01411-5

[62] McCrow-Young, A. (2021). Approaching Instagram data: reflections on accessing, archiving and anonymising visual social media. *Communication Research and Practice*, *7*(1), 21-34.

ADVANCING DATA ANALYSIS AND AUTOMATED DECISION-MAKING

- Can advanced analytics and automation improve the value and insights derived from local community data?
- How are automated decision-making systems leveraging data access and advanced modelling through machine learning and natural language processing?

Predictive modelling and machine learning (ML) techniques have increasingly taken advantage of large datasets such as those discussed above. Image classification and analysis methods, natural language processing (NLP) and remote sensing create new possibilities in preparing for and responding to disasters.[63] These technologies and techniques bring innovation and risks as they make sense of potentially incomplete or inaccurate data and automate analysis and decision-making.

For example, ML has automated satellite imagery analysis to identify suitable places for relief helicopters to land.[64] Combined sets of crowdsourced data (i.e., OpenStreetMap, MapSwipe and OsmAnd,[65] an offline map and mobile navigation application) were used to develop a ML model for humanitarian mapping aiming at object labelling (e.g., houses, buildings and roads) from satellite images. This object labelling helped to inform communities about vulnerable people's locations during a humanitarian crisis[66] and identify roads in remote areas.[67] Whereas satellite data are collected via machines, other valuable data sources are generated by people on the ground before, during and after emergencies, filling gaps but introducing different challenges, such as data ownership and privacy concerns.[68]

Valuable insights can be generated through analysis of communication circulating via social media, news and similar sources, building on new developments in NLP to address its complexities and scale. NLP has been used to develop a hazard risk awareness index combining Twitter data with other datasets, including population, internet use rate and hazard characteristics.[69] Similarly, insights can be generated

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[63] Li, G., Zhao, J., Murray, V., Song, C., & Zhang, L. (2019). Gap analysis on open data interconnectivity for disaster risk research. *Geo-Spatial Information Science*, *22*(1), 45-58.
[64] Antoniou, V., & Potsiou, C. (2020). A deep learning method to accelerate the disaster response process. *Remote Sensing*, *12*(3), 544.
[65] https://www.openstreetmap.org, http://mapswipe.org/, https://osmand.net/
[66] Chen, J., Zhou, Y., Zipf, A., & Fan, H. (2018). Deep learning from multiple crowds: A case study of humanitarian mapping. *IEEE Transactions on Geoscience and Remote Sensing*, *57*(3), 1713-1722.
[67] Li, P., He, X., Qiao, M., Miao, D., Cheng, X., Song, D., ... & Tian, Z. (2021). Exploring multiple crowdsourced data to learn deep convolutional neural networks for road extraction. *International Journal of Applied Earth Observation and Geoinformation*, *104*, 102544.
[68] Hayes, P., & Kelly, S. (2018). Distributed morality, privacy, and social media in natural disaster response. *Technology in Society*, *54*, 155-167. Hayes, P., & Jackson, D. (2020). Care ethics and the responsible management of power and privacy in digitally enhanced disaster response. *Journal of Information, Communication and Ethics in Society*.
[69] Karimiziarani, M., Jafarzadegan, K., Abbaszadeh, P., Shao, W., & Moradkhani, H. (2022). Hazard risk awareness and disaster management: Extracting the information content of twitter data. *Sustainable Cities and Society*, *77*, 103577.

during events by aggregating news relevant to a defined disaster[70] to support situational awareness. It should be noted, however, that this approach does not offer predictive or anticipatory insights.

Forecast-based financing[71] has enhanced disaster preparedness and response by giving people at risk of or impacted by emerging disasters access to resources to be more effective first responders. The IFRC has been an international pioneer in this field, involved in forecast-based early action methods since 2014[72] and continuing global leadership with a movement-wide resolution in 2022.[73]

Similarly, predictions of adaptability in disaster circumstances, such as how small businesses would be involved in supporting the community in disaster response, have been enhanced using common ML algorithms.[74] This research involved applying a typical ML method to datasets about how small businesses supported or could support their communities to add data to predictions.

Artificial intelligence and algorithmic modelling pose many risks that are the focus of global debate and scrutiny. Much can go wrong in gathering and using data to drive and automate decision-making in humanitarian and disaster contexts. These techniques pose issues regarding reliability, transparency, accountability, privacy in personal data use, autonomy and agency. Those most affected or at risk of emergencies must be involved in designing and using these technologies and techniques if they solve local disaster preparedness and response problems.

COMMUNITY-ORIENTED METHODS AND LOCAL DATA CAPABILITY

- What are the existing community-based approaches to disaster preparedness, and how can data analysis support and be integrated into these approaches?
- What can be done to enable community-oriented data capability and action?

These data gaps regarding communities vulnerable to disaster are unlikely to be resolved without the involvement of the people and organisations within those

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[70] Domala, J., Dogra, M., Masrani, V., Fernandes, D., D'souza, K., Fernandes, D., & Carvalho, T. (2020, July). Automated Identification of Disaster News for Crisis Management using Machine Learning and Natural Language Processing. In *2020 International Conference on Electronics and Sustainable Communication Systems (ICESC)*(pp. 503-508). IEEE.
[71] van den Homberg, M. J., Gevaert, C. M., & Georgiadou, Y. (2020). The changing face of accountability in humanitarianism: Using artificial intelligence for anticipatory action. Politics and Governance, 8(4), 456-467.
[72] Tozier de la Poterie, A., Clatworthy, Y., Easton-Calabria, E., Coughlan de Perez, E., Lux, S., & van Aalst, M. (2021). Managing multiple hazards: lessons from anticipatory humanitarian action for climate disasters during COVID-19. *Climate and Development*, 1-15.
[73] Council of Delegates of the International Red Cross and Red Crescent Movement (2022). *Strengthening anticipatory action in the Movement: Our way forward. Background paper.* https://rcrcconference.org/app/uploads/2022/05/09_CoD22-Anticipatory-action-Background-document-FINAL-EN.pdf
[74] Davis Pierel, E., Helgeson, J., & Dow, K. (2021). Deciphering Small Business Community Disaster Support using Machine Learning. https://dx.doi.org/10.2139/ssrn.3888481

communities. Community-led or community-oriented approaches describe how community members can be empowered and involved in disaster mitigation, response and action processes.

Communities are connected by geography or proximity but also by shared interests. Disasters affect people in geographic areas and involve a much wider community of interest, concern and voluntary action. Digital volunteers who help to crowdsource crisis information have become a regular part of disaster response and can complement those acting on the ground.[75]

It is more likely to be local actors—whether businesses, groups, individuals or 'community connectors'[76]—who are the 'first responders'[77] or most willing to engage in disaster preparedness activities and are ready to respond when disaster events occur. The case study of community response noted below (Indigo Valley) shows the roles that community volunteers and local resources play in disaster recovery and preparedness.

In research and practice, there is increasing emphasis on enabling local communities to identify and address their needs. This focus aligns with approaches to community resilience as an effective way to address disaster risks. The IFRC Road Map to Community Resilience explains the role that people, businesses, groups and organisations in local communities need to play in managing disaster risks before they occur:

> Resilience is not something that can be brought to or built for communities. Strengthening resilience at every level is a participatory journey led by its beneficiaries.[78]

Community members can have areas of expertise or authority that transcend categorisation.[79] Since disaster-impacted communities are typically their own first responders, relying on assumptions about roles can elide that expertise.[80]

New approaches to resource mapping and work in building community data capability can make a difference. National Red Cross chapters have been successful around the

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[75] Radianti, J., & Gjøsæter, T. (2019, July). Digital volunteers in disaster response: accessibility challenges. In *International Conference on Human-Computer Interaction* (pp. 523-537). Springer, Cham.

[76] Wallace, C., Farmer, J., & McCosker, A. (2019). Boundary spanning practices of community connectors for engaging 'hardly reached' people in health services. *Social Science & Medicine*, *232*, 366-373. Wallace, C., McCosker, A., Farmer, J., & White, C. (2021). Spanning communication boundaries to address health inequalities: the role of community connectors and social media. *Journal of Applied Communication Research*, *49*(6), 632-650.

[77] Stallings, R. A., & Quarantelli, E. L. (1985). Emergent citizen groups and emergency management. *Public administration review*, 45, 93-100. Roberts, A., Nimegeer, A., Farmer, J., & Heaney, D. J. (2014). The experience of community first responders in co-producing rural health care: in the liminal gap between citizen and professional. *BMC health services research*, *14*(1), 1-10.

[78] IFRC (2016). Road map to community resilience: Operationalizing the Framework for Community Resilience, Geneva, page 5. https://www.ifrc.org/sites/default/files/1310403-Road-Map-to-Community-Resilience-Final-Version_EN-08.pdf

[79] Calyx, C. (2020). Sustaining citizen science beyond an emergency. *Sustainability*, *12*(11), 4522.

[80] Roberts, A., Nimegeer, A., Farmer, J., & Heaney, D. J. (2014). The experience of community first responders in co-producing rural health care: in the liminal gap between citizen and professional. *BMC health services research*, *14*(1), 1-10.

world in supporting local emergency committees to lead disaster risk reduction measures,[81] reflecting trends towards co-producing community-based disaster risk reduction.[82]

Indigo Valley case study

A report of community-led recovery initiatives following the devastating 2015 Barnawartha-Indigo Valley bushfire in Victoria provides valuable insights for future disaster preparedness. The report documents the community-level resources—people, expertise, programs, actions and efforts—that drove the recovery.

Initiatives for facilitating community connectedness and resilience included financial workshops, debriefs and action planning, land care and bushfire planning workshops, youth or gender-specific activities, a newsletter and a Good Neighbour Program. Varied community buy-in and demand demonstrated that a one-size-fits-all approach to connectedness as a measure of resilience is inappropriate.

Local information sharing systems and resource and infrastructure management processes were crucial. A community newsletter shared information relevant to disaster recovery, such as fencing, fire control lines, replacement water and waste transfer stations during the recovery period. This was emailed, with addresses collected through coordinators of phone trees, as well as dedicated drop boxes within a geographic area where people could pick up hard copies. While phone tree coordinators connected some community segments, there was a physical alternative for people who opted out of email or phone connection to receive information.

Some community action addressed land and property management. For instance, The Good Neighbour Program targeted people who live adjacent to vacant crown or public land or a community facility, linking people to agencies administering the land to improve its management and address risks. These actions require extensive often volunteer coordination.

Underpinning these community-led responses to recovery is an important layer of information gathering and sharing, which can be enhanced through resource mapping technology but must support rather than supplant local needs.

[81] Hostettler, S., Jöhr, A., Montes, C., & D'Acunzi, A. (2019). Community-based landslide risk reduction: a review of a Red Cross soil bioengineering for resilience program in Honduras. Landslides, 16(9), 1779-1791.
[82] McLennan, B., Whittaker, J., & Handmer, J. (2016). The changing landscape of disaster volunteering: opportunities, responses and gaps in Australia. *Natural Hazards*, *84*(3), 2031-2048.

Two-way partnership approaches in Indigenous communities are examples of strengths-based disaster risk reduction in Australia[83] and internationally.[84] These approaches value and leverage local knowledge and expertise, such as in using Indigenous fire management approaches or deploying drones in Kakadu National Park to monitor a biocultural landscape.[85] These projects underscore the importance of ongoing processes of building relationships and trust.[86]

Building on this research, we seek to enable new inclusions of local community data to address preparedness and change the way people organise to prepare for disasters by building capability, local knowledge and resources.

KEY TAKEAWAYS

- **Humanitarian data portals, commons and exchanges**

  Humanitarian data portals established by governments, research collectives and humanitarian organisations have been used to aid humanitarian action.

  But there has been little research testing the incorporation of local knowledge (e.g., localised social and resource data with environmental data and infrastructure data) as key data sources for promoting humanitarian action and preparedness.

- **Mapping crises, risks and vulnerabilities**

  Most previous research has used location-based disaster or humanitarian data mapping to enhance situational awareness and predict risk and vulnerability.

  Environmental and disaster modelling offers important tools for predicting and responding to emergencies. We need to build on open-source and open-access mapping tools to improve the integration of local knowledge and resources into the picture.

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[83] Ali, T., Buergelt, P.T., Paton, D., Smith, J.A., Maypilama, E.L., Yuŋgirrŋa, D., Dhamarrandji, S. and Gundjarranbuy, R., 2021. Facilitating sustainable disaster risk reduction in Indigenous communities: Reviving Indigenous worldviews, knowledge and practices through two-way partnering. *International journal of environmental research and public health*, *18*(3), p.855.

[84] Ali, T., Paton, D., Buergelt, P. T., Smith, J. A., Jehan, N., & Siddique, A. (2021). Integrating Indigenous perspectives and community-based disaster risk reduction: A pathway for sustainable Indigenous development in Northern Pakistan. *International Journal of Disaster Risk Reduction*, *59*, 102263.

[85] Macdonald, J.M., Robinson, C.J., Perry, J., Lee, M., Barrowei, R., Coleman, B., Markham, J., Barrowei, A., Markham, B., Ford, H. and Douglas, J., 2021. Indigenous-led responsible innovation: lessons from co-developed protocols to guide the use of drones to monitor a biocultural landscape in Kakadu National Park, Australia. *Journal of Responsible Innovation*, *8*(2), pp.300-319.

[86] Ingram, A. (2021). Community-led disaster resilience in Nauiyu Aboriginal community. The Humanitarian Leader, Paper-018. Every, D., & Richardson, J. (2018). A framework for disaster resilience education with homeless communities. *Disaster Prevention and Management: An International Journal*, *27*(2), 146–158. https://doi.org/10.1108/DPM-08-2017-0196

- **Crowdsourcing local knowledge: social media data**

  Social media has been a successful way for local communities to connect in the face of emergencies, gather information and share resources. It has also been an effective research tool as a source of local knowledge to improve situational awareness.

  Social media functions as a communication infrastructure—where individuals and community groups can share vital information—*and* generates local area data that can aid preparedness and community resource mapping.

- **Advancing data analysis and automated decision-making**

  AI and Automated Decision-Making (ADM) have contributed to better understanding of emergencies by combining environmental data with inputs about real-time conditions or predicting from past events.

  While addressing the risks in reliability, accountability and trust they generate, these techniques have the potential to assist disaster preparedness.

Combining data capability with community-based methods

- Despite the importance of community-led approaches to disaster response and preparedness, the question of how to better generate, integrate and use data about local community resources to improve disaster preparedness remains a challenge. Challenges include the reliance on ever-changing and varied local expertise and capability, ensuring that the digital and data tools are accessible and where possible opensource, and addressing data and AI governance to avoid harmful outcomes.

MAPPING COMMUNITY RESOURCES: Project design

A COMMUNITY RESOURCE MAPPING PLATFORM

Drawing on lessons from scoping workshops and the review of current research and practice presented in this report, we have designed a data analytics pipeline and platform to support local community-level disaster preparedness.

Disaster preparedness can be enhanced by improving data practices targeting community *strengths* and *assets*. This work can assist regional, rural and remote communities, where there are often data gaps, prepare for disaster events.

We recognise the many challenges to community-centred design and the importance of ethics, accountability and sustainability in any data and automated decision system. The four key steps to building community resource mapping capability are:

Step 1. Identifying useful datasets representing local resources that can aid disaster preparedness and build community resilience—**what data?**

Step 2. Establishing a pipeline for responsible, ethical and inclusive data analytics and visualisation—**how to manage and process that data?**

Step 3. Exploring and testing the functionality of an open platform for responsible data analysis and dashboard and map-based outputs—**what can it show?**

Step 4. Embedding within communities and organisations through collaborative practice and user testing to build capability—**what pathways to sustainability?**

The inputs and desirable outcomes of a community resource mapping tool can be broadly represented in the following diagram (**Figure 3**). The central dotted line represents the challenges in moving from gathering useful information about local community resources to creating effective outputs through analysis and visualisation.

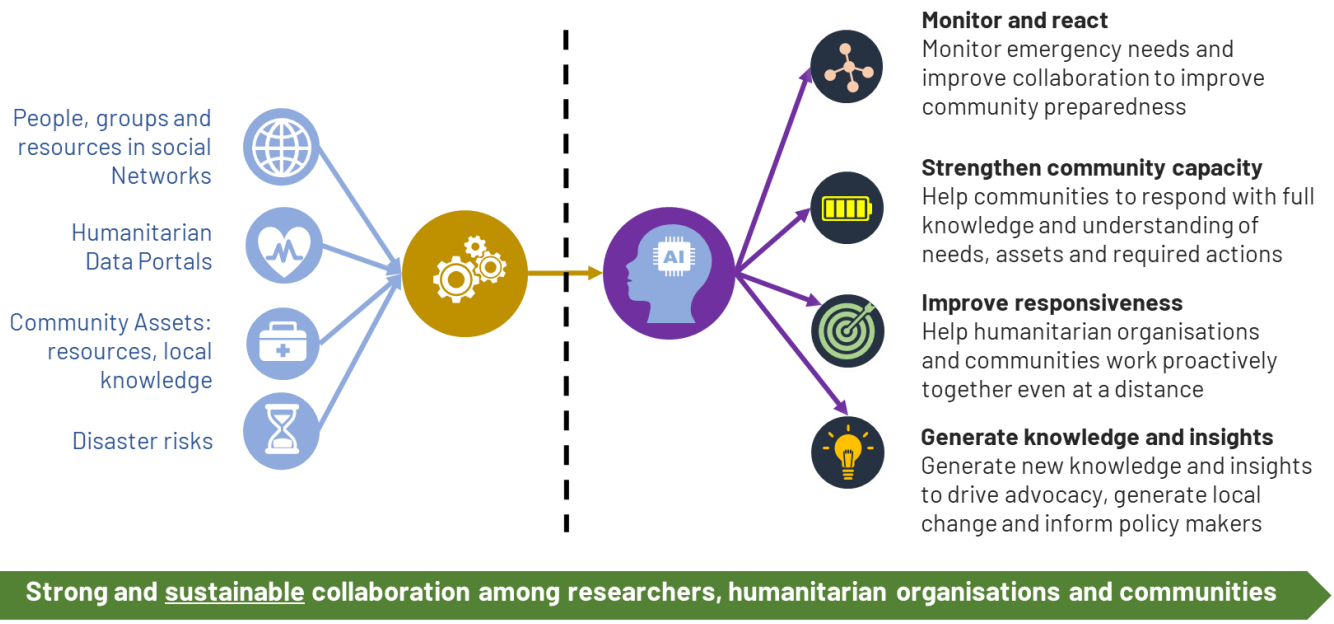

Figure 3. Data collaboration, capability building and analysis to enable community disaster preparedness

DATA SOURCING, PREPARATION AND ANALYTICS PIPELINE

Our community resource mapping pipeline (**Figure 4**) represents a testbed process for addressing the challenges of improving data scarcity and leveraging local community strengths, resources and assets data for disaster preparedness.

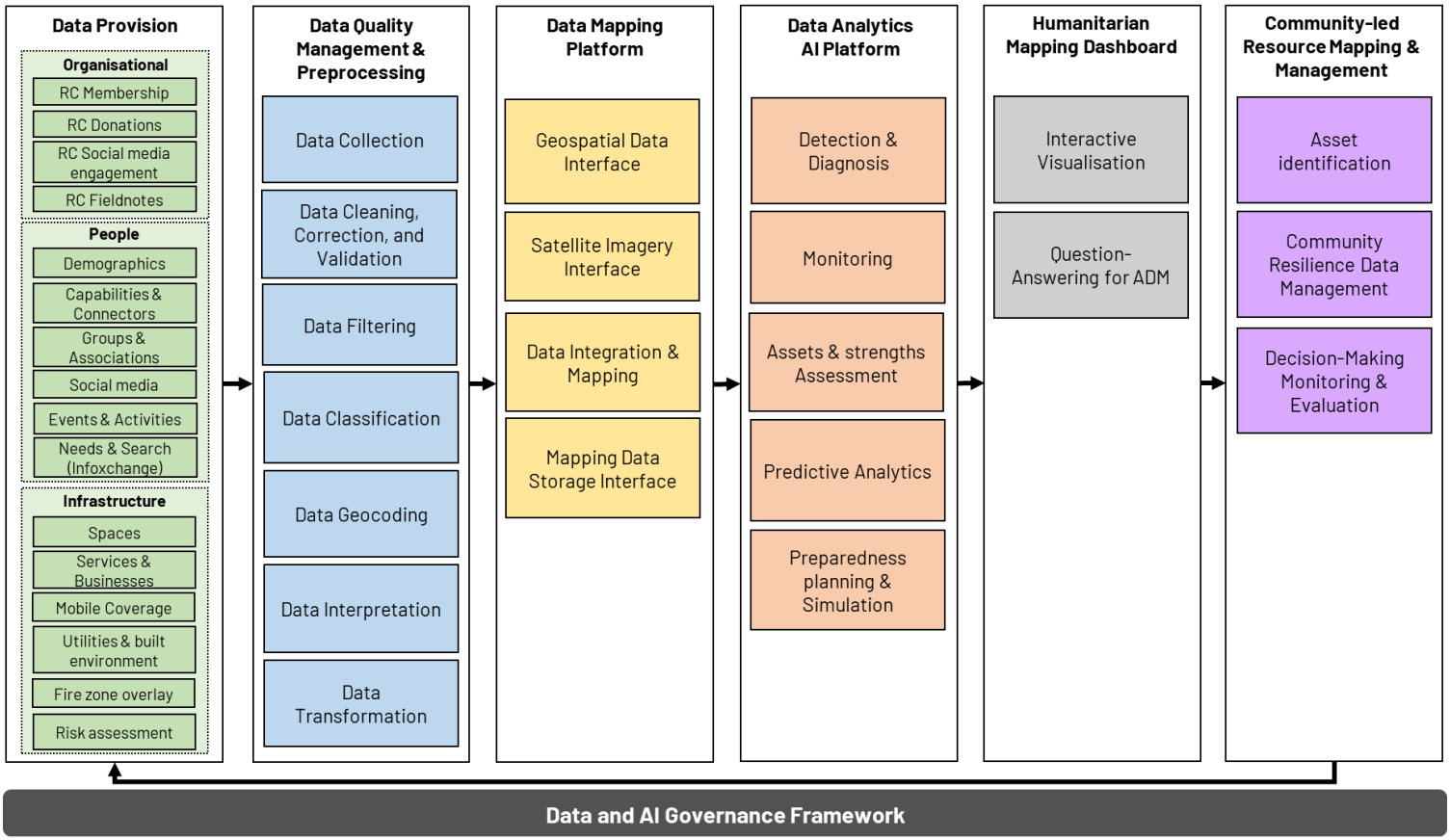

Figure 4. A community resource mapping pipeline for disaster preparedness

This beta phase pipeline was developed by synthesising several initial project research sources, involving input from several sources. We held workshops with Australian Red Cross personnel with expertise and responsibility for data analytics, emergency management, volunteering and community development.

These workshops helped establish the rationale, targets and broad goals for the work, which led to the founding of an Advisory Group in August 2021 to identify relevant datasets and develop a community resource mapping pipeline strategy. Advisory Group members were experienced in humanitarian emergency work at Australian Red Cross, data science at CSIRO and community data analytics at Seer Analytics, with separate discussion with humanitarian data analysis practitioners at the 510Global group based in Amsterdam. The August data exploration workshop surfaced numerous resource datasets, including those grouped in the Data Provider column of **Figure 4**.

Desk research, including the information presented in the background research and practice review above, established existing best practices and developments in

humanitarian mapping and open data access and use over time. This body of work continues to inform the design and goals for the community resource mapping pipeline.

The *RediCommunities: Community-Led Resilience for Emergencies* guide and toolkit offered an additional source to guide the project and pipeline design. Based on the IFRC *Roadmap to Community Resilience*,[89] RediCommunities establishes a set of steps and processes to assist individuals, volunteers and community groups to build 'the resilience of their communities to natural and man-made hazards, climate change and other emergencies'.[90]

The *RediCommunities* toolkit sets out four stages for communities to work through 1) engaging and connecting, 2) understanding community risk and resilience, 3) taking action for resilience and 4) learning for resilience. Our community resource mapping pipeline is designed to contribute specifically to the step of 'understanding community risk and resilience'.

In community development, this aligns with the work of 'community asset mapping'.[91] As a participatory process, asset mapping has been shown to align better goals such as disaster preparedness with local community needs, strengths and values. By developing data-driven resource mapping practices and tools, we aim to help surface latent community strengths, make them visible and gear them toward preparedness action.

ABOUT THE RESOURCE MAPPING DATA PIPELINE

The resource mapping data pipeline can advance knowledge about the state of preparedness in any local community by generating insights into its strengths, assets and resources. Ultimately, the pipeline is designed to be led and managed by community members. As a beta test version, we have set out **seven key units** as an ongoing cycle of work in 1) gathering, 2) preprocessing, 3) processing, 4) analysing, 5) mapping and visualising and 6) aiding preparedness action for local communities. Underpinning these processes is 7) a data and AI governance framework.

1. **Data provision.** This part of the pipeline involves gathering data from a range of sources. These sources will be mostly open-access, available via various portals, exchanges and sites. They could be combined with organisational data in privacy-preserving ways through data collaboration activities and agreements. In line with community asset mapping practices and the RediCommunities toolkit, these data

[89] IFRC (2016). Road map to community resilience: Operationalizing the Framework for Community Resilience, Geneva, page 5. https://www.ifrc.org/sites/default/files/1310403-Road-Map-to-Community-Resilience-Final-Version_EN-08.pdf

[90] Australian Red Cross (2019) RediCommunities: Community-Led Resilience for Emergencies. https://www.redcross.org.au/emergencies/resources/resources-for-communities/

[91] See for example CreatingCommunities (2016) 'Neighbourhood Knowledge: Why You Should Map Your Community Assets', available at https://www.creatingcommunities.com.au/. Jakes, S., Hardison-Moody, A., Bowen, S., & Blevins, J. (2015). Engaging community change: The critical role of values in asset mapping. *Community Development*, *46*(4), 392-406.

sources can be any information about resources in a geographically bounded area that can help discover a community's strengths and, in the process, highlight gaps. In our pipeline, we have included a) useful Australian Red Cross data that can contribute to understanding local area assets and resources, b) information about people, groups, businesses and organisations, capabilities or expertise and c) infrastructure resources, including spaces and places, environmental features.

2. **Data quality management and preprocessing**. Once useful resource and asset data have been identified or generated, they need to be preprocessed and managed for quality. This process involves data cleaning, correction and validation using various techniques, including manual or automated checks to ensure reliability and trustworthiness. It also involves filtering out vague, inaccurate and unethical (e.g., privacy-invasive) data. Data classification and geocoding—or adding geographical coordinates—are processes that help to sort and prepare the data for analysis and map or dashboard-based visualisation.
3. **Data mapping platform**. Preprocessed data can then be gathered and integrated within a geospatial data interface. It could be part of a dashboard setup such as PowerBI or Tableau or an open mapping tool like OpenStreetMap or NationalMap. Data integration and secure cloud storage can be used to support an open map or publicly accessible dashboard.
4. **Data analytics platform**. When resource and asset data are gathered and mapped to a local area, data analysis can gain additional insights. This analysis could involve detecting and diagnosing gaps or forecasting response and recovery. Possibilities for analytics are open and aided by emerging techniques in ML, predictive modelling and NLP. Rather than advocating for specific analytics processes, we note the importance of exploratory data analysis and the potential for simulation as the key goal of this part of the data pipeline. Many established disaster modelling and mapping tools focus on risk analysis and disaster impact prediction. Mapping community resources prioritises community connection, action and resilience building.
5. **Humanitarian mapping dashboard**. With the previous processes in place, the goal is to enable the production of a publicly accessible humanitarian mapping dashboard. This dashboard brings together the information gathered and processed through the previous steps. It enables users to access and contribute to the resource mapping project, with tailored data visualisation and the potential for dialogue-based question answering for ADM. It could involve easy access to answers about the number of residents in a suburb in a fire- or flood-threatened area, types of small businesses or services, location of outdoor recreation centres and available accommodation.
6. **Community-led resource mapping and management.** While each of the previous steps and processes can be community-led, community oversight and management of the resource mapping data pipeline should be both an endpoint and a starting point. This change may be realised in a co-production and participatory fashion or through partnerships. The overarching goal is to establish the processes and tools

or platform interfaces that can enable local communities to lead resource mapping practices as a disaster preparedness activity.

7. **Data and AI governance framework.** Underpinning each step in the resource mapping data pipeline are data governance and AI governance principles where appropriate. These processes can involve simple steps to ensure that all data are secure, de-identified, privacy-preserving, non-sensitive and managed, and that a data steward has responsibility and accountability for sustaining these governance practices over time.

NEXT STEPS

The resource data pipeline described here represents a trajectory plan. Through ongoing project collaboration with Australian Red Cross, we will test elements of initial steps in the data pipeline, nominating and testing data collection and preprocessing for a local community and establishing the viability of resource mapping as a community resilience tool.

Final reporting will present the outcomes of the pilot project testing and analysis with visual outputs that will demonstrate the viability and benefits of digitising and automating aspects of community resource mapping.

Further work will enable higher-level development, analysis, humanitarian mapping outputs and user testing to establish open-source tools to enable community-led co-creation and deployment.

GLOSSARY

Anticipatory action. Any measures implemented before an event in anticipation of that event, often based on risk or vulnerability analysis, combined with forecasting.

Assets. In the context of humanitarian action, assets include people, groups, services, infrastructure, resources and local knowledge that would assist in disaster response. Assets include capabilities or expertise that exist in the community.

Community data action. Any localised approach to gathering, processing and sharing data about local knowledge and resources that can inform preparedness work, generate community connection and contribute to building community resilience.

Community-level data. Data that are generated and collected or sourced from a local community rather than from external sources outside the community.

Community-oriented methods / Community-led approaches. Methods or approaches that take the lead from local communities and their needs and strengths.

Community resource/asset mapping. Community resources or assets include people, groups, services, infrastructure, local knowledge and expertise, events and activities that can support community resilience in a disaster. Mapping these resources involves

collecting information about the availability and location of resources within a community.

Crowdfunding. In the context of disaster response, crowdfunding is a method for connecting financial resources to people who need them, usually generated through crowdfunding platforms such as GoFundMe from various citizen sources.

Crowdsourcing. The use of information provided by a collective for data gathering and analysis, whether on social media or dedicated platforms.

Data capability / local data capacity. The local community's range of abilities and expertise in working with and using data.

Data donation. The act of providing (usually personal) data for research, analysis or other specified purposes.

Disaster preparedness. Precautionary measures to reduce the impact or likelihood of disasters in advance.

Geocoding. Producing geographic coordinates for data about a place.

Predictive modelling. Using mathematical processes to predict events or outcomes by finding patterns in data.

Remote sensing. Gathering information about an object or phenomenon (e.g., terrain or environment) from a distance, such as by satellite, drone or aircraft.

Resilience. The ability of communities (and their members) exposed to disasters, crises and underlying vulnerabilities to anticipate, prepare for, reduce the impact of, cope with and recover from the effects of shocks and stresses without compromising their long-term prospects (IFRC definition as noted above, section 2).

Risk. An uncertain situation of exposure to danger, harm or loss.

Situational awareness. Having information and understanding about what is happening at a given moment.

Strengths-based approaches. Models and practices that involve people in change by building on their resourcefulness and existing capacities.

Vulnerability assessment. Individual or population, sub-population or environmental risk factors that represent susceptibilities to harm or loss in the case of adverse events.

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