

# Flood risk governance in Brazil and the UK: facilitating knowledge exchange through research gaps and the potential of citizen-generated data

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## Abstract

**Purpose** – The study aims to identify the gaps and the potentialities of citizen-generated data in four axes of warning system: (1) risk knowledge, (2) flood forecasting and monitoring, (3) risk communication and (4) flood risk governance.

**Design/methodology/approach** – Research inputs for this work were gathered during an international virtual dialogue that engaged 40 public servants, practitioners, academics and policymakers from Brazilian and British hazard and risk monitoring agencies during the Covid-19 pandemic.

**Findings** – The common challenges identified were lack of local data, data integration systems, data visualisation tools and lack of communication between flood agencies.

**Originality/value** – This work instigates an interdisciplinary cross-country collaboration and knowledge exchange, focused on tools, methods and policies used in the Brazil and the UK in an attempt to develop trans-disciplinary innovative ideas and initiatives for informing and enhancing flood risk governance.

**Keywords** Cooperation, Disaster risk, Capacity building, Science–policy interface

**Paper type** Research paper

## 1. Introduction

Disaster risk governance is a major challenge in several areas around the world (Murray, 2017). In Brazil, for instance, the 2011 catastrophe in the Rio de Janeiro state catalysed political shifts towards the creation of a national disaster risk governance which includes formal instruments – such as policies, plans, laws – as well as informal such as social movements, non-government organisations' (NGOs) engagement. At the same time, in the UK, disaster risk has progressively found its way to the top of the governmental agenda since 2001, through shifts in the understanding of governance and management of risk (Mann, 2007). The UK has adopted an “all hazards” approach to governing disaster risk, which builds upon the established system for emergency planning and engagement between different stakeholders, emphasising the concept of resilience (Cabinet Office, 2003) and focusing on devolution of responsibilities to local authorities and multi-agency (Chmutina and Boshier, 2017). These devolved responsibilities mean that the different nations of the UK (England, Northern Ireland, Scotland and Wales) have had different development paths of their flood risk management (FRM) systems, with England and Wales being the first to proactively develop warning systems (Parker *et al.*, 1995). However, comparative analyses have also found significant similarities between FRM in England and Scotland (Hegger *et al.*, 2013). These similarities will be the focus of the current paper, whilst an exploration of the differences among the devolved systems are left to future work.

Flood hazards are one of the layers composing disaster risk, while vulnerability, capacity building and risk mitigation policies are also elements that define disaster risk in these two countries. Brazil has an inequality more visible at intra urban scale, especially in risk-prone areas, where people face substandard sewage and drainage systems, and other forms of deprivation. While not facing the same socio-spatial inequalities, flood vulnerability and risk are not equally distributed across the UK either, with social disadvantages playing an important role in the equation (Sayers *et al.*, 2018).

Flood risk mapping, performed at both the climatological and the weather time scales, which are used for planning and flood warnings applications, respectively, are generally based on field observations of limited spatial coverage that require coarse extrapolations to cover wider regions in Brazil. The other issue with the predominantly monitoring-based warning systems is the low antecedence time of the detection of events with risk of natural hazards, relative to more advanced numerical forecasting systems. Fleischmann *et al.* (2021) reported recent advances in flood hazard mapping in Brazil achieved through the expansion of hydrological monitoring networks, remote sensing and numerical modelling techniques. The low accuracy of digital terrain models of rivers and floodplains remains a hurdle for inundation modelling at the national scale.

The UK has gone a long way in establishing high-resolution flood hazard maps and impact-based forecasting systems over their territory. The technical information has been made available online to the public with supporting material explaining it in a way that is readily understood by people outside the field of hydrology. The “Flood map for planning” (Cabinet Office, 2021a) provides a service to search which flood zone a location is in, as part of land use planning. With an interactive map, it provides guidance to the public if planning a development will require undertaking a more detailed flood risk assessment. The “Flood Information Service” (Cabinet Office, 2021b) provides real-time information on flood warnings. They apply the risk matrix to determine the risk level combining the rating of expected level of impact according to streamflow and the rating of the probability of streamflow above the impact thresholds based on ensemble hydrological forecasting. It allows viewing the latest river and sea levels at a given location, checking the long-term flood risk for an area and viewing the five-day flood risk among other services.

Despite recent advancements, Brazilian and British systems are still in need of addressing various disaster risk elements to improve their flood risk governance apparatus. The scope of this article is to instigate an interdisciplinary cross-country collaboration and knowledge exchange, focused on tools, methods and policies used in the two countries in an attempt to develop trans-disciplinary ideas and initiatives for informing and enhancing Disaster Risk Management (DRM) and eventually contributing to the implementation of the Sendai framework (UNDRR, 2015). To achieve that, we explore research gaps and the potentialities of citizen-generated data (CGD) to support flood risk governance in Brazil and the UK. We have a broad understanding of the term CGD in this article to refer to the various types of data that are generated by citizens (as opposed to official agencies), either consciously for a public purpose – e.g. in initiatives labelled as citizen science, community-based research, crowdsourcing, volunteered geographic information – or as a by-product of digital citizen interactions – e.g. using social media or mobile apps. Whilst CGD has attracted interest in several application domains (e.g. Lämmerhirt *et al.*, 2018; Kullenberg and Kasperowski, 2016), the focus of this article is on the challenges related to flood risk governance.

Research inputs for this work were gathered during an international virtual dialogue that engaged experts from Brazil and the UK during the Covid-19 pandemic, in the framework of the international project “*Waterproofing Data: Engaging Stakeholders in Sustainable Flood Risk Management for Urban Resilience*” (Coaffee *et al.*, 2021). “*Waterproofing Data*” (WPD) is an international project that investigates the governance of water-related risks, with a focus on social and cultural aspects of data practices and is funded by the Economic and Social Sciences Research Council (ESRC), the São Paulo Research Foundation (FAPESP) and German Federal Ministry of Education and Research (BMBF), in collaboration with NORFACE, the Belmont Forum and the International Science Council.

In the next section, we unfold the methods, the webinar agenda, the online tools and the steps used to promote dialogues in the four focus groups. In Section 3, the main findings are shared considering the four main topics that guided the discussion: (1) risk knowledge, (2) flood forecasting and monitoring, (3) risk communication and, (4) flood risk governance. Finally, we shed light onto potential future pathways to enhance flood risk governance in both countries.

## 2. Methods

The online workshop took place on Monday 8 June 2020 and lasted 4 h. It was planned as part of the midterm meeting of the WPD project, and focused on generating a platform for knowledge exchange between more than 40 public servants, researchers from natural and social sciences, a varied mix of practitioners and other technicians engaged with flood forecasting, prevention and response in Brazil and the UK. Participants were recruited to

include following a snowball sample, with invitations sent to initial contacts, who suggested further relevant academics and practitioners to be invited. Following procedures approved by the ethics review (in the UK and Brazil), all workshop participants received previous information with the purposes of the study and how the workshop results would be anonymously used in research. Due to barriers of language and lack of access to the internet, it was not possible to include the flood-prone communities of Brazil and the UK in this activity, but they have participated in other in-person workshops of the overarching project.

The main objectives of the workshop were the following:

- (1) Share experiences and compare methods and processes related to FRM and flood data governance in Brazil and the UK;
- (2) Understand the potential and challenges of using CGD to support FRM; and
- (3) Define an agenda for future research collaborations.

The first part of the workshop was focused on six individual presentations on the topic of flood risk governance in Brazil and the UK. Scientists and policymakers from both countries explained different approaches and methods of addressing flood risk in their respective countries, major governance challenges as well as their experiences with flood warning systems and the utilisation of social media and other forms of CGD in the warning system. In more detail, the topics covered were:

- (1) Introduction to FRM in Brazil and the UK;
- (2) Flood forecasting approaches in Brazil and the UK; and
- (3) Citizen science and FRM.

The second part of the workshop was dedicated to focus group discussions. The participants were split into four small and mixed groups (6–8 people from Brazil and the UK per group) to facilitate the dialogue on four main topics: (1) risk knowledge, (2) flood forecasting and monitoring, (3) risk communication and (4) flood risk governance. Each of these groups has three main questions to discuss that are summarised in [Table 1](#).

Participants had 60 min to discuss their ideas within their focus groups and synthesised a collective reaction to the workshop topics. Through the use of the Milanote digital platform, group members were able to discuss and add their comments in an interactive board, with the help of two facilitators per group. After the group discussions, the participants joined again the general online room where nominated presenters by each group analysed the main research gaps, the potential of CGD and the research ideas on knowledge co-production. The next section shares the inputs of these three main questions in the four main broad topics: (1) risk knowledge, (2) flood forecasting and monitoring, (3) risk communication and (4) flood risk governance.

### 3. Results

#### 3.1 Risk knowledge

*3.1.1 Research gaps.* Conversations spanned across aspects of risk knowledge. Specific concerns on dealing with uncertainty in decision-making were raised. As argued by a Brazilian geologist: “*There are not only uncertainties in risk models but also regarding both the definition of risk and disaster risk in order to communicate about risk knowledge, and the audience to whom the researchers are communicating to*”. British participants presented similar problems the country faces with uncertainty stating that “*in the UK, there are good predictions of organised rainfall systems, but prediction of thunderstorms and associated flash floods are still quite poor and the uncertainties are not well described*” (UK-based hydrologist).

Topics	Risk knowledge	Flood forecasting and monitoring	Risk communication	Flood risk governance
Goals	Identify gaps in risk knowledge in Brazil and the UK, noting similarities and differences between the two contexts	Identify gaps in flood forecasting and monitoring in Brazil and the UK, noting similarities and differences between the two contexts	Identify gaps in risk communication in Brazil and the UK, noting similarities and differences between the two contexts	Identify gaps in flood risk governance in Brazil and the UK, noting similarities and differences between the two contexts
	Explore the potential of CGD in enhancing risk knowledge in Brazil and the UK	Explore the potential of CGD in enhancing flood forecasting and monitoring in Brazil and the UK	Explore the role of environmental education and CGD in risk communication	Explore the potential of CGD to enhance flood risk governance
Gap analysis	Come up with research ideas on co-producing risk knowledge with local citizens What are the gaps in risk knowledge? What are the needs for research? What types of data are needed?	Come up with research ideas for engaging citizens in flood forecasting and monitoring What are the gaps in the flood forecasting and monitoring? What are the needs for research?  What types of data are needed?	Come up with research ideas on the potential of environmental education to enhance flood risk governance What are the gaps in risk communication?  What are the roles of education and citizen science in warning systems? How do we promote people-centred warning systems? What types of data are needed?	Come up with research ideas on the potential of citizen generated data to enhance flood risk governance What are the gaps in our flood risk governance? What are the needs for research? What types of data are needed?
CGD	To what extent are citizen science methods used? What are the potentials and challenges to include CGD for improving risk knowledge?	To what extent are citizen science methods used? What are the potentials and challenges to include CGD for flood forecasting and monitoring?	To what extent are citizen science methods used? What are the potentials and challenges to include CGD in risk communication and environmental education?	To what extent are citizen science methods used? What are the potentials and challenges to include CGD in risk communication and environmental education?
Research ideas	How can we engage citizens to improve risk knowledge? What are future research directions?	How can we engage citizens to improve flood forecasting and monitoring? What are future research directions?	Is there any potential for enhancing flood risk governance through environmental education? How? What are future research directions?	Is there any potential for enhancing flood risk governance? How? What are future research directions?

**Table 1.** Working groups, goals and questions in the topics of risk knowledge, monitoring, communication and governance

Other participants highlighted the need for uncertainty to be represented at different scales in forecasting, arguing that while specific data may allow a good regional scale forecast, it is not able to predict local conditions accurately; thus, high temporal resolution in disaster forecasting is a very critical part of DRM that needs to be carefully considered.

Participants stated that to define disaster risk, the inherent physical vulnerability of the affected area and population needs to be considered. Participants from Brazil explained the difficulties in addressing the aspect of vulnerability – including the conditions of houses during risk mapping – since there are more than 5,000 municipalities in need of analysis. At the same time, UK participants stressed the need to think about types of vulnerability such as social, economic and institutional, with one of them arguing that *“it is difficult to collect data about infrastructure in the UK because the data sources and the stakeholders are sometimes not clear”*. Finally, a number of research gaps and questions about flood knowledge, forecasting and response arose during the discussion, including questions such as: *Where do critical impacts of flooding mostly occur? What are the indirect impacts of flooding on critical infrastructure? Who knows about these impacts? How can relevant data and information to support DRM can/should be collected?*

**3.1.2 Potential of citizen-generated data.** Following the directives of the meeting (Table 1), CGD was discussed as a viable option for addressing existing research gaps. Therefore, although there are many types of non-professional data in the UK, such as a snow hashtag, used to collect data from enthusiasts and amateur weather stations that report basic weather information, a huge potential for new initiatives has also been recognised. Looking to the future, data from automobile and CCTV systems (i.e. activated windscreen wipers indicating rain etc.) could prove invaluable sources of flood risk data. Additionally, local stories and indigenous knowledge were also mentioned in the discussion, with a participant arguing that memories of severe events are often preserved for many generations in Brazil.

Participants discussed examples of citizen science utilisation for DRM. One of them pointed out the importance of documenting and comprehending the understandings of people’s geographical locations to increase the efficiency of the spatial information communicated to them – e.g. they often do not know the names of local rivers or nearby settlements (except big towns) or road names/numbers. A geologist from Brazil argued that citizen science data can be very useful in dealing with the lack of data: *“In Brazil, there are not always good digital elevation models, which makes models difficult. In this way, many mappings are made based on field evidence. So, it would be very useful if the population could collaborate in the historical records of flood events”*.

Another hydrologist from Brazil stated, *“there is a need for a framework to include citizen science data in real-time monitoring”*. For him, one of the main challenges is how these citizen science initiatives can be kept in the long term. During the conversation about this particular challenge, the essential role of engaging schools and community groups as mediums of communicating hazards and their impacts to local communities was particularly highlighted. According to a participant with a social science background, such a long-term engagement could contribute to the consolidation of relationships between scientists and stakeholders: *“In risk communication, the audience needs to be considered carefully. Maps can be appropriate for one sector, but for others verbal narratives may be much more powerful in risk communication”*.

**3.1.3 Research ideas.** As previously outlined, data provided by citizens play an important role in DRR. To keep citizens motivated, some feedback on their data needs to be provided to them as well as an effective way of visualisation, such as gamification or other innovative visualisation techniques, as there is a variety of data types provided by citizens, and thus, the methods for data collection need to be adapted accordingly. For instance, indigenous knowledge and local stories could be gathered by sitting down with people, listening and documenting their personal experiences.

Another method could be sketch maps (Klonner *et al.*, 2021): people mark their personal flood risk knowledge of local areas in paper maps, which are afterwards automatically georeferenced and ready to be used for further geospatial analysis, combined with other data, such as technical sensor data. Data are portrayed on a Web portal, and thus, citizens can

access and see their own contributions, a process that could lead to motivation for further engagement. In addition, social media data are an excellent novel source of disaster-related information, and it is important to find ways to extract risk information from photos of a flood, for example.

Where possible, mobile apps need to be developed where community leaders and members can feed in real-time information. This development should be co-produced with community leaders in a dialogical way (Albuquerque and Almeida, 2020; Coaffee *et al.*, 2021) so as to pinpoint the main areas of concern prior to the app development, such as the identification of elements that people consider essential within their respective communities. In this way, the benefits of both the development and utilisation of the end-product (mobile app) and the capacity building process through data collection for the local community would be maximised.

The final part of this discussion included a brainstorm section, which led to the generation of interesting research ideas on the basis of interdisciplinary collaborations and transdisciplinary methods. Some participants mentioned that new methods should be created to promote citizen science to the public sector, emphasising media campaigns to encourage people to get involved in citizen science and the promotion of specific hashtags to facilitate the data analysis process. Other strategies were also proposed, such as the potential to work with arts bodies to build engagement with citizens, which could provide a different perspective to scientist-led projects, while mediums like poetry and educational campaigns in schools were also mentioned. “*Methods need to be developed with teachers and students*”, proposed one anthropologist from Brazil. “*Ideally, educational campaigns also engage students with data collection so that they can deeply understand the data collection methods and methods of modelling. In this way future use is encouraged*”, complemented by one researcher with a background in volunteer geographic information (VGI). Finally, acquiring data from people with key occupations positioning them in the right place to observe impacts, such as public servants (i.e. police, utilities engineers), but also long-distance drivers would be significantly beneficial for improving risk knowledge.

### *3.2 Flood forecasting and monitoring*

*3.2.1 Research gaps.* Participants have identified three research gaps: data visualisation, data and system integration and forecasting improvement. In terms of data visualisation, suitability for decision support systems, especially the way different types of data are made available for reading and interpretation, was stressed. It was mentioned that data visualisation should consider the production of user-based displays (for operational forecasters, stakeholders and general public) to incorporate their knowledge and address their interests. Additionally, data and system integration should consider how to deal with different types of data, and identify ways to promote the interoperability of heterogeneous monitoring platforms, to invest in system-of-systems approaches and real-time data integration. Participants also discussed the difficulty to receive feedback from disaster response agencies and people on the ground, pointing out the importance of communication flow.

*3.2.2 Potential of citizen-generated data.* Regarding the potential of CGD, participants have agreed on the importance of social sensing in four main uses:

- (1) Forecasting activities;
- (2) Impact assessment;
- (3) Model validation and improvement; and
- (4) Decision-making processes.

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Finally, participants have highlighted the need of considering passive (scraping what is there on Twitter) and active (asking for inputs, e.g. WOW) forms of social sensing, since different publics will be engaged in different methods of participation.

*3.2.3 Research ideas.* Participants set two main topics of future research: the problem of engaging citizens and the ways of designing these research paths.

Engaging citizens was considered a major challenge for social sensing because of the misunderstandings about the essence and content of social sensing, which was considered between the group as the use of locally generated knowledge for scientific and governmental purposes. However, one must consider the need to promote spaces for dialogue in which citizens themselves present their demands and the ways in which these demands can also be resolved by agents of science and government.

Regarding future research paths, proposals may vary from the production of increasingly accurate local data for flash flood forecasting, creation of effective vulnerability indicators to be used in forecast, mapping and decision-making, visibility and integration of systems and data, promotion of partnerships with citizens and improvement of data flows for joint action.

### *3.3 Risk communication*

*3.3.1 Research gaps.* Three main gaps were identified by the discussants and are presented below.

First, even though scientists and citizens speak the same language – Portuguese or English – the use of communication tools has specific challenges. Common problems relate to disconnections between what scientists want to say and what people understand, which might take place due to differences in background and to the ways the information is communicated. Scientists should be attentive to telling people what they need to know, which requires learning about users' requirements, and to using a less technical language. This user-friendly communication implies the use of reference words and standard visual delivery of warnings, including pictures, images and symbols. Future research can contribute to filling these gaps by indicating more appropriate ways of communicating and increasing people's engagement.

Secondly, trust-building is essential in any communicative process involving risks, but there is not much structured knowledge on how to promote it. "*Studies and practitioners have already indicated that planning risk perception activities with citizens and having people recognized by the community among the promoters of a project can leverage trust and people's understanding of risk communication*", said one of the experts on DRR education.

Another gap relates to the link between risk communication and science. Considering that risk includes magnitude and probability, scientists have to deal with communication questions that are currently unanswered: When is the best time to communicate risk, and to act on it? How to communicate the uncertainty surrounding quantitative risk estimates?

*3.3.2 Potential of citizen-generated data.* CGD was viewed as a tool with low cost and great potential for data production. It can contribute to generating up-to-date and country-wide information, scaling-up more informed participation and engaging interested parties, e.g. on Twitter and Facebook.

However, CGD is often perceived by scientists as not "scientific enough", unreliable and time-consuming, requiring validation and corrections. It is also depicted to incorporate an inherent data bias, since it usually relates to impactful phenomena, and not to common events that could verify scientific models. Therefore, it is necessary to have a better understanding of how and when we should engage citizens with data generation, considering different types of hazards and people's routines.

In the UK, the British Geological Survey (BGS) has been using CGD, despite problems related to data acquisition in terms of quantity, quality and location, since data availability



does not always match data needs. For example, there is an abundance of information about London, while simultaneously, data about remote areas of Scotland are rather scarce. In Brazil, on the other hand, governmental agencies rarely use CGD, and its adoption is viewed with significant caution due to the continental dimension of the country and the unequal access to technologies of information and communication by different groups of citizens.

*3.3.3 Research ideas.* Considering the previous discussions, research ideas have been addressed on two different issues. First, the building of research and public policies that integrate CGD, DRR and resilience, and second, the need for theoretical and practical advances on how science can co-produce and incorporate data from passive (the use of bots in Twitter, e.g.) and active forms of citizen participation (i.e. citizen data collection, through homemade rain gauges) in current schemes of flood risk communication and governance.

### *3.4 Flood risk governance*

*3.4.1 Research gaps.* The final topic of the focus group discussions during the workshop was concentrated around flood response capabilities and flood risk governance. Participants agreed that approaches towards flood risk governance and gaps in research in Brazil and the UK have some differences but most importantly share key similarities. Therefore, while Brazil's territorial size and the federal governance model raise concerns about the appropriate scale in flood risk forecasting and response, in the UK, the level of detail in different administrative scales was characterised as adequate for facilitating flood forecasting and response; yet, a gap between planning and FRM was identified. Moreover, while Brazilian participants stressed the need for more accurate data and warnings on flash floods, particularly at neighbourhood level, both geographic groups identified the need for historic data from local citizens to complement existing flood risk models in both countries. In general, the absence of local, contextual knowledge from the flood risk governance apparatus was pinpointed, especially by Brazilian participants.

Further need for understanding of local context was a major issue of discussion within the group. Participants noted that the lack of understanding of citizen needs and problems limited the accuracy of flood models while concurrently hampering the ability of providing an integrated and effective flood response.

Another gap discussed was the complex governance structures and unclear jurisdictions between authorities and operational agencies. While in the UK, the Natural Hazards Partnership (NHP) provides some coordination among involved agencies, in Brazil, the additional administration level (state level) increases the complexity of flood risk governance mechanisms. This inherent problem of governance structures ultimately creates institutional problems of collaboration among flood-related agencies in both countries, which ultimately reduces the capacity to predict and confront flooding events. Coordination of activities and clarification of jurisdictions and responsibilities were undoubtedly the most key research topics discussed by the group.

Finally, the need for a wider restructuring of flood risk governance apparatus with broader inclusion of local communities and stakeholders and central coordination has been underlined as a vital objective for more effective flood response.

*3.4.2 Potential of citizen-generated data.* Participants stated that CGD can provide a timeline for flood events and inform flood risk response agencies, but also cultivate a flood resilience culture to local citizens and even stimulate behavioural change, through targeted visualisations and educational practices.

Additionally, group discussions emphasised the importance of producing place-based knowledge through CGD to complement existing qualitative and quantitative datasets by focusing on generating fine-grained information on different scales, and most importantly for smaller scales where information is often scarce.

In a nutshell, CGD was seen by Brazilian and British participants as an indispensable component of effective risk governance, with immense capabilities. Yet, considerations regarding the transferring of biased citizen assessment to newly created CGD, a reality that could add a level of difficulty in flood risk monitoring and response, were also underlined and seriously taken into account.

*3.4.3 Research ideas.* The last part of the group discussion was dedicated to emerging research ideas for enhancing flood risk governance through exploiting the potentialities of CGD in Brazil and the UK. Emerging research ideas stressed the need for connecting urban and regional planning to flood response, planning for addressing the impact of climate change and localising the objectives and implementation of global directives, such as the sustainable development goals (SDGs), to more local realities.

#### 4. Discussion

Exploring transdisciplinary methods for improving disaster risk governance is a major challenge for academics, practitioners and local authorities around the world (Murray, 2017). Transcultural comparative dialogue and knowledge exchange between DRM agents with dissimilar experiences in confronting urban risks, needs to be encouraged and promoted as a platform for the co-designing of ideas, methods and practices.

The accelerated importance of citizen participation in FRM through the production of CGDs has been widely recognised in academic literature (Lautze *et al.*, 2011; Wehn *et al.*, 2015) not only as a complementary data source but also as a means for enabling the empowerment of local communities (Albuquerque and Almeida, 2020). However, as CGD production, circulation and utilisation vary across different geographical locations, their potential to facilitate a more comprehensive governance of flood risks is still unclear. Therefore, the fundamental focus of this workshop was to explore this potential through investigating research gaps in risk knowledge, flood forecasting and monitoring, risk communication and flood risk governance, through small-group discussions. Table 2 provides an integrated summary of the research gaps, CGD potential and research ideas derived from the discussions among the different focus groups.

Based on the discussions, the major research gaps identified in both countries relate to the lack of local data, lack of data integration systems and data visualisation tools and lack of communication between flood agencies. In more detail, in Brazil, locally relevant data are scarce, and hence, the validity of flood forecasting models is subsequently compromised. On the other hand, despite the adequacy of flood-related data in the UK for several administrative levels and geographic locations, the lack of adequate visualisation tools in conjunction with the absence of a national data integration system limits the forecasting and response capacity of flood agencies. Finally, a common issue noted was a problematic communication among flood responsible agencies, which coupled with vague and unclear responsibilities of such agencies result in a complex and problematic flood response apparatus.

These challenges are similar to those reported by other studies around the world. In their analysis of early warning systems (EWS) in Africa, the Caribbean and South Asia, Lumbroso *et al.* (2016) interviewed several practitioners who mentioned barriers such as the lack of high-quality data, lack of technical and technological capacity to generate weather forecasts, deterioration of monitoring rain gauges, poor accessibility of warning systems, etc. This scenario was confirmed by Dávila (2016), who analysed 21 flood warning systems in the Latin America and Caribbean (LAC) and reported that monitoring tasks were being performed without sufficient risk knowledge: 62% have hazard maps, while 37% have information and studies about vulnerability, and 20% promoted social participation in monitoring activities.

In the WPD workshop, participants highlighted the potential of CGD to contribute to the improvement of flood risk governance. The provision of low-cost country-wide data with the ability to inform and validate existing flood models along with the capacity to stimulate behaviour

**Table 2.**  
Gaps, potential of CGD  
and research ideas  
according to the four  
focus groups

	Risk knowledge	Flood forecasting and monitoring	Risk communication	Flood risk governance
Research gaps	<ul style="list-style-type: none"> <li>• Uncertainty</li> <li>• Vulnerability</li> <li>• Flash flood prediction</li> <li>• Data on the above</li> <li>• More local data</li> <li>• Impact data</li> <li>• Vulnerability indicators/social parameters</li> </ul>	<ul style="list-style-type: none"> <li>• Data visualisation, data and system integration and forecasting improvement</li> <li>• Data visualisation suitability, user-based displays, multiple data management, interoperability of heterogeneous monitoring platforms, system-of-systems issues, real-time integrations, increase communication flow and joint action</li> <li>• Earth Observation satellite data, flood maps, digital terrain models and vulnerability/socioeconomic indicators</li> </ul>	<ul style="list-style-type: none"> <li>• Use of communication tools</li> <li>• Trust-building</li> <li>• Link between risk communication and science</li> <li>• Focus on citizens – their language, needs, trust bridges and understanding on science</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of communication between flood risk agencies</li> <li>• Complex governance structures and unclear jurisdictions</li> <li>• Lack of communication between different FRM stakeholders</li> <li>• Limited data availability in small administration scales</li> <li>• More focus on local contextual realities is needed</li> <li>• Deeper involvement of local communities in flood risk governance</li> <li>• Small-scale high-quality data</li> <li>• Contextual and place-related data</li> </ul>
Potential of CGD	<ul style="list-style-type: none"> <li>• Brazil: Need for a framework for use. In the UK, used for validation/ground-truthing</li> <li>• Getting large amounts of data: frequently updated; from otherwise unobserved areas</li> <li>• Quality control</li> <li>• Need to consider different audiences</li> </ul>	<ul style="list-style-type: none"> <li>• Initial practices for social sensing</li> <li>• Potentials: to forecast, to map impacts, to validate models and to contribute in decision-making processes</li> <li>• Challenges: data standards, consider passive and active forms of social sensing, consider citizens needs</li> </ul>	<ul style="list-style-type: none"> <li>• CGD not used by Brazilian government</li> <li>• UK used CGD but with challenges</li> <li>• Getting updated, low-cost and country-wide data</li> <li>• Quality control</li> <li>• Need to consider quality and location issues</li> </ul>	<ul style="list-style-type: none"> <li>• CGD is only partially used in specific cases in the UK and Brazil and mostly for research rather than operational purpose</li> <li>• CGD can provide a timeline for flooding events</li> <li>• CGD can be used to cultivate a resilience culture to local people</li> <li>• CGD can complement existing datasets</li> <li>• Assessment of local people might be biased and can add a layer of difficulty for flood response</li> <li>• CGD can stimulate behavioural change towards floods</li> </ul>

(continued)

	Risk knowledge	Flood forecasting and monitoring	Risk communication	Flood risk governance
Research ideas	<ul style="list-style-type: none"> <li>• Engagement through schools, community groups, public servants</li> <li>• Media campaigns, games, arts</li> <li>• Feedback – seeing their own data used</li> <li>• Focusing on key citizen scientists in public sector: police, engineers</li> <li>• Aiming for specific/ different sectors</li> <li>• Development of methods for collecting and sharing data</li> </ul>	<ul style="list-style-type: none"> <li>• It is necessary to consider the need for dialogue in which citizens themselves present their demands and the ways in which these demands can also be resolved by agents of science and government</li> <li>• Production of increasingly accurate local data for flash flood forecasting, creation of effective vulnerability indicators to be used in forecast, mapping and decision-making, data and systems visibility and integration, partnerships with citizens and improvement of data flows for joint action</li> </ul>	<ul style="list-style-type: none"> <li>• Research and public policies that integrate CGD, disaster risk reduction and resilience</li> <li>• Advances on how science can co-produce and incorporate citizen participation in current schemes of flood risk communication and governance</li> </ul>	<ul style="list-style-type: none"> <li>• Focusing on better communication between flood-related agencies</li> <li>• Clarification of responsibilities and jurisdictions of flood-related agencies</li> <li>• Further engagement of local communities in flood risk governance</li> <li>• Incorporation of climate change impact</li> <li>• Localisation of the SDGs in Brazil and the UK</li> <li>• More effective connection between urban planning and flood risk</li> <li>• Formally established platform for knowledge exchange in flood risk governance between Brazil and the UK</li> </ul>

Table 2.

change was underlined as the most essential. While the first potential is mostly related to the usage and circulation of flood-related data, the latter should be rather observed through the lens of data generation as an opportunity for transformation of local reality, through the gradual cultivation of a flood resilience mentality both within local communities and across DRM agents (Pitidis and Coaffee, 2020). The engagement of citizens in the generation of flood-related data may also help to address a major challenge related to the making information of flood risks intelligible to the general population. This challenge has been discussed in previous literature, e.g. as regards to the city-scale accessibility of emergency services (fire and rescue) (Green *et al.*, 2017).

Nevertheless, the potential of CGD to support flood risk governance is a challenging and complicated process and thus should be dealt with caution. Challenges acknowledged by the workshop participants are in accordance with academic literature (Degrossi *et al.*, 2018; Albuquerque and Almeida, 2020) and generally focus on the quality of the collected CGD and the subsequent need for the establishment of quality control mechanisms to ensure the validity, accuracy and reliability of the collected information. Moreover, the need to develop adequate systems to enable the interoperability and efficient combination among different data sources was also underlined.

## 5. Conclusions

FRM is a particularly complex yet instrumental challenge for local authorities regardless of geographical locations. Brazil and the UK are continuously exposed to flooding events, which are sometimes coupled with other challenges, such as the current global pandemic that put pressure on the entire disaster response apparatus, as the December 2021 and January 2022 floods in the states of Bahia and Minas Gerais demonstrated. Therefore, there is an increasing need for both improving existing flood forecasting and response mechanisms and exploring alternative pathways to enhance knowledge exchange among academics, practitioners and communities in both countries.

Further engagement with community groups and individuals through formally and informally established institutions, such as universities, schools and citizen organisations, with a specific focus on CGD generation, curation and usage is needed. Additionally, both countries need to elucidate the responsibilities of flood-related agencies and develop efficient communication strategies and feedback circulation among them, and a more effective connection between urban planning and flood risk.

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