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Using the 'myVolcano' mobile phone app for citizen science in St. Vincent and the Grenadines: a pilot study

Official Development Assistance, Earth Hazards & Observations, Informatics, Geoanalytics & Modelling Programme

Open Report OR/17/045

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BRITISH GEOLOGICAL SURVEY

Official Development Assistance, Earth Hazards & Observations, Informatics, Geoanalytics & Modelling PROGRAMMES

Using the 'myVolcano' mobile phone app for citizen science in St. Vincent and the Grenadines: a pilot study

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Summary

The British Geological Survey (BGS) has been working with Caribbean partners on the role of citizen science in increasing resilience to natural hazards. The work has largely focused on the potential use of the myVolcano smartphone app, which was developed by the BGS following the 2010 Eyafjallajökull and 2011 Grímsvötn eruptions in Iceland. During these eruptions the BGS asked the UK public to collect particle samples, subsequently analysing these for ash presence to map the distribution of ash fallout across the UK. These requests led to the development of the myVolcano app, which was designed to capture transboundary and distal observations of volcanic ash and emissions. The observations are made visible to other users via an interactive map built into the app. The map interface has global coverage and the data collection methods (free-text descriptions and photographs) are such that information about any natural hazard, anywhere in the world, can be captured.

In 2015, BGS carried out an ESRC-DfID-NERC funded scoping study in collaboration with the University of the West Indies' Seismic Research Centre (UWI SRC), to test the potential use of the app in environments affected by proximal volcanic hazards. The study focused on St. Vincent and the Grenadines and investigated the potential for capturing a wider variety of observations for use by the public, operational scientists and civil protection. The study, which included a combination of desk study and remote interviews, highlighted the potential for, and challenges of, using such an app for increasing resilience to natural hazards and the need for a follow-up study in St Vincent.

In March 2017, a workshop and school activities were held in St. Vincent to collect feedback from potential users of myVolcano, hereafter referred to as the pilot study. Workshop participants came from across government, monitoring agencies, emergency response and telecommunications. As part of the workshop, a multi-hazard scenario was 'played out' to stimulate discussions on the usability of the app, data gathering and processing, and participants' use of existing citizen science applications. Discussions developed around data validation and quality assurance, data sharing and presentation, local management of data by nominated scientists (e.g. to facilitate real-time decision making) and the associated need for a locally appropriate app (i.e. no one size fits all). This last point is particularly significant when considering the utility of an app in several countries – the user interface, at least, requires specific tailoring to the country's needs. Using this feedback, the BGS Official Development Assistance (ODA) programme is currently funding collaborations with Caribbean partners in order to modify the app to meet the local requirements, including widening the multi-hazard application and enhancing two-way information sharing. Of particular importance is how best to share critical information with those making observations and how to make observations available to decision-makers and monitoring scientists in real-time (e.g. through local management of the app).

1 Background

1.1 CITIZEN SCIENCE IN VOLCANIC ENVIRONMENTS

Volcanic environments are typically under-monitored, in part owing to the cost of equipment and maintenance (Brown et al., 2015a). Evidence suggests, however, that communities can participate, not only in the monitoring of their volcanic environment, but in discussions that raise awareness, understanding and preparedness, whilst also supporting early warning systems (e.g. Stone et al., 2014).

Community observers can bridge the gap and enhance the trust between citizens and scientists, as well as enhance social capital (Stone, et al., 2014; Stevenson et al. 2013). For example, past or ongoing citizen science initiatives have involved citizens collecting volcanic ash fallout (Bernard, 2013; Stevenson et al., 2013), observing and monitoring their environment on a daily basis to help reduce community risk (Stone et al., 2014) and helping to understand the evolution and impacts of volcanic eruptions that may contribute towards aid, recovery and mitigation efforts (e.g. Loughlin et al., 2002). Figure 1 illustrates the components of increasing resilience to natural hazards where citizen science could contribute.

Figure 1: Components of increasing resilience to natural hazards where citizen science could help.

Due to the dynamic nature of volcanic environments, there are opportunities to engage with citizens on an almost continuous basis to assess flooding, landslides, felt earthquakes and so on. Many volcano observatories collect information on earthquakes and their impacts (e.g. UWI SRC, United States Geological Survey, GeoNet New Zealand etc.), sulphurous odours (e.g. Iceland Met Office) or ash samples (e.g. Alaska Volcano Observatory (Wallace et al., 2015), Montserrat Volcano Observatory etc.) during eruptions.

1.2 CITIZEN SCIENCE AND MYVOLCANO

myVolcano was developed as a tool for collating observations, photographs and sampling location of distal volcanic ash following the eruptions of Eyafjallajökull and Grímsvötn volcanoes in 2010 and 2011, respectively. During these eruptions the British Geological Survey (BGS) asked the UK public to collect particle samples, which were analysed by microscope for the presence of ash and subsequently used to map the distribution of ash fallout in the UK (Stevenson, et al., 2012; 2013). The app was developed to ensure a more streamlined process of data collection in the event of future eruptions affecting the UK. A scoping study of citizen science in St. Vincent (Mee and Duncan, 2015) proposed that involving citizens, communities, scientists and other key

stakeholders in the collection, analysis and sharing of observations via myVolcano could help, in part, to address the shortfall in data collected from volcanic environments.

The study identified a number of key challenges, including:

- Managing data validation and quality assurance (including rumour quelling);
- Ensuring resilience of key systems (i.e. telecommunications);
- Motivating volunteers, managing expectations and ensuring safety;
- Data sharing (between users, scientists and decision makers);
- Appropriate mobile phone platforms (e.g. iOS, Android etc.).

In order to address the challenges identified during the scoping study, and to test the app with potential users, it was identified that an in-country workshop was required, which would include demonstrating the app to a range of potential users – both of the app and the data it would collect. With funding from the Global Geological Risk Platform of the BGS Official Development Assistance (ODA) Programme, a stakeholder workshop and several school activities were carried out in March 2017 and this report discusses the approach to, and results from, those activities.

1.3 DEVELOPMENT HISTORY

The principle functions of myVolcano are to:

- Upload free-text observations;
- Upload photographs;
- Upload simple measurements of distal volcanic ash samples;
- Learn how to collect distal volcanic ash samples;
- View global volcano information (locations, eruptive history etc.);
- Access others users' observations.

Figure 2 summarises the development history of the app, including additions such as translation into Spanish, inclusion of 'home region' pages and development on Android.

	2014 March/April	2014 November	2015 February	2017 March
VERSIONS	V 1.0 V 1.1 V 1.1.1	V 1.2 V 1.2.1	V 1.3	V 2.0
PLATFORM	iOS	iOS	iOS	iOS and **Android**
MAP LAYERS IN MYVOLCANO	Volcanoes Observations Basemaps	Volcanoes Observations Various basemaps	Volcanoes Observations Various basemaps	**Home region pages** **VAAC areas map** Volcanoes Observations Various basemaps
ADDING AN OBSERVATION	Free-text description Add photo Collect ash sample Ash sample measurements	Free-text description Add photo Collect ash sample Ash sample measurements	Free-text description Add photo Collect ash sample Ash sample measurements	**Streamlined interface** Free-text description Add photo Collect ash sample Ash sample measurements
ADDITIONS AND UPDATES	myVolcano website Web version of the app Download data facility Bug fixes	**Spanish version** myVolcano website Web version of the app Download data facility	**Photo GPS for location** Spanish version myVolcano website Web version of the app Download data facility	Photo GPS for location Spanish version myVolcano website Web version of the app Download data facility

Figure 2: Timeline of myVolcano developments (new additions in red text)

At the time of the workshop, version 1.3 of myVolcano was published and available for download on Apple devices, whilst version 2.0 (available on both Apple and Android) was developed but unreleased. There was also a third prototype (unreleased) 'multi-hazard' version of myVolcano which included a number of more detailed questions about hazards, such as landslides, volcanic gases, flooding, earthquakes etc. (Figure 3).

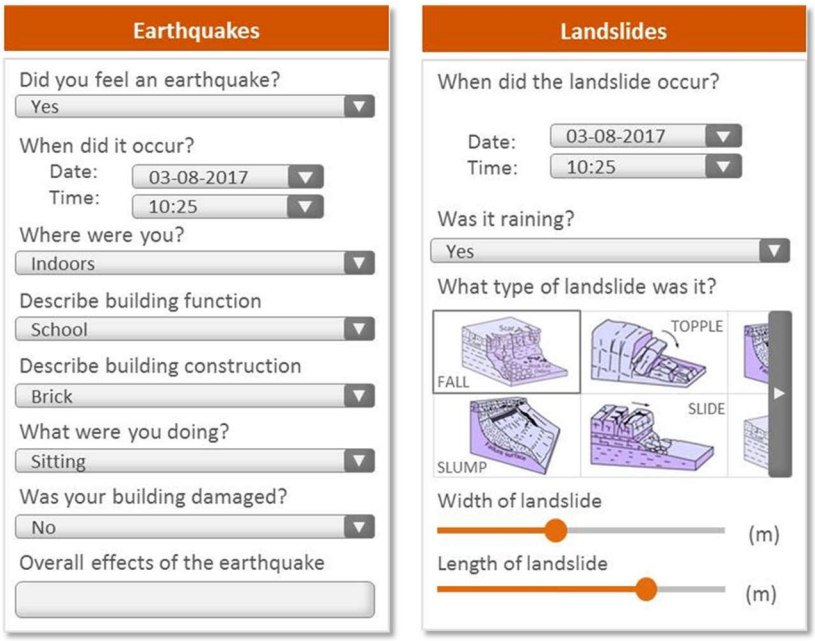

Figure 3: Examples of more detailed questions about a range of hazards in the prototype 'multi-hazard' version of myVolcano.

A simplified version of the myVolcano was also duplicated on a website to enable non-iOS users (prior to Android development) to submit and access observations (Figure 4).

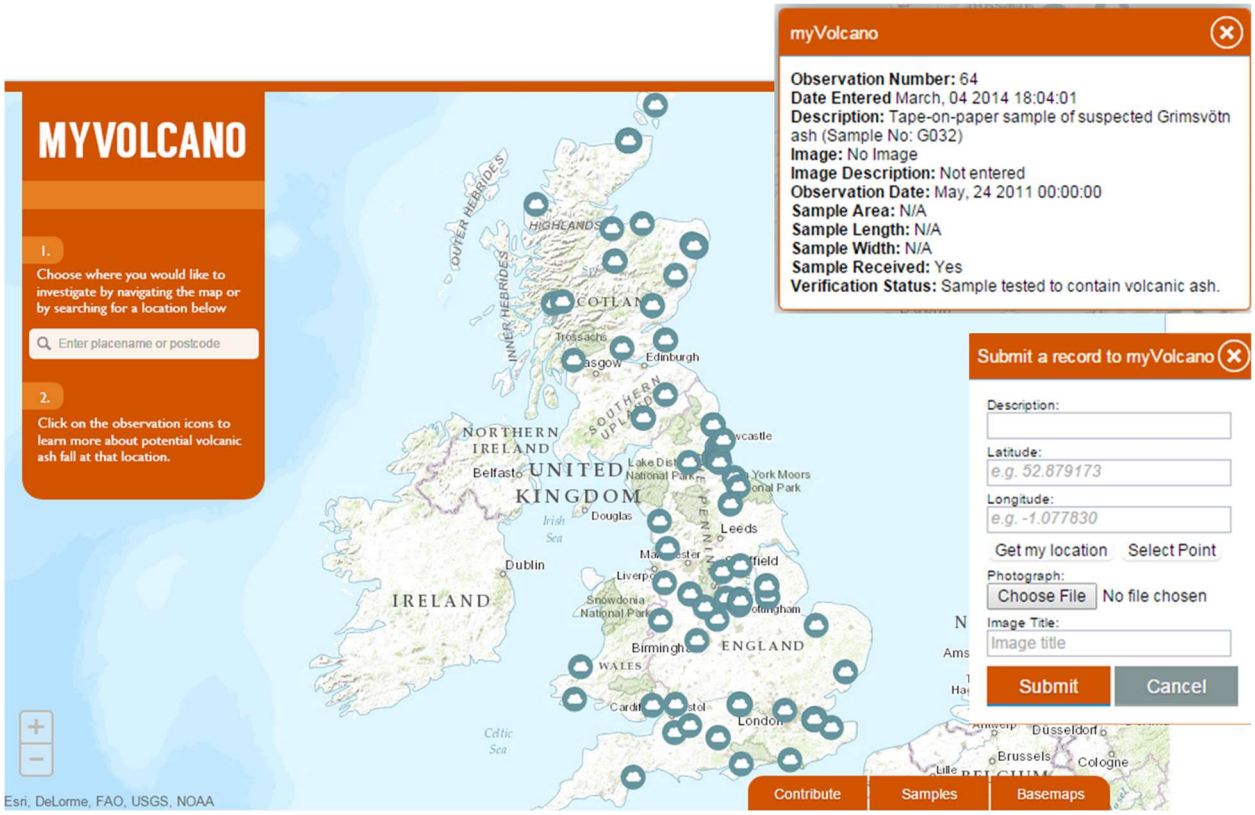

Figure 4: The web version of myVolcano allows users to upload images and descriptions and view all submitted observations, but does not show global volcano information.

1.4 VALIDATING OBSERVATIONS

When observations are submitted via myVolcano, they are subject to a checking process before being published in the app (Figure 5). This process involves checking for malicious or offensive content, as well as empty or irrelevant submissions. Checking is currently done by the BGS Enquiries team, which does not check for scientific validity of observations, nor does it provide any additional interpretation of the submissions. Since checking is only performed during normal business hours, it usually takes approximately 24 hrs for submissions to be approved and longer over weekends and public holidays. There may also be a delay due to different time zones if observations are posted outside of the UK. Once an observation has been through the checking process and has been approved for publication, it is then made visible to other users via the map interface, although users must restart the app for them to become visible. The subject of how to manage incoming observations was a key theme for the workshop.

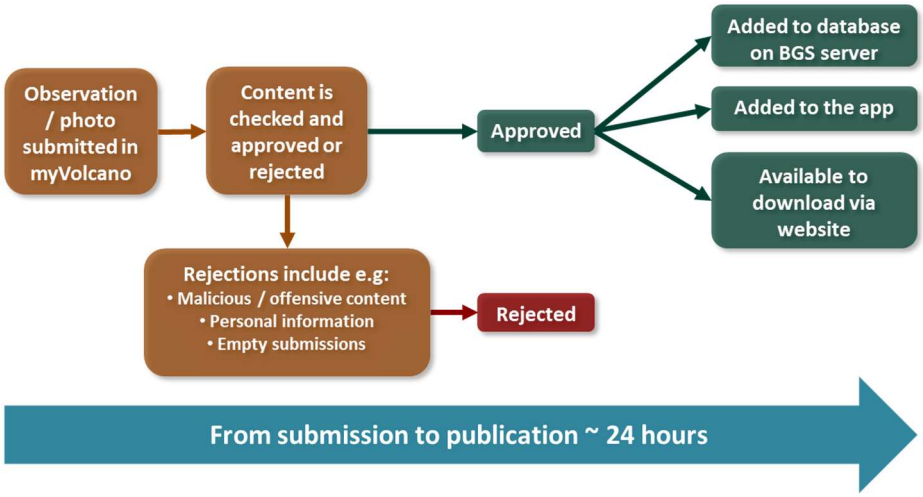

Figure 5: The existing verification process for all new observations and photos submitted in myVolcano, which can take up to 24 hrs before being approved and published.

2 Aims and objectives

The overall aim of the workshop and school visits was to explore the practicality and usefulness of recording observations through the app by groups of potential users (including both uploaders and users of the app data), and in addition to raise awareness and encourage uptake of the app.

The objectives were to:

- Explore the existing/potential role of citizen science in St. Vincent;
- Raise awareness of the myVolcano app;
- Identify types of data or information that users would like to see in myVolcano and how they would use it;
- Provide an opportunity to test how data are uploaded and accessed through myVolcano and gather feedback on functionality;
- Explore issues around: everyday observations, data quality and assurance, language, trust, data sharing, telecommunications redundancy, health and safety, motivating volunteers, utilisation in a crisis, etc.;
- Gather suggestions for improvements;
- Gather information about mobile phone usage and most popular operating systems in St. Vincent (e.g. Android vs. iOS);
- Encourage use of myVolcano to provide the opportunity to analyse incoming data over the coming weeks and months post-field visit;

- Continue building a community of interested stakeholders.

The following section briefly describes St. Vincent and the Grenadines in terms of hazards, risk and disaster management.

3 St. Vincent and the Grenadines

3.1 HAZARD AND RISK PROFILE

St. Vincent and the Grenadines (SVG) is an archipelago state in the Eastern Caribbean. The active volcano (La Soufrière) sits in the north of the main island (St. Vincent) and the island is exposed to a number of natural hazards including flooding, tropical cyclones, earthquakes and landslides. Ninety-seven percent of the population live within 30 km of the volcano (Loughlin et al., 2015). Since 1700, La Soufrière volcano has erupted explosively at least four times and exhibited several non-explosive, effusive eruptions (Robertson, 1995). During the last century alone, there were two major eruptions that had significant impacts: an eruption in 1902 that resulted in the deaths of 1565 people (Aspinall et al., 1973) and an eruption in 1979 that resulted in no deaths but caused extensive damage to crops and livestock (Lindsay et al., 2005). Since 1990 most fatalities in St. Vincent have been caused by floods and landslides and most economic losses are caused by tropical cyclones (UNISDR, 2015).

SVG is a Small Island Developing State (SIDS) with an estimated population of 109,373 and GDP per capita of US$ 6515 in 2012 (GFDRR, 2014). Thirty percent of the population lives below the national poverty line (GFDRR, 2014). The public external debt relative to GDP ratio was 70 % in 2012, which results in St. Vincent and the Grenadines having limited capacity to manage fiscal impacts of exogenous shocks (GFDRR, 2014).

3.2 HAZARD ASSESSMENT AND MONITORING

Collectively, the University of the West Indies Seismic Research Centre's (UWI SRC) scientific staff has had experience of volcano-seismic crises in several Caribbean islands over the past three decades (SRC contribution to Brown et al., 2015a, 2015b). Over half the present staff (60 %) has experience of volcanic eruptions (SRC contribution to Brown et al., 2015a, 2015b). They also monitor and advise on earthquake and tsunami hazard across the region. There are 35 full-time staff (19 scientific, 8 technical and 8 support staff) made up of seismologists, volcanologists and geologists, amongst many others (SRC contribution to Brown et al., 2015b). There exists, therefore, substantial regional knowledge and expertise. However, there is also a significant demand on capacity, especially during volcanic unrest and hazardous events: SRC currently monitors active volcanoes on 8 territories (a total of 21 volcanoes) of the Lesser Antilles (SRC, personal communication, 2011) where 12 of the islands have one or more active volcanoes (see Lindsay et al., 2005). On St. Vincent, UWI SRC collaborates with a small local unit called the Soufrière Monitoring Unit, which operates from the Ministry of Agriculture in Kingstown.

3.3 DISASTER MANAGEMENT

The National Emergency Management Organisation (NEMO) of SVG was established in January 2002 to coordinate the use of all available resources (local, regional and international) to ensure that all the people of St. Vincent and the Grenadines are better able to mitigate against, prepare for, respond to and recover from disasters in the shortest possible time (Government of St Vincent, 2017).

4 Workshop methodology and approach

The workshop and school activities in St. Vincent had the dual purpose of raising awareness of myVolcano and gathering feedback on all aspects of the app and were designed to target a range of participants. The primary activity was a workshop, which involved focus group discussions with key stakeholders, in particular those deemed most likely to use the data being collected by the app (e.g. scientists, decision makers, disaster managers etc.). A second activity directed at secondary school children, involved presentations and question-and-answer sessions and was designed to explore myVolcano from the point of view of someone providing the observations. Questionnaires were provided to the workshop participants and school students after the activities to gather specific feedback on mobile phone operating platforms and attitudes towards myVolcano. A presentation was also given to staff at UWI SRC in Trinidad and informal discussions around the functionality and potential of myVolcano provided further feedback from the perspective of monitoring scientists. The following sections describe the sampling, design and implementation of activities and discuss the details of the methods and approaches adopted during the workshop and school visits.

4.1 APP VERSIONS

It was uncertain how many attendees would have Apple devices and therefore be able to download the published version of myVolcano (v1.3) on their own devices. Therefore, BGS staff provided 3 iPads and 3 laptops with various versions of myVolcano installed. These included:

1) The published version 1.3 of myVolcano installed on all 3 iPads and available to participants with iOS devices;
2) The unreleased version 2.0 of myVolcano, which was installed on 2 iPads and 2 laptops;
3) The prototype 'multi-hazard' version of myVolcano, installed on one of the iPads;
4) The web-version of myVolcano, which was accessible to all users either via their own devices (smartphones, tablets and laptops) or classroom PCs.

The version of myVolcano that participants had access to was dependent on which group they were in and the quality of Wi-Fi connectivity. For example, the majority of the school participants used the web version of myVolcano.

4.2 WORKSHOP DESIGN

4.2.1 Attendees and activities

Workshop attendees (24 participants) were identified from previous work on resilience building (e.g. through the Strengthening Resilience in Volcanic Areas (STREVA) project) and by NEMO. A deliberately wide range of participants was targeted across government, monitoring agencies, emergency response, disaster risk management and telecommunications.

The workshop was designed to run for 3 hours to accommodate the availability of participants. It was split into four activities designed to introduce the concept of citizen science, the myVolcano app and enable different levels of participation, including:

1. An interview-style discussion between workshop convenor A. Hicks and volcanologist R. Robertson on the importance of making observations and citizen science, which was conducted in front of the other attendees;
2. An introductory presentation about myVolcano to workshop attendees;
3. Several focus group discussions framed around a multi-hazard scenario on St. Vincent to explore the usability of myVolcano and the usefulness of the data that it can capture;

4. Feedback and summarisation of the main findings of the day and an opportunity for workshop participants to complete feedback questionnaires.

4.2.2 Multi-hazard scenario

In order to stimulate discussion, a scenario was adapted from previous UWI SRC/NEMO events and was run alongside a focus group discussion (Figure 6). The scenario was designed around an eruption and was broken into four parts: unrest, pre-eruption, ash plume and explosion. Each stage of the eruption was designed to include a variety of sensory information (visual, sounds and smells) and included both related (e.g. volcanic) and non-related (e.g. flooding, storms) hazards (Appendix 1). myVolcano was pre-loaded with a number of text observations and photographs to illustrate each stage in the scenario and to stimulate discussions on what constitutes a useful observation.

Figure 6: Workshop participants take part in a focus group discussion framed around a volcanic eruption scenario, to explore the potential uses of myVolcano (photo credits: Samantha Engwell, BGS © NERC).

A written guide was provided to each focus group, which included questions to facilitate the discussion, whilst allowing for flexibility for different thoughts and themes to emerge. The questions focused upon the following areas:

- Participants' current use of citizen science;
- Perceived users of myVolcano and their requirements;
- How data is visualised in myVolcano;
- Challenges/problems associated with making observations and using myVolcano;
- Other data/information that would be useful in myVolcano;
- Suggested improvements.

4.2.3 Feedback questionnaires

Questionnaires, completed at the end of the workshop, were selected as a means of capturing additional, specific information about individual participants. These included questions about:

- Participants' organisation and role;
- Participants' mobile/smart phone platform (e.g. iOS, Android etc.);
- Feedback on myVolcano;
- Whether or not participants would download and use the app;
- When and how they would use it.

The questions included a mixture of free text and Likert (or rating) scale questions and were intended to be concise, owing to the fact that participants had already engaged in three hours of workshop activities. A copy of the workshop questionnaire is included as Appendix 2.

4.3 IMPLEMENTATION OF THE WORKSHOP

The workshop opened with an interview-style exercise between A. Hicks (BGS) and R. Robertson (UWI SRC), which was conducted in front of the other workshop attendees. The aim was to explore the meanings of the terms 'scientist' and 'citizen scientist' and discuss some existing citizen science initiatives in the Caribbean. The aim of this exercise was to highlight the importance of making observations and how citizens can make a valuable contribution to this data collection effort. Using local examples and anecdotes, the workshop convenors were able to explore the idea of science in terms that were tangible to participants:

> "He knew more about geology and he was an amateur geologist/volcanologist. In a sense he was a naturalist – he knew everything about St. Vincent, he knew about birds, but he wasn't trained in that field. He was, in my head, a citizen scientist because he acquired knowledge in a particular way and he applied that knowledge and he made conclusions based on that." (R. Robertson, talking about a citizen of St. Vincent who was a trained vet and an amateur geologist)

Overall, the interview was about engaging and empowering the participants in the room to see their role as potential citizen scientists and users of citizen science data, and that citizen science in the Caribbean is not new:

> "So citizen science is…not just observations, there are programs which involve people actually doing measurements and taking information and gathering data, quite apart from just visual observations or qualitative stuff, but actually measuring things and collecting it back." (R. Robertson)

> "I think a lot of what we call citizen science is people who have always been around, observing nature, observing human systems and making conclusions based on it all. A lot of people wouldn't think of themselves [as a scientist] like that." (R. Robertson)

The myVolcano app was then presented as a means by which observations can be shared and visualised. The history behind the app was described, and the functions and implementation of myVolcano were presented in detail by S. Engwell (BGS). The workshop then proceeded into the participatory group exercise using the scenario of an eruption to simulate use of the app and stimulate discussions about its functionality. Participants were encouraged to discuss citizen science and the app's role in the scenario, and were given the opportunity to test myVolcano.

4.3.1 Profile of the discussion groups

Participants were split into three different groups of approximately 6-8 participants per group, based on where they were situated in the room with a facilitator was assigned to each group. A detailed profile of the groups was not possible to capture, but in general they could be categorised as:

- Group A (Facilitated by A. Hicks): had a wide range of participants spanning the Information Technology Services Division, GIS Planning, Service Commission, Soufriere Monitoring Unit (SMU) and NEMO. Although an iPad was available with the most recent (unreleased) version of myVolcano (Version 2.0) this was not working at the time. Most participants used their phones to interact with the web-based version of the app, whilst some downloaded the published version of myVolcano (Version 1.3) onto their own devices.

- Group B (Facilitated by S. Engwell): dominated by technicians from Digicel and other communications companies. They had access to the unreleased Version 2.0 of myVolcano on an iPad and focused particularly on the technical aspects of the app, providing information and feedback on the usability and feasibility of using myVolcano in St.

Vincent. They generally perceived themselves as providers of information and did not deviate from this role when working through the scenario.

- Group C (largest group; Facilitated by C. Jordan): had a range of participants but also had a consensus of feedback. They had access to a prototype (unreleased) of a multi-hazard version of myVolcano, which includes more detailed forms for users to complete about different hazards. There was some focused feedback on myVolcano, but the main feedback related to the overall usability of myVolcano during the 'full emergency lifecycle'.

4.3.2 Limitations

A flexible approach to the delivery and gathering of findings from the workshop was adopted: although activities had been planned and resources generated in advance, the approaches needed to be adaptable in the event of anticipated (e.g. Wi-Fi connectivity) and unanticipated issues. The workshop design was heavily reliant upon internet availability (a finding of the study in itself) and the limited number of devices available to participants during the workshop. In the event of Wi-Fi connection problems, the flexibility of the workshop design was such that it could run without internet. However, this would mean relying heavily on the web version of myVolcano which only contains the most basic functionality (e.g. adding and viewing observations). The Wi-Fi issues encountered during the workshop emphasised these inefficiencies in the web version of myVolcano, intended to be a stand-in service for non-iOS users whilst an Android version of myVolcano was being developed. These issues have since been addressed by completing the development of myVolcano on Android, which was released in April 2017. However, the heavy use of the website version of myVolcano (particularly during the school visits, as outlined in Section 6) has highlighted the need for an equivalent web-based tool which contains the same functionality as any released versions of myVolcano.

One of the earliest constraints identified during the 2015 scoping study was that iOS devices are not abundantly used in St. Vincent, with Android being the preferred platform (Mee and Duncan, 2015). This was confirmed by the post-workshop questionnaires (Section 5.5), which showed a predominance of Android platform usage amongst workshop participants.

4.4 SCHOOL VISITS

A total of four schools were visited during the pilot study, organised by Idelia Ferdinand of the Ministry of Education, Government of St. Vincent and the Grenadines. Two of the schools were mixed, whilst the other two comprised a boys' and a girls' school. All children were of secondary school age (Table 1). As with the workshop, issues with internet access were expected to limit the extent to which activities could be implemented and therefore activities were designed with a degree of flexibility. The purpose of the visits was to raise awareness of myVolcano, whilst also collecting feedback from a target user group. The length of visits was limited to single or double class lengths and were, therefore, designed to accommodate two exercises: (1) questions on the definition of scientists, citizen scientists and observations and (2) an opportunity to input data into myVolcano and provide feedback on their experience. The students were provided with an activity sheet (Appendix 3) to compile their answers, which used both free text and Likert scale questions, similar to those used in the workshop questionnaire.

4.5 ETHICS AND INFORMED CONSENT

Ethical considerations were taken into account when designing the workshop and associated activities to ensure that risks were minimised. The questions asked at the workshop did not extend to personal information beyond the name, organisation and job title and type of mobile phone owned by the participant. In the case of the school visits, some additional personal information was requested, including the age and gender of the participant and the school they attended, as it was considered that this background information might inform the analysis. All of the data

collected is stored according to NERC/BGS data procedures and privacy policies, and participants and students have been anonymised for the purpose of this report.

All participants of the workshop and school visits were fully informed of the purpose of the project and that their contributions would feed into (1) informing future app developments, (2) enhancing current understanding of the role of citizen science and (3) key outputs, including this report. Written consent was deemed unnecessary owing to the scope of the project. The school visits were attended by teachers and facilitated by the Ministry of Education, who were aware of the purpose of the visits.

Table 1: Summary of school visits (NB: different schools/groups had access to different versions of the app i.e. some used the web version whilst some used mobile devices).

School	Location	Description of activities	Number of participants	Gender
St. Vincent Girls' High School	Kingstown	Almost all students had a smart phone and/or an iPad. Internet did not allow for easy access to the app. 1 hour class: Presentation and both exercises	46	Female
St. Vincent Grammar School	Kingstown	Almost all students had a smart phone or access to one. Internet allowed some students to access the app. Some downloaded the app, while others used the webpage. 50 min class: Presentation and both exercises	27	Male
Thomas Saunders Secondary School	Kingstown	Almost all students had access to a smartphone. Access to was WiFi poor 1 hr 10 mins class: Presentation and both exercises	28	Mixed
Mountain View Adventist Academy	Richland Park	All students had individual access to a school laptop and internet. Most students uploaded information via the webpage, but one student used the published app. 1 hour class: Presentation and both exercises. Finished with STREVA video on St. Vincent (due to available time).	19	Mixed

5 Findings from the stakeholder workshop

The qualitative results of the workshop were analysed using the analysis software NVivo. The semi-quantitative questionnaire results were analysed using Excel. The findings from the workshop are divided into five main themes: (1) types of data and their usefulness; (2) challenges in collecting and visualising observations; (3) suggested improvements to myVolcano; (4) perceived role of myVolcano; and (5) findings from the post-workshop questionnaires.

5.1 TYPES OF OBSERVATIONS (DATA) AND THEIR USEFULNESS

Much of the content of the focus group discussions related to using the data collected by myVolcano during an event (emergency/disaster), therefore the emphasis was on how quickly that information could be received and displayed in the app. Real-time functionality was therefore at the forefront of the group discussions. Related to this were discussions around data verification, and the 24-hour delay in uploaded observations appearing in myVolcano (shown in in Figure 5).

Suggestions to improve this included the ability to update and discuss information (e.g. by adding a commentary) or filtering data (e.g. by only uploading unverified data for high hazard areas).

Perceived useful formats of data extended to different media (e.g. videos and audio recordings). In terms of making and sharing observations, photographs were deemed to be more powerful than written descriptions; however, there was an acknowledgement from Group A that (1) this is dependent on the quality or subject of the photo and (2) that it might be challenging/impossible to take photos of some hazards (e.g. "an explosion" or "earthquake rumbling").

The relative usefulness of two different photographs of flooding was discussed by one group (Figure 7). In the first example (Figure 7a) they stated that they would focus solely on the photo and pay little attention to the accompanying text because the photo was useful as it was. With the second example, they felt that the photo of the damaged bridge (Figure 7b) was most relevant to those responsible for repairing the bridge.

In general, the usefulness of observations differed from one person to another as they were generally considering the usefulness of each photo from their own perspectives i.e. what would be useful to their work, or to their routine (e.g. if it might affect their normal route home from work). Group A commented on the fact that some of the observations might be more useful for scientists (e.g. "cloud over the volcano") than for those in the group. It was agreed that photos and descriptions about the eruption would be most useful for the Soufriere Monitoring Unit and SRC.

Figure 7: Photographs showing flooding and bridge damage in St. Vincent used in the workshop scenario (photo credits: Anna Hicks, BGS © NERC).

Group B also suggested that photographs might be better than descriptions because they show what is happening without interpretation. For example, Group C noted that "cloud from the volcano" is an interpretation and therefore questioned its reliability.

There were also suggestions for incorporating additional information into myVolcano (e.g. information on different hazards and contact details of emergency groups), as well as mechanisms of exchanging information. Suggested improvements included how the uploaded observations should be displayed to provide updates on the current situation (e.g. via push notifications from NEMO) and advice on what to do during an emergency.

For those able to view the additional multi-hazard check list in the prototype Version 3, the ability to input more detailed descriptions about hazards was viewed as a useful functionality, however users might require explanations as to what the different tick boxes (e.g. 'pyroclastic flows') mean. Unfortunately, Wi-Fi limitations meant that only one group had the opportunity to look at this additional functionality, limiting feedback.

5.2 CHALLENGES IN UPLOADING AND VISUALISING OBSERVATIONS IN MYVOLCANO

Participants noted several challenges related to collecting observations using myVolcano in its current design. In terms of uploading, there was a suggested need for more detailed location descriptions (e.g. not just the name of a town) and Group C stated that they found it confusing that the GPS icon was the same as the drop-pin in Google. There were suggestions that Google maps should be used as the base maps in myVolcano (currently provided by ESRI) but there is a limit on daily usage of Google maps, after which there is a charge.

The name 'myVolcano' also created some confusion in that it emphasised the application to volcanoes and less so to other hazards, and there were suggestions of renaming the app to something less specific, such as 'myIsland'. There was also a question as to how information from text messages (e.g. from people without smartphones) could be integrated into myVolcano. Throughout the discussions, there were several suggestions that the app should be 'all-encompassing'. This was mentioned both in terms of functionality and data (e.g. to be more efficient than in its current state) as well as in terms of potential advice that is provided through the app. For example, Group B agreed that they would be unlikely to visit a website or social media for advice *as well as* check the app. Instead they would prefer all information to be available in the same place. This was also linked to people's motivation to use the app.

Improvements to visualisation on the map were also discussed, with groups A and C suggesting the use of different symbols for different hazards and group C suggesting that filtering data could help users to gain a quick understanding of the current situation. The existing icon – a cloud, which represented the location of ash observations from the first version of myVolcano – was considered no longer suitable (Figure 8).

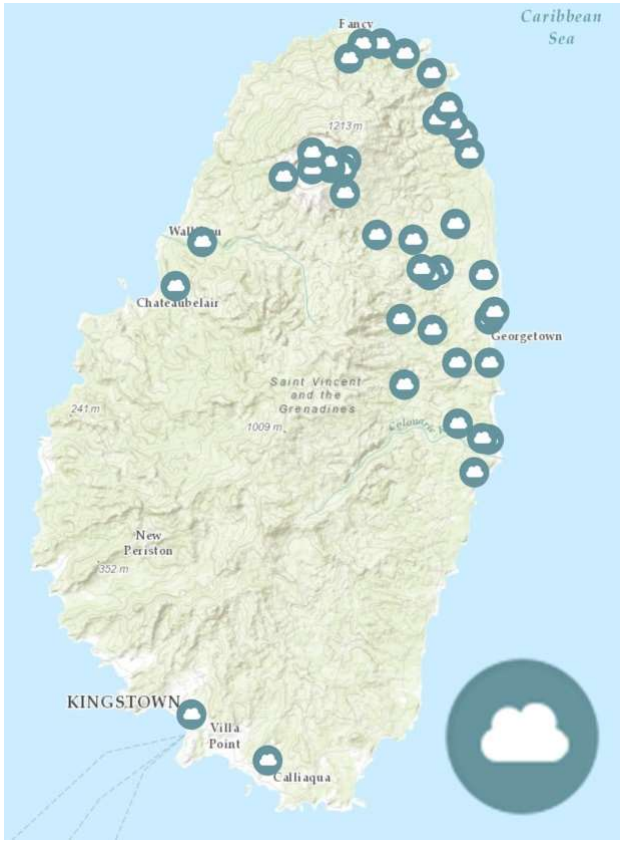

Figure 8: The existing observation icon in myVolcano is represented by a cloud, which was initially to represent locations of ash observations in version 1 of myVolcano. The icon provides no insight into what type of hazard or observation is being presented. (Background mapping provided by ESRI Online).

One group also raised a concern regarding duplication of photographs (e.g. several people providing images of the same scene) and whether this would clog up the map interface. Group B suggested that adding a filter to enable a subset of observations to be viewed based on the time they were taken (e.g. most recent submissions) would enable better interpretation of the information. Furthermore, there were discussions about whether the observations should be displayed as they are received or with a level of interpretation (e.g. by a validator such as SRC or NEMO staff). Suggestions ranged from adding a comment (e.g. by the validator) to help qualify the observation (but without altering its original form), to providing advice (e.g. alerts) from the local authorities and decision makers (e.g. NEMO).

More practically, both the challenges of maintaining Wi-Fi access during the workshop and technical discussions regarding communication systems on island led to concerns about low bandwidth and operating offline. myVolcano does not currently cache data and so map layers and observations were not visible when offline. Furthermore, the limited Wi-Fi access meant that some participants were relying on the web tool rather than mobile app, which emphasises the importance of maintaining a web tool. The workshop questionnaires, however, highlighted that respondents were more likely to use an app over a web tool.

Linked to these challenges is the theme of system redundancy in St. Vincent. Digicel are working on methods for using apps and data when there is no internet and Group C expressed some faith that the authorities/companies would keep communication systems working during an event. There was also the suggestion that filtering the observations could help when using the app during times of low bandwidth (e.g. less content to load). Thus, although challenges were identified, participants also suggested a number of improvements that would refine myVolcano and make it more suitable to their purposes. These are presented in the following section.

5.3 SUGGESTED IMPROVEMENTS: MEETING USER NEEDS

Participants identified a number of suggestions and strategies for overcoming the challenges they had identified and how to meet their required needs. These are summarised in Figure 9 (see Appendix 4 for detailed responses). Many of the suggestions were interrelated and, whilst some were specific to the needs of St. Vincent (e.g. localised place names), it is clear that these would be transferable to other locations.

Many of the suggested improvements related to the subject of communication and whether it should be (1) interactive (between uploaders and recipients), (2) more informative and (3) actionable. Two-way communication, also identified in the 2015 scoping study (Mee and Duncan, 2015), was deemed an essential component of myVolcano that would not only improve preparedness for and response during crises, but also increase motivation of users as they would be more inclined to use the app if they felt that they were receiving action-based information in return.

Ideas for improving communication were also highly linked to the verification process, since much of the discussion focused on an event/emergency situation. Means of improving the efficiency of the verification process by, for instance, encouraging a forum-based commentary, filtering data depending on the location (high hazard area) and key words and labelling whether it was verified or not, were all suggested.

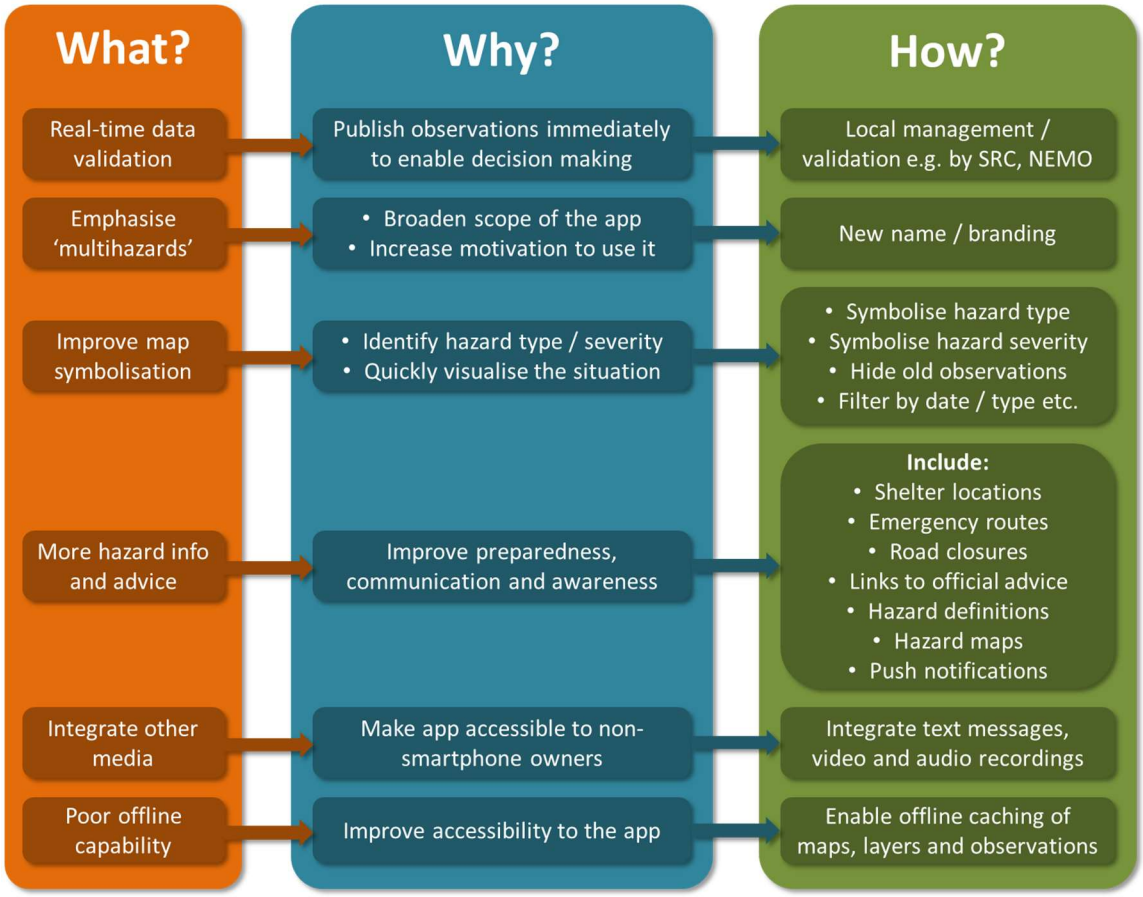

Figure 9: Summary of suggested improvements to myVolcano made by participants during the workshop (detailed list of suggestions in Appendix 4).

5.4 PERCEIVED ROLE OF MYVOLCANO: MOTIVATION FOR USING THE APP

Throughout the discussions, four perceived roles for the app were identified:

(1) Education and raising awareness;
(2) Communication;
(3) Providing information and advice;
(4) Decision-making.

Whether the app would enable a two-way exchange of data and information between citizens and scientists and emergency managers/responders emerged throughout the discussions. There was a perceived need for users to receive feedback from official authorities (e.g. scientists, civil protection etc.), whether through awareness raising, communication or actionable advice, and that having a single app that is 'all-encompassing' – i.e. an app that tells the user what is happening and what to do, as well as allowing them to upload an observation – would be optimal. In addition, it was felt that myVolcano would need to be more efficient than existing tools (e.g. Facebook) "otherwise people will just continue to do what they already do" (participant in final discussion).

5.5 WORKSHOP QUESTIONNAIRES

Of the 27 people who attended the workshop, 24 participants filled in the post-workshop questionnaire with a median completion rate of 87.5 % (average 82 %). The organisational profile of those who responded to the questionnaire is given in Appendix 5. All participants, with the exception of one who provided no answer, own a smartphone, with at least 83 % using an Android platform and only one using iOS (Figure 10).

In terms of existing applications used by the participants for sharing data, Facebook and WhatsApp were the preferred platforms. This reiterates the need for myVolcano to complement, combine and build upon existing applications for sharing data, as users do not want multiple applications for different functions.

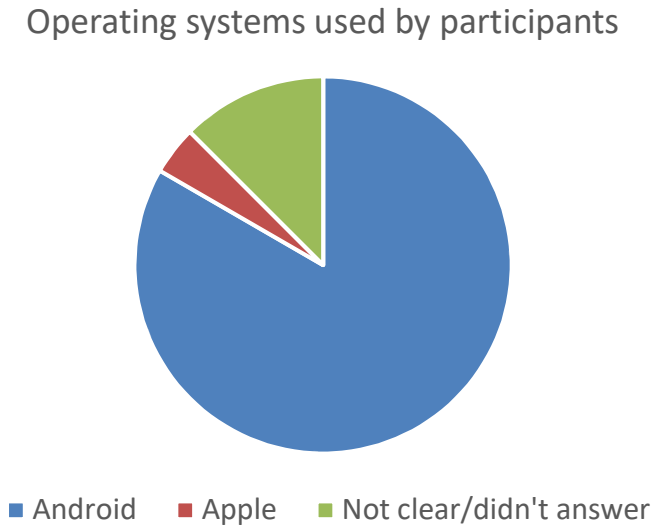

Figure 10: Proportion of operating systems used by questionnaire respondents

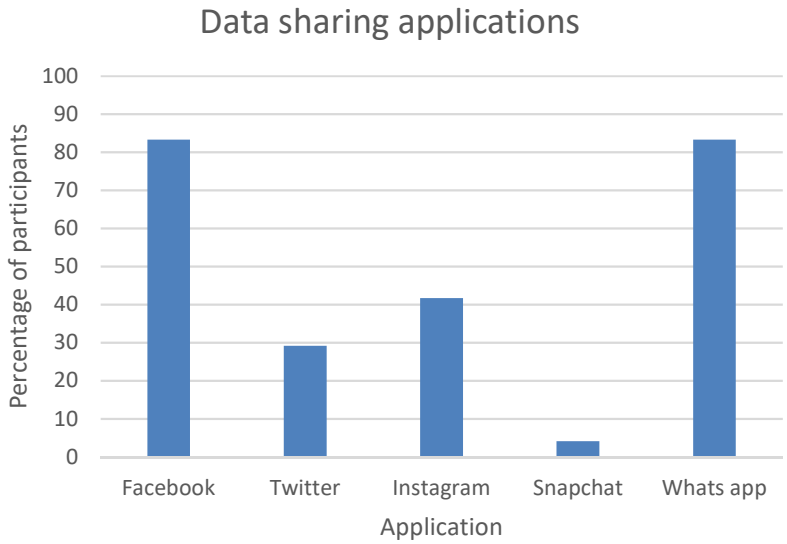

Figure 11: Data sharing applications typically used by questionnaire respondents

5.5.1 Likelihood of downloading and using the app

Overall, the responses were positive. There was a general sense that respondents would download the app (54 % very likely; 29 % "likely"). However, it was slightly less likely that participants would use myVolcano for uploading their own observations (42 % very likely; 29 % likely) or that they would use the data uploaded into myVolcano (33 % very likely; 42 % likely). More participants were uncertain as to whether they would upload observations to myVolcano (17 %) compared with downloading myVolcano (8 %), which may reflect the limited contact participants had with the app (Figure 12). Seventy-one percent of respondents' answers stated that they were either very likely (29 %) or likely (46 %) to use myVolcano as a source of other information, which

is in line with the numerous workshop discussions around communication and receiving 'useful' information.

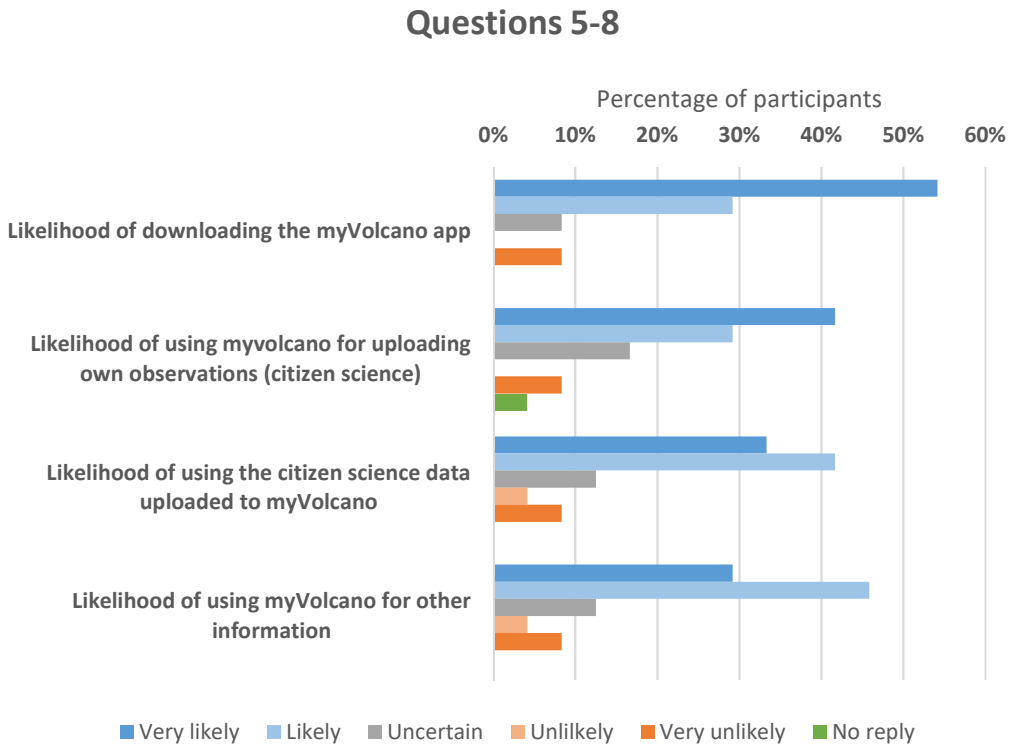

Figure 12: Results of the Likert scale questions in the participant questionnaire

5.5.2 Usability of myVolcano and suggested improvements

In terms of using myVolcano, 54 % of respondents stated that they were more likely to use the app than the website and another 4 % said they would use both, depending on their situation (i.e. if at home or not). Twenty-five percent of respondents did not answer this question whilst one participant mentioned that their choice would depend on their device and connection. In terms of when they would use myVolcano to upload observations, 10 respondents said they would make observations during working hours, seven of whom stated that they would also do this in their spare time (two stated it would *only* be in their spare time). Other respondents either did not provide answers or were more ambiguous in their responses, with some simply stating that they would use it depending on circumstances e.g. "once there is an event or activity that would alert and assist the public" (i.e. notify the public about what is going on).

Of those that answered the question regarding whether they would use the information in myVolcano for decision-making in their work (6 did not), 11 could apply it to their work, for instance, those working in monitoring and emergency response (SMU and Police) saw how the app could assist them in informing NEMO and engaging with their rescue teams.

Other respondents reflected on how myVolcano might be useful for other agencies, rather than their own. Three were more conditional in their answers, with two emphasising that they would first like to see the information verified before it would be used to aid decision-making. Others were less certain at present, with one stating that "[I] would have to see the full app version then [I] could say" (Respondent W20). Two respondents stated explicitly that they would not use myVolcano for their work, but one of these mentioned that they would use it personally (it was just not relevant to their role as an IT technician).

5.5.3 Suggested improvements

Sixteen of the questionnaire respondents (62.5 %) suggested improvements to myVolcano, which generally echoed the group discussions. Examples of improvements included:

- Ensuring information is disseminated to app users;
- Feedback on uploads – from scientists/emergency managers to observers;
- Data filter;
- Change symbology;
- Add layers showing vital infrastructure (e.g. shelters);
- Technology capacity (capacity to run on older machines and slower connections);
- Renaming the app (e.g. to "myDisaster", "myIsland").

Other points included making the app "more user-friendly". Those who did make suggestions for improvements also emphasised their support for myVolcano, describing it as "…a very useful app [but that] the useful recommendations from this workshop need to be incorporated into the app." (Respondent W11).

6 Findings from the school visits

Worksheets were completed by 120 students across the four secondary schools. A summary of questionnaire results is given in Appendix 5, with the main findings discussed in the following sections. [NB: Students at one school had their own laptops which may skew some results.

6.1 CURRENT MOBILE PHONE USE AND DATA SHARING APPLICATIONS

Of all the students' responses, 105 (88 %) said that they owned a smartphone. Similar to the stakeholder workshop participants, the dominant operating system is Android (Figure 13).

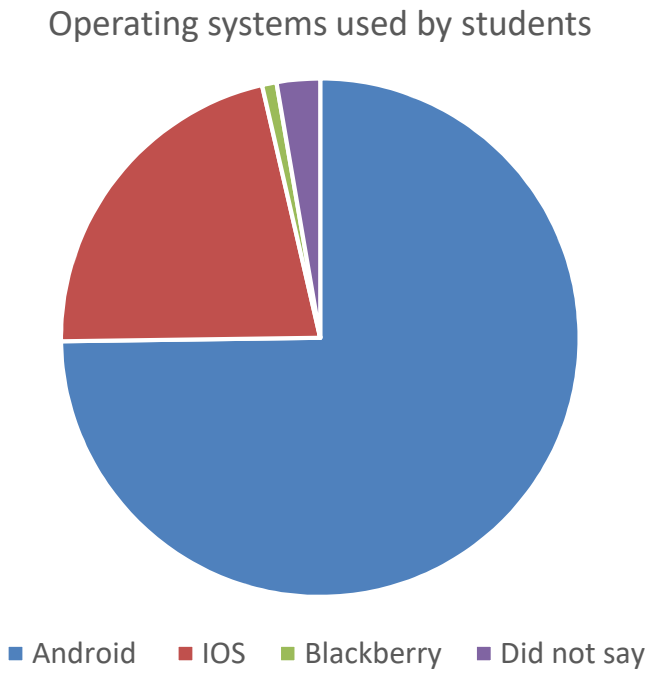

Figure 13: Proportional use of operating systems by students. Four students mentioned that they had two devices, one Android and iOS.

In terms of current applications for data sharing, the dominant apps used across all of the schools were Facebook and WhatsApp (Figure 14). There was, however, a dominance of SnapChat users

amongst the Girls' High School students (72 % of participants) compared with the other schools, which could be partly explained by their access to iOS (SnapChat was primarily designed for this platform). Thirteen participants (28 %) from the Girls' High School stated that they used iOS devices, compared to only 6 (26 %), 3 (24 %) and 2 (17 %) in the St. Vincent Grammar School, Thomas Saunders Secondary School and Mountain View Adventist Academy, respectively. In the case of Mountain View Academy, only 11 % of the participants mentioned SnapChat. SnapChat is a self-deleting platform, so arguably does not lend itself well to citizen science observations.

Students mentioned a much greater variety of other applications they used for sharing information compared with the workshop participants, including Pinterest, email (Gmail and Outlook), Skype, tumblr, imo (free video calls and chat), Messenger (Facebook), kik (instant messaging), Aviary Instasize (photo editors). What can be interpreted from this is that students are motivated users in terms of applications for sharing different types of media: text, pictures, videos, but that unless myVolcano complements or integrates with existing mechanisms for sharing, it may be challenging to motivate students to use another application, unless it does something more than those they already have access to. A way of addressing this might be to design citizen science experiments based around using myVolcano that compliment or can be integrated into the school curriculum.

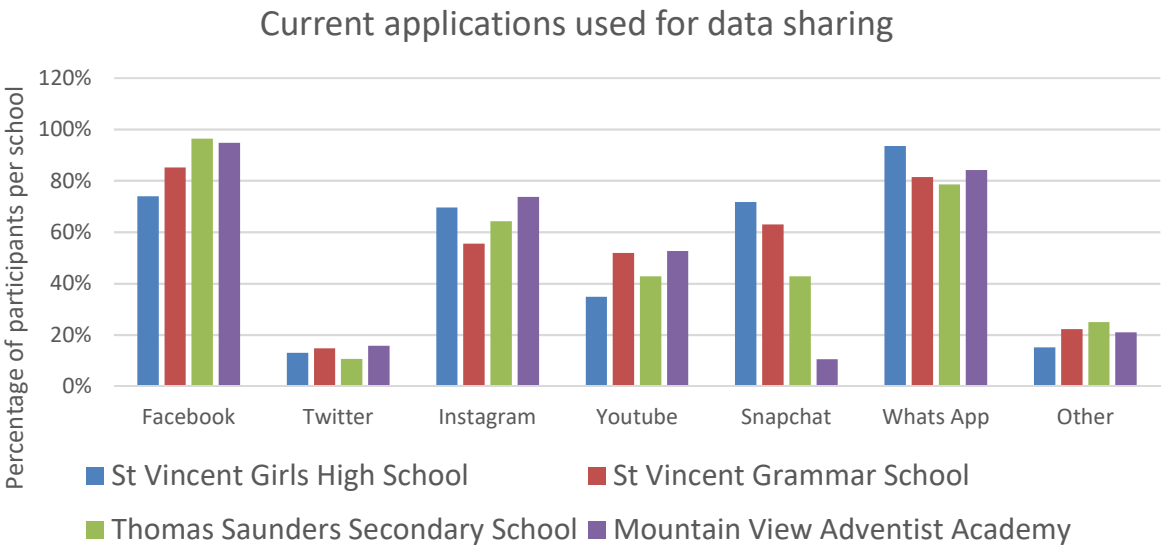

Figure 14: Examples of applications used for data sharing by the students. The y-axis values represent the number of mentions of each application as a percentage of the overall participants per school who took part and the activity.

6.2 LIKELIHOOD OF DOWNLOADING AND USING MYVOLCANO AND OBSERVATIONS

It was positive to note, particularly with regard to motivating students to use myVolcano, that most students (82 % of the total 120 who took part) stated that they either found the app "very easy" or "easy" to use (Figure 15). In some of the schools internet access limited the extent to which students were able to test the app, for instance in the Girls' High School and to a lesser extent in the Thomas Saunders Secondary School. Indeed, there was a slight decrease in "easy" and "very easy" responses for the Girls' High School: 76 % compared with 84-86 % for the other schools. The Girls' High School also had the highest proportion of uncertainty around the ease of use, with 24% compared to a range of 5% (Mountain View Academy) to 14% (Thomas Saunders Secondary School) for the other three schools. In general, however, students either perceived or could demonstrate that myVolcano was easy to use (Figure 15).

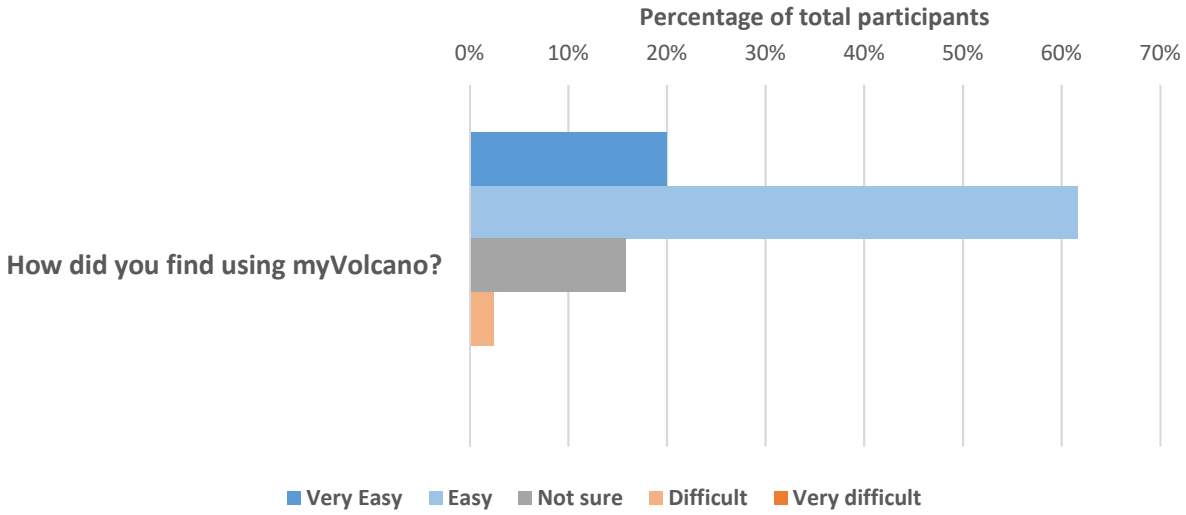

Figure 15: Summary of answers to question 4 from all four school groups. No group stated that it was "very difficult" to use myVolcano (full results in Appendix 6).

In terms of whether or not students would download and make use of the app, either by uploading their own observations or the observations used by others, there was generally a positive response, but with an increasing degree of uncertainty across the answers (Figure 16); for instance, whilst 52 % of students are either "very likely" or "likely" to use myVolcano to upload their own citizen science observations, 39 % were unsure (the same value as those who ticked "likely") and students were even more unsure (42 %), when it came to them making use of the observations. This uncertainty actually surpassed those who said they were "likely" to make use of the observations when treated separately from those who answered "very likely". These answers to some extent support the findings of the workshop, which emphasise a positive interest in the app, but a limited enthusiasm for adopting it without significant modifications.

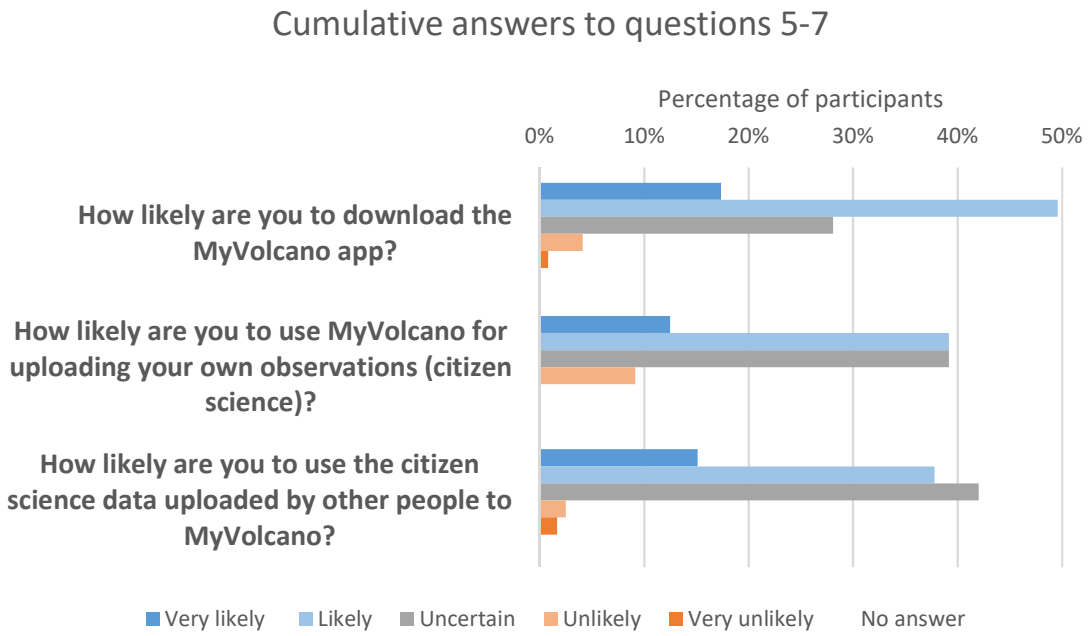

Figure 16: Summary of answers to questions 5 to 7 from all four school groups (see Appendix 6 for a breakdown of these results per school).

7 Discussion

myVolcano was originally developed to gather transboundary observations of distal volcanic hazards (i.e. ash and gas/aerosol emissions) with the principal aim of helping scientists to constrain the movements of, and understand the characteristics of, such hazards. Whilst ash, gas and aerosol were the primary focus of the app, it was designed in such a way that it could be used to gather observations of *any* hazard or natural phenomena around the globe (i.e. by accepting photographs and free-text descriptions). Through the 2015 scoping study (Mee and Duncan, 2015) several adaptations to the original design of myVolcano were identified, including a more explicit inclusion of all natural hazards affecting the region and development of the app on Android. Several issues were also highlighted by the 2015 study, such as the need for local data validation and management, data sharing, resilience of key systems and how to motivate users, ensure their safety and manage their expectations. The 2017 pilot study in St. Vincent has built upon these original findings, most importantly by directly engaging with potential users of the app. Through the workshop, the key needs of users (uploaders and recipients of information) in the context of using myVolcano as a citizen science tool in St. Vincent were identified.

In general, participants were positive about the app, but would only be likely to use it pending improvements. The desire for an **all-encompassing app**, which could both accommodate two-way communication between citizens and officials, as well as recording a whole range of hazards, emerged. Capturing multiple hazard observations could help **identify cascading hazards, impacts and timescales** which, whilst complex, could contribute towards more effective and timely assessment and management of an evolving hazardous situation. Participants also expressed the need for **informative and interactive communication**, particularly around the concept of giving and receiving 'response advice' from NEMO i.e. where people should go during an emergency; what they should do during a hurricane, etc. This was discussed in both passive and active terms, ranging from raising awareness to active advice based on feedback from actual observations. Two-way exchange of information and inclusion of actionable information was emphasised throughout the discussions. Better understanding the role of existing data sharing applications (Figure 11 and Figure 14) for citizen science will help to refine this component.

Another major theme to arise from discussions was **motivation**, as it was deemed that myVolcano would need to be more effective for communicating than existing approaches (e.g. Facebook), be multi-purpose and remove emphasis on volcanoes. School students were identified as a particular group of users that could be targeted in the 2015 scoping study (Mee and Duncan, 2015). Whilst there was enthusiasm for myVolcano, it is clear that more will need to be done to incentivise their interest, as there remained a significant degree of uncertainty as to the extent to which they would use the app, inferred as being partly owing to the Wi-Fi connectivity problems during the workshop. As Figure 11 and Figure 14 demonstrate, participants are already making use of a number of data sharing platforms, so for myVolcano to be relevant to their needs, it would need to be all encompassing or be integrated within existing means of data sharing.

The theme of **localisation** also emerged during the discussion, in the context of improved functionality of the app (the inclusion of local maps and information), but also through the local management of the observations in the app. There was an emphasis on **visualisation**, making observations clearer (e.g. labelled by hazard and filtered), as well as discussions about **data validation and real-time application** of myVolcano (something the app was not originally designed for). Many of the points raised by participants were in the context of real-time, emergency situations, rather than recording day-to-day observations. This may in part be owing to the choice of scenario. Although the scenario was designed to capture the time span of an event (e.g. from pre- to post-event), it arguably lacked emphasis on the 'day-to-day' monitoring and observing of the multi-hazard environment. It was greatly emphasised that there should be minimal delay in visualising and being able to use the observations recorded by myVolcano, whether these are in their original form or with added interpretation. Filtering data, being able to comment on

observations and the suggestion that those doing the validation should add a summary or interpretation to the observation to improve its usefulness, were all suggested.

Section 5.3 and Figure 9 presented the concerns and suggested improvements participants raised, some of which have already been addressed in V2 of myVolcano (released in April 2017). In terms of the **resilience of key systems**, both the challenges of maintaining Wi-Fi access during the workshop and technical discussions regarding communication systems on island led to concerns about low bandwidth and operating offline. Suggestions for improved offline/low bandwidth usage were made, but there was also a mention from one group that they would have confidence that key systems would not fail during an event. A fundamental function of the app that currently doesn't work without internet access is availability of the map bases, which are streamed via online web map services. A way of addressing this is to cache map tiles within the app which can then be called when working offline. The related concern of **availability of appropriate technology**, emerged from the workshop questionnaires and the school worksheets, where it was evident that Android is the dominant platform and thus myVolcano needs to be available on this platform. This has subsequently been addressed since the workshop and an Android version of myVolcano was released in April 2017.

The issue of **ensuring the safety of volunteers** emerged throughout both the workshop and school activities. During the workshop, Group A emphasised that myVolcano would not necessarily encourage people to get any closer to a hazard than they already do (i.e. to take a photograph). During the third stage of the scenario exercise (at the peak of the eruption), Group A felt that people would still be trying to take photographs (through myVolcano or otherwise), whereas a police officer in Group C recalled that during the 1979 eruption people were too busy running to safety at this stage of an eruption rather than taking photographs. The app would need to carefully address safety concerns to ensure that users' safety comes before recording observations in the app, for example ensuring people are not returning to evacuated/affected areas before they have been declared safe by authorities.

The results of the workshop have provided evidence to support the five components of resilience building where citizen science is perceived to have a role (Mee and Duncan, 2015):

1. Coordination and collaboration between scientists, authorities and citizens: users want the app to create a dialogue between these key groups;
2. Decision-making by institutions and individuals: the identified role of the app as a decision making tool;
3. Anticipation of natural hazards by monitoring institutions, authorities and citizens: the discussions around verification and the 24 hour delay emphasised the need for timely, actionable information;
4. Capacity building of institutions and communities: emphasis on awareness raising as a key role of the app;
5. Co-production of knowledge: suggestion to build a commentary between uploaders and recipients of data; localisation of the app.

Although positively received by participants, the results of the scoping study indicate that myVolcano in its current form is not fully fit for purpose in St. Vincent, without a number of technological, design and operational (including local management of the app) changes and additions.

8 Conclusions and next steps

The workshop and school visits have identified that local input to modification and ownership of myVolcano are required to make it a viable and sustainable option for citizen science in St. Vincent. Citizen science is not a new activity in St. Vincent in the sense that many of the earliest

observations of volcanic eruptions were made by citizens. It also has a number of institutions involved in the monitoring and managing of emergencies that would benefit from tools to share data to assist in the monitoring and management of multiple hazards and crises.

The need for an all-encompassing app, which includes multi-hazard functionality, is clear. myVolcano was not designed to be exclusively for volcanic hazards, but its name is perceived to be hindering its application beyond volcanic hazards. The list of suggested improvements in Figure 9 demonstrates the types of customisations required in St. Vincent. Whilst these customisations might also apply to other countries there are, undoubtedly, going to be additional specifications required to create an app that is fit for purpose in a particular country. There is, therefore, clearly a need for in-country agencies to have access to software that they can adapt for their own means.

In conjunction with the visit to St Vincent in 2017, there have been two parallel pieces of development work on the app. The first is the development of a cross-platform version of the app and the second is to develop more targeted multi-hazard functionality, either within myVolcano or in a new app or tool. The intention is that these tools will be made available to in-country partners, for them to make the modifications they require, manage their data locally and feed into global database of citizen science observations.

8.1 MYVOLCANO VERSION 2.0: CROSS PLATFORM AND HOME PAGES

Since the workshop, myVolcano version 2.0 has been released (April 2017), which was designed based on the feedback from the scoping study (Mee and Duncan, 2015) and ongoing discussions with Caribbean partners (R. Robertson). The new version was developed as a cross-platform tool, meaning that myVolcano is now available on Android, as well as iOS. The cross-platform technology means that the app only needs to be developed once and is then ‘deployed’ onto the two different platforms, whereas previously, the development needed to be done for each of the separate platforms. The ‘app’ can also be loaded onto laptops and PCs, thereby providing a ‘desktop’ version of myVolcano that both supersedes the web version that was available during the workshop and has the same functionality as the mobile version. This new ‘cross-platform’ approach has provided a more efficient and cost-effective way of development.

Two major updates were made to myVolcano in version 2.0. The first is the improved workflow (Figure 17), which also removes the emphasis upon volcanic ash (although users can still add information about ash and see how to collect samples).

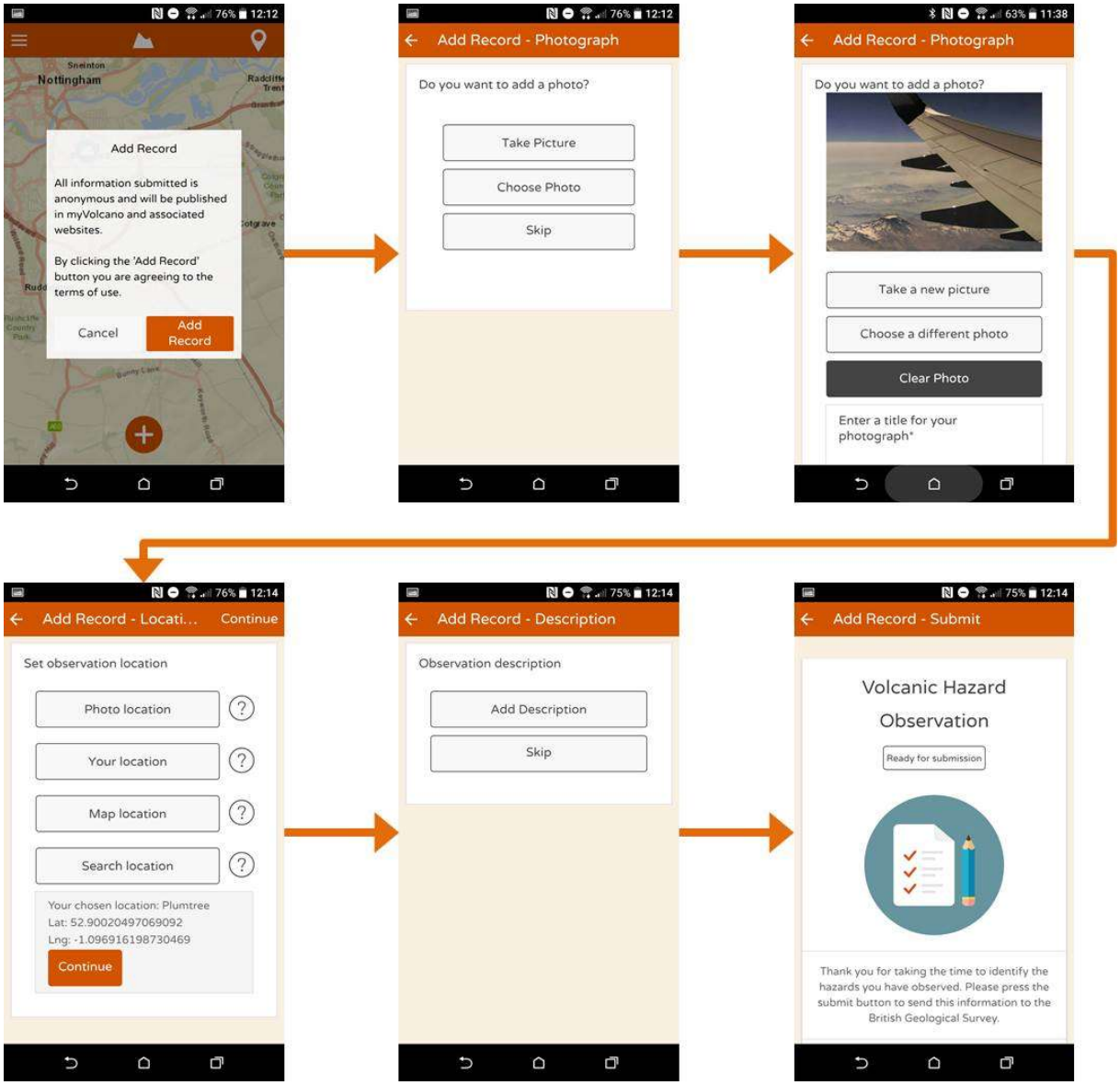

Figure 17: The new workflow for adding a record guides provided a more streamlined process for uploading observations.

The second is the addition of 'home regions' (Figure 18). The home region pages contain information about monitoring and emergency management in that region, and currently include 30 volcanically active countries or regions of the world. A second phase of home regions is planned, which aims to compile pages for several countries in Africa, as well as many other countries including Spain, Greece, France, and Papua New Guinea.

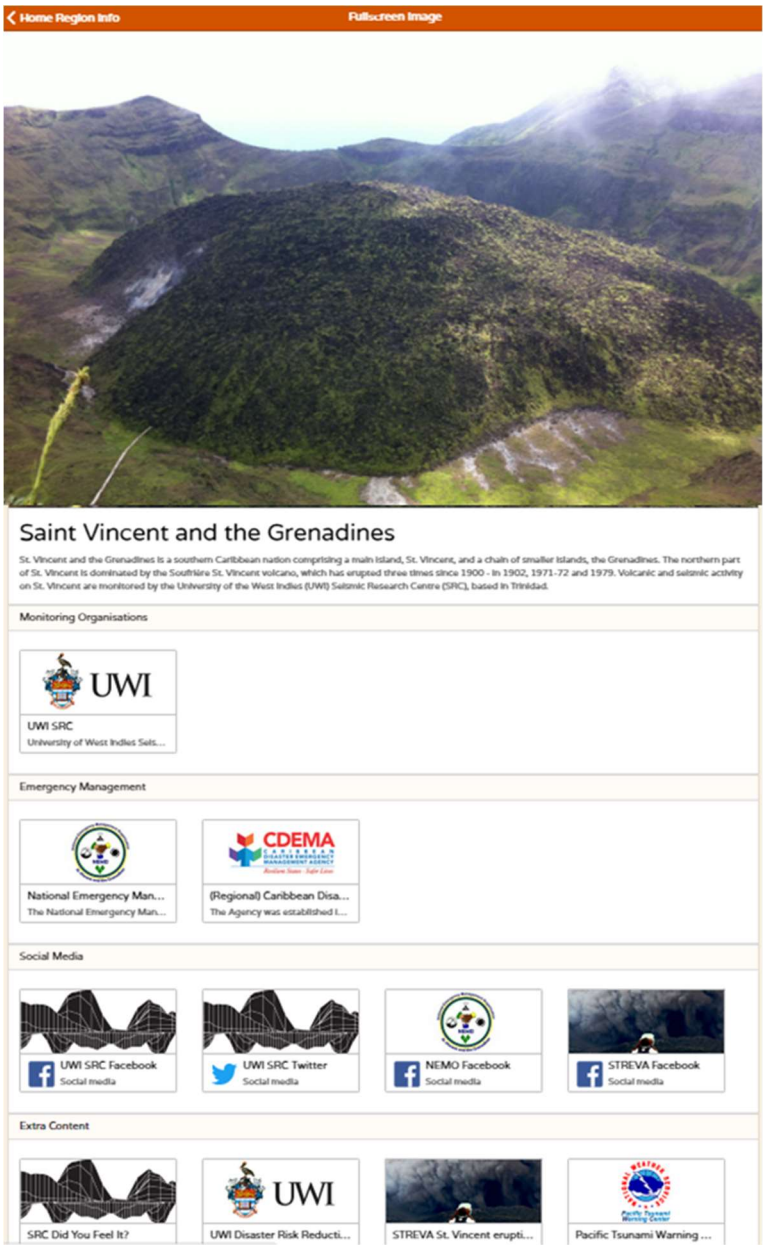

Figure 18: 'Home region' page for St. Vincent, with links to the monitoring organisation (UWI SRC), emergency management (NEMO) and other relevant social media and citizen science initiatives.

Future versions of myVolcano will also be translated into Spanish, as with previous versions, and possibly additional languages (e.g. French, Italian, Icelandic, Amharic) determined through needs assessments with project partners in different countries. There are also plans to develop technology to enable multiple photographs to be uploaded in one record (currently only one photo per record is permitted) and to enable addition of videos (a recommendation from the pilot study).

We will also continue to look at how we can improve the range of information provided through the interactive map e.g. inclusion of hazard maps, monitoring organisation information, volcano activity alert levels etc. However, as the findings of this study suggest, more adaptations are needed to meet the requirements of users.

8.2 "MULTI-HAZARD" FUNCTIONALITY: DETAILED OBSERVATIONS

Although myVolcano has been designed such that the user should be able to record an observation of any hazard (i.e. through free text descriptions), the idea behind adding hazard specific questions

came as a means of capturing more detail and would also enable filtering of the data by hazard type. These more detailed questions would be an optional extra for users, who would still be guided through the initial addition of photographs or free-text descriptions.

The first proposed component of the additional questions is the inclusion of toggle boxes to categorise what type of hazard or phenomena the user thinks they have observed (Figure 19).

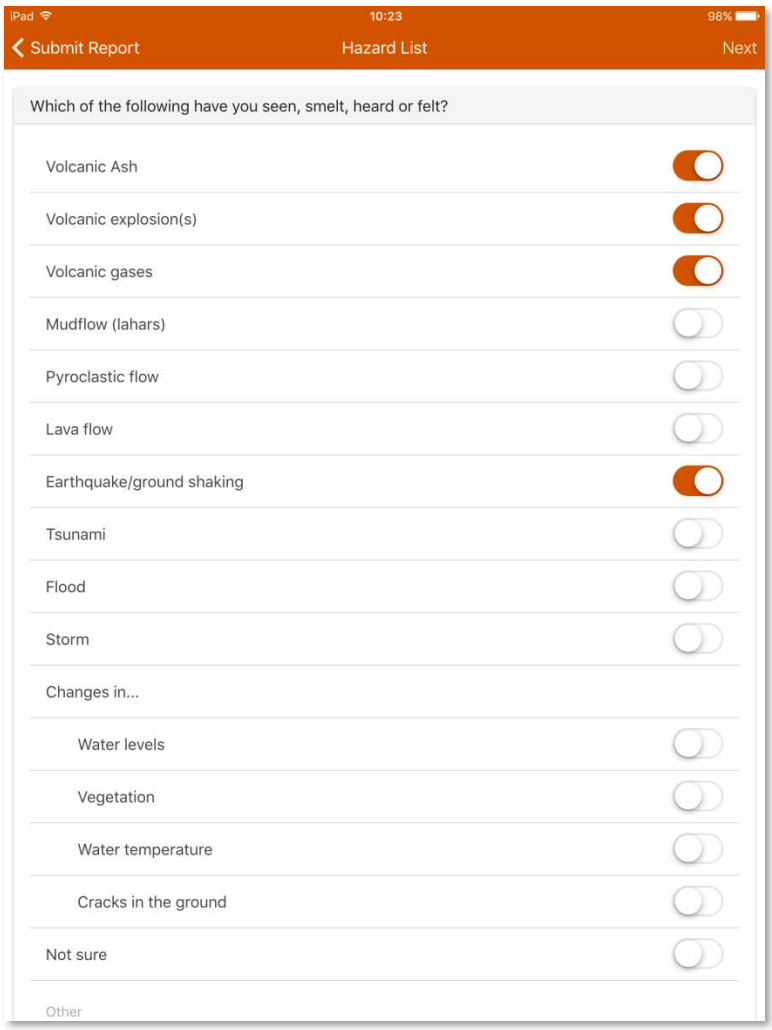

Figure 19: Checklist for users to identify the principle hazard they have observed.

Based on their answers, they would then be directed to additional (optional) question pages, asking for specific details regarding the hazards they have identified (e.g. Figure 3). The addition of these questions would assist with data management, since there is an early process of data organisation, making it easier for the agency receiving the data to manage and interpret the data. Categorisation will also enable observations to be symbolised by hazard type in the map, helping to improve the visual impact of observations. During the workshop, there was little opportunity to gather feedback on the proposed multi-hazard questions owing to the challenges of internet access.

8.3 LOCALISATION AND LOCAL OWNERSHIP

In addition to improvements to the existing myVolcano app, the next phase of the project will look to transfer existing knowledge and technology from myVolcano to provide a more localised, decision-support tool to enable various organisations (e.g. emergency managers, monitoring scientists, emergency services and infrastructure/utility companies) to best manage and respond to multiple hazards.

The recommendations of this study are, therefore, that BGS continues to develop the technology for citizen science apps for hazard and environmental change observation, including for myVolcano and/or a new multi-hazard app, and to make this technology available to local in-country agencies. These agencies can then adapt the 'global' app design to meet their specific needs (co-produced with BGS if support is required), manage their local data and contribute to a global data set of citizen science observations stored by BGS. The BGS' role would be to manage the data globally as the app is applied and adapted in other countries, thereby creating a database of citizen science observations of multiple hazards across the world, which can be used for research purposes. BGS' legacy would be in the co-design of an extensible toolkit with partners, which could be rolled out across other countries.

Figure 20 outlines the conceptual approach and the steps to achieving these are summarised as follows:

(1) BGS to co-design a generic open-source multi-hazard app that can be adapted by local agencies (a toolkit)
(2) Local agencies adapt the multi-hazard app to build customised applications to meet their needs (e.g. localisation, links to social media: "all encompassing" concept). NB: This could also be done by BGS if the local agencies want support in doing so, or do not have the capacity to continue development on their own.
(3) Local agencies manage their own data, including the verification process and/or identify where they need data management support (e.g. from BGS)
(4) Data collected at the local scales feeds into global datasets managed by BGS, as part of global initiatives, e.g. Global Volcano Model.

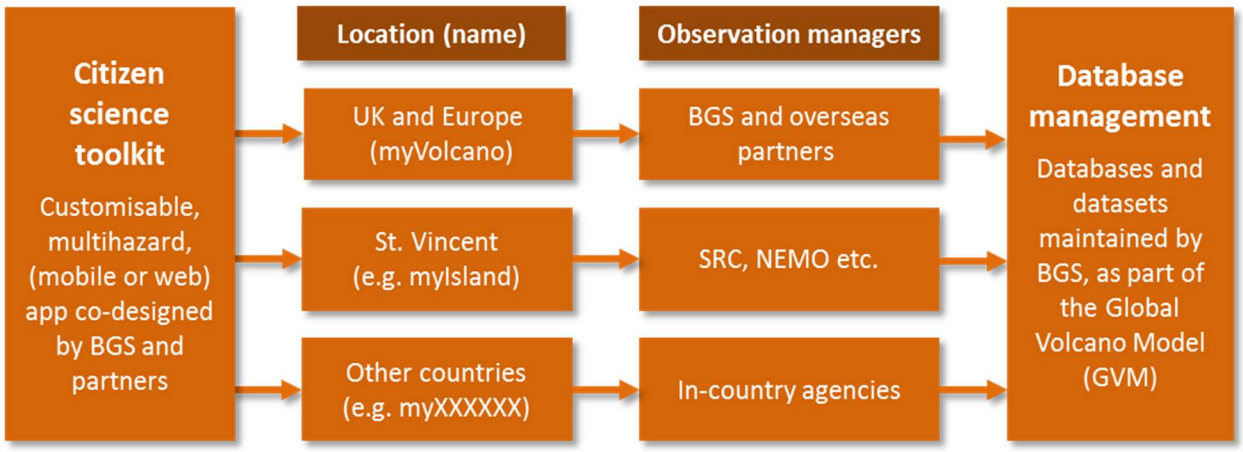

Figure 20: Conceptual diagram of the process of app localisation and ownership.

The plan is for BGS to support the app development through our Global Geological Risk ODA Platform, with co-design and co-development with our partners in the Caribbean and elsewhere.

References

British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: https://envirolib.apps.nerc.ac.uk/olibcgi.

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Appendix 1 Scenario exercise for stakeholder workshop

1

Introduction

In order to give the opportunity to test the app, we're going to explore a scenario of a period of volcanic unrest and eruption.

We'll divide into groups of two, and each group will have access to the MyVolcano app on both a laptop and an IPad. We'll run through the scenario in four parts. During each part you will have the opportunity to explore, input and visualise data in the app. Most importantly, we want to hear from you, but to help guide your discussion we've included a set of suggested questions to follow.

The purpose of the scenario is to allow you the opportunity to feedback on both the usability of the app and whether the data it collects is useful to you. Richie will lead the scenario, whilst Anna and Sam will sit with each group. They will be there to help you use the app and to facilitate addressing each of the questions. The scenario will give you the opportunity to both input and visualise data with the aim being that it helps you think about undertaking and using citizen science. One person in the group should take notes and we'll need one volunteer to feedback at the end of the exercise.

Before we start, you'll have the opportunity to have a play with the app and ask for help from the facilitators about how to use it.

The scenario exercise will last approximately 1 hour.

We hope you enjoy it!

2

May (unrest)

Over the last three months there have been felt earthquakes in the north of St Vincent. SRC report 'swarms' of earthquakes.

There have been landslides in the crater. People who visit the crater have been noticing and taking photos of other changes in the environment (e.g. cracks in the ground, more fumaroles on the old lava dome). Some have used the app to record these observations.

It's the rainy season and there has been heavy rainfall for several weeks generating floods and landslides.

3

Group activity A

Within the device photo gallery/printed on the table, there are some photographs that have been taken. Please upload these photos to the app, along with a location (provided) and a description. The main purpose here is to explore how easy/difficult it is to load information into the app.

Things to consider might include:

- How easy is it to input information?
- What types of information are most relevant and useful to you during a pre-eruption (unrest) period?
- How could you use this information? E.g. for anticipation, for preparedness, for awareness raising?

You have 15 minutes to implement and discuss.

4

1st June (pre-eruption)

SRC report a change in the earthquakes, swarms are more intense. There are reports from people working around Orange Hill that there was a rumbling coming from the volcano.

Bad weather is allowing only occasional clear views of the volcano. There has been some reported flooding in the river valleys, but the full extent of the flooding remains unclear. Descriptions of damage from flooding have been uploaded into the app.

5

Group activity B

Within the app, you will find some of the observations that people have made. These are observations from before past eruptions at St. Vincent. The main purpose here is to think about the types of observations you would find useful in your work.

Things to consider might include:

- Is the information useful in its current form?
- At this stage in the scenario, how might you use the information collected?
- Are there any issues with the information? Observation vs. interpretation.

You have 15 minutes to implement and discuss.

6

2nd June (ash plume)

At midday there is a sudden volcanic explosion. It produces a plume of ash visible from all parts of the island. Reports from Orange Hill that the ash is flowing along the ground from the crater.

There is ash fall in the north of St Vincent. There is temporary darkness and raining mud that lasts for about one hour. Afterwards there is abundant steam, grey clouds and rumbling noises from the crater area.

7

Group activity C

Explore what has been recorded in the app, how it is presented and consider its usefulness for your work.

Things to consider might include:

- What types of observations are most relevant and useful for your work during a significant event?
- The ability of people to make observations and uploading these into the app during a significant event.
- Would you use information from the app as a resource during a rapid response situation?

You have 15 minutes to discuss.

8

13th June (explosion)

Rainfall generated mudflows in valleys overnight.

There are continued reports of 'rumbling' noises. Areas west of the volcano are reporting ongoing light ash fall, grey clouds, abundant steaming in the crater area and the smell of rotten eggs.

At 4pm there is a larger explosion with ash fall across most of the north and east of the island and in Kingstown. Stones are reported falling in several places.

Ash cloud reaches Barbados and St. Lucia by 5pm.

9

Group activity D

In the final 10 minutes, consider how the app might be useful in the current situation.

Things to consider might include:

- What would be best way to visualise the information
- Could the app be used as a source of official information?
- How might you use and redistribute information? Would it be used in formal reports?

You have 10 minutes to discuss.

10

Part 2

GROUP DISCUSSION AND FEEDBACK

11

Introduction

You now have 30 minutes to discuss the MyVolcano app and the use of citizen science in your work in greater detail. A series of questions are listed below, but please use the time to raise other points relevant to you. You may have already answered some of these questions during your discussions alongside the scenario. At the end of the discussion, there will be five minutes for each group to feedback a few of their points.

Think about how your answers to these questions might differ depending on whether it was (a) before an event (e.g. before an eruption), (b) during an event (e.g. disaster) and (c) after an event (e.g. during recovery).

[I WONDER IF WE SHOULD MIX THE GROUPS UP AT THE POINT?]

12

Group discussion

1. Do you currently use or collect observations/citizen science? How?
2. Can you see any challenges or problems associated with collecting observations (and using an app like MyVolcano to do so)?
3. Who do you see as being users of the app? As uploaders data? As users of the data collected?
4. Is it useful to receive the data as a set of observations, or would you like it in a different form? Should the data uploaded to the app then be visible to the public (i.e. in the app)?
5. Is there additional information would you like to see and access in the app?
6. Do you have any suggestions for improvements/additions to the app (layout, functionality, etc.)?

Think about how your answers to these questions might differ depending on whether it was (a) before an event (e.g. before an eruption), (b) during an event (e.g. disaster) and (c) after an event (e.g. during recovery).

Appendix 2 Stakeholder workshop – feedback questionnaires

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

myVolcano Workshop Questionnaire

Name:……

Organisation:……

Role in organisation: ……..

1. Do you own a smart phone?

2. What type and (if a smart phone) operating system (e.g. Android, Apple iOS, etc.)?

3. What apps do you use for sharing information? (Tick all that apply)

- ☐ Facebook
- ☐ Twitter
- ☐ Instagram
- ☐ Youtube
- ☐ Snapchat
- ☐ Whats app
- ☐ Others:……

4. Do the majority of your friends/relatives/colleagues own a smart phone? Yes/No

5. Based on the discussions at the workshop, how likely are you download the MyVolcano app:

Very likely — Likely — Uncertain — Unlikely — Very unlikely

6. How likely are you to use MyVolcano for uploading your own observations (citizen science)?

Very likely — Likely — Uncertain — Unlikely — Very unlikely

7. How likely are you to use the citizen science data uploaded to MyVolcano?

Very likely — Likely — Uncertain — Unlikely — Very unlikely

8. How likely are you to use MyVolcano for other information?

Very likely — Likely — Uncertain — Unlikely — Very unlikely

Please turn over…

9. Are you more likely to use the app or the website? Why?

10. Would you make observations using myVolcano during your work or during your own time? Why?

11. Would you use the information (the observations) submitted to myVolcano for decision-making in your work? How?

12. Any other comments on MyVolcano?

13. Any suggested improvements for the workshop?

Many thanks for your participation in the workshop. Your feedback will be used to improve the app and understanding of the role of citizen science in disaster risk reduction.

Appendix 3 School visits – feedback worksheet

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

myVolcano schools' worksheet

Name:……

Age:……

Gender:……..

School:……

Space for answers (questions will be provided during the presentation)

Background questions

1. Do you own a mobile/cellular phone? Yes/No

2. What type and (if a smart phone) what operating system (e.g. Android, Apple iOS, etc.)?

3. What apps do you use for sharing information online? (Tick all that apply)

- ☐ Facebook
- ☐ Twitter
- ☐ Instagram
- ☐ Youtube
- ☐ Snapchat
- ☐ Whats app
- ☐ Others:……

4. On a scale of "very easy" to "very difficult", how do you find using myVolcano?

Very easy — Easy — Not sure — Difficult — Very difficult

5. How likely are you download the MyVolcano app?

Very likely — Likely — Uncertain — Unlikely — Very unlikely

6. How likely are you to use MyVolcano for uploading your own observations (citizen science)?

Very likely — Likely — Uncertain — Unlikely — Very unlikely

7. How likely are you to use the citizen science data uploaded by other people to MyVolcano?

Very likely — Likely — Uncertain — Unlikely — Very unlikely

Appendix 4 Suggestions for improvements to myVolcano from workshop participants

Identified by workshop participants		Analysis		
Suggestion	**Reasons**	**Outcome**	**Themes**	**Comments**
Ability for users to update and comment on observations	*Have a thread of information come through that people could update, would also be useful. Group B specifically mentioned this in their discussion.*	Assist with verification process	Verification/ validation and interaction	
Adding an informed comment to the observations by the authorities	*The people who are validating the information could add to this information by adding something else, not by altering the original observation, but could add a comment to qualify the observation*	More informative data output	Visualisation and verification/ validation	
Change name/emphasis	*Instead of myVolcano, why not myIsland? Emphasis on volcanoes needs to be removed. Group A: emphasis on volcanoes needs to be weaker; Group C: two working at community scale said to increase the profile of the flood and landslide component. Final discussion suggestion of changing name.*	More interest and motivation to use the app	Scope, perception and motivation	Future app version or new app?
Change symbols	*Change symbols of observations (clouds) to represent the hazard. Instead of a cloud it would be better if they related to the type of observation being made. They should also reflect the level of danger to stop people having to investigate all the observations when time is essential and bandwidth is potentially low.*	Ability to make a faster visual analysis of the current situation	Visualisation and data management	The already developed multiple hazard tick list could be used as a means of filtering, with appropriate background information.
Contact details of observer ("citizen scientist")	*To allow follow up of observations, could ask users to provide their contact information when downloading the app.*	Actionable information	Communication, interaction and verification	Originally not added to the functionality, owing to data protection implications.
Data filter	*More visible timestamp or filtering by date/time.* *Could distinguish between information provided by the public and that provided by officials using separate maps or layers?* *How would you manage the observations in terms of how long you show them for? Is there a cut-off point that we could use after which we hide observations to avoid the map becoming crowded.* *Old versus new observations?* *Prioritise posts based on key words?*	Helps to manage issues related to low bandwidth, helps to avoid overcrowding of observations.	Visualisation, verification and data management	
Detailed descriptions of hazards	*For instance the severity of the hazard.*	Increased usability of the data	Data management	The already developed multiple hazard tick list could be used as a means of filtering, with appropriate background information.

Identified by workshop participants		Analysis		
Suggestion	**Reasons**	**Outcome**	**Themes**	**Comments**
Information about hazards	*E.g. red, yellow and green zones; basic information on hazards and mitigation.*	More informative	Communication: awareness raising and education	A layer could be added within the app.
Information about a possible or current situation	*Guidance within the app on what a dangerous situation would look like; situation on the ground; area most affected; closed roads/passable roads Warnings from NEMO, Push notifications*	More informative	Communication: awareness raising, advice and decision-making	Requires resource from NEMO and/or linking to existing notifications
Information on what to do	*What to do and what to expect next. Locations of shelters and emergency routes, including whether these are open or not.*	More informative	Communication: advice and decision-making	
Link to official organisations	*Emergency response organisations, including who and how to contact.*	More informative	Communication: advice	Home pages are a step towards this
More specific location information	*Latitude and longitude are meaningless and the maps require more detail to help users locate their observations. Location information needs to be more descriptive. The app should open directly at your location.*	Improved usability	Localisation	
Notifications	*Would be good to enable notification of observations or events for a specific area of interest. Could have push notifications/alerts using NEMO.*	More informative	Motivation - increase up take if receiving information from NEMO.	Requires resource from NEMO/linking to existing notifications
Offline functionality	*Group B noted that Digicel are currently working on methods for using apps and data when there is no internet.* *Group C noted that the iPad did not cache any of the maps or observations* *Concern that communication systems would still be working, but also faith that authorities and companies would keep them going.*	Greater redundancy	Resilience of systems	
Other media	*Integrating text information from people who do not have smart phones. Lots of people use Facebook.* *Capacity to upload videos and audio recordings?*	Integrated app	All encompassing	
Real time functionality	*Instantaneous information - if not in real time, not very useful.*	More informative in real-time	Verification	

Appendix 5 Summary of responses from all school visits

On a scale of very easy to very difficult, how did you find using myVolcano?							
	Very easy	Easy	Not sure	Difficult	Very difficult	No answer	Total
St Vincent Girls High School	5	30	11	0	0	0	46
St Vincent Grammar School	5	18	3	1	0	0	27
Thomas Saunders Secondary School	10	14	4	0	0	0	28
Mountain View Adventist Academy	4	12	1	2	0	0	19
Total	**24**	**74**	**19**	**3**	**0**	**0**	**120**
How likely are you download the MyVolcano app?							
	Very likely	Likely	Not sure	Unlikely	Very unlikey	No answer	Total
St Vincent Girls High School	5	25	15	1	0	0	46
St Vincent Grammar School	7	9	8	2	1	0	27
Thomas Saunders Secondary School	6	13	8	1	0	0	28
Mountain View Adventist Academy	3	13	3	0	0	0	19
Total	**21**	**60**	**34**	**4**	**1**	**0**	**120**
How likely are you to use MyVolcano for uploading your own observations (citizen science)?							
	Very likely	Likely	Not sure	Unlikely	Very unlikey	No answer	Total
St Vincent Girls High School	3	11	24	8	0	0	46
St Vincent Grammar School	3	13	8	3	0	0	27
Thomas Saunders Secondary School	4	14	10	0	0	0	28
Mountain View Adventist Academy	5	9	5	0	0	0	19
Total	**15**	**47**	**47**	**11**	**0**	**0**	**120**
How likely are you to use the citizen science data uploaded by other people to MyVolcano?							
	Very likely	Likely	Not sure	Unlikely	Very unlikey	No answer	Total
St Vincent Girls High School	8	16	19	3	0	0	46
St Vincent Grammar School	4	8	11	1	2	1	27
Thomas Saunders Secondary School	4	14	10	0	0	0	28
Mountain View Adventist Academy	2	7	10	0	0	0	19
Total	**18**	**45**	**50**	**4**	**2**	**1**	**120**