iĀWHINA: Towards Designing an Offline Disaster Mobile Application

Ahmed Al-Sadi
Whitireia Community Polytechnic and
Wellington Institute of Technology
ahmed.al-sadi@weltec.ac.nz

Thelma Moses
Wellington Institute of Technology
thelma.moses@weltec.ac.nz

Saed Altawabeyeh
University of Auckland
salt475@aucklanduni.ac.nz

ABSTRACT

The aim of this paper is to present the design stages of a built-for-purpose disaster response mobile application called iĀwhina. The authors propose to design iĀwhina as an interactive user-friendly offline mobile application that provides flawless user experience to support and aid in emergency response situations. The prototype works in both online and offline modes, using ad hoc network technology. The design process followed during the development of the user interface is based on a set of usability criteria that are presented in this paper. A systematic literature review on the usability criteria for disaster mobile applications and discussions with industry experts helped to finalize the user interface elements that will enhance the usability of the application. The relevant features that will be included in the application were drawn from literature. A discussion on how the design process plays a critical role in designing disaster mobile applications is also presented.

Keywords

UI design, User experience, Disaster mobile applications

INTRODUCTION

A disaster is defined as an extraordinary event that causes significant disruption and impact that exceeds the capacity of the available resources and the organisations to deal with (Alexander, 2002). Earthquakes, volcanic eruptions, tsunamis, pandemics, floods, and other such events are classified as disasters. The COVID19 pandemic and the 2021 volcanic eruption in Tonga are recent examples of disasters. For centuries, these events have occurred all over the world causing devastating consequences (Quarantelli et al., 2007). When a disaster strikes, people's normal lives are disrupted, and there is a desperate need for assistance, rescue, and relief for the victims of the disaster. Disasters can cause incalculable human, structural, and economic losses if not managed properly.

In recent years, there has been a surge of interest in the development of mobile applications aimed at providing aid during and after major natural disasters (Wang et al., 2018). These applications depend on Information and Communication Technology (ICT) which plays a key role in the management of any type of disasters. It facilitates efficient communication to help connect people, share information, and maintain communication between and among victims and rescuers (Andersen & Spitzberg, 2020; Pipek et al., 2014). These technologies continue to contribute significantly to disaster management through built-for-purpose disaster management mobile applications. Such disaster management apps have been developed for crowdsourcing, collaboration (among and between rescuers and victims), alerting and information, notification and collating information from various sources (Tan et al., 2017).

Despite significant increase in the number of disaster management apps, the research on their usability and user experience, and the public evaluation of their usefulness is limited. According to Tan et al. (2020) there is limited research on the user experience of such disaster mobile applications. Most of the related research focuses on the functionality of the applications. Only few researchers have examined disaster management apps from the perspective of the citizens who are the intended users (Ahmad et al., 2018). Furthermore, most of the current mobile app usability studies focus on services that are employed in non-disaster situations like mobile banking

and health management (Azad-Khaneghah et al., 2021; Tan et al., 2019).

The primary objective of the research is to develop a user-friendly offline mobile phone application called (iĀwhina). 'Āwhina' means 'to assist, help, support, or benefit' in the Māori language. The 'i' in the name was introduced to connote the information and communication technology embedded in the application. iĀwhina is a collaborative built-for-purpose disaster response mobile application that will be used by the community immediately after disasters. It will be designed to enable community members to collaborate and respond in emergency situations when the communication infrastructure is either cut-off or unreliable and the availability of support services is unpredictable. The achievement of offline communication is done with a wireless ad hoc communication network. Due to the nature and the purpose of the application, the usability attributes for this application may vary from those proposed in the literature.

In this paper the design stage of the mobile application iĀwhina presented. The paper describes the process through which the researchers identified and defined the user interface elements for the application that will enhance its usability. This paper is structured as follows: It begins with a brief overview of the studies from where the user interface design elements and design principles were identified and defined. Then the methodology followed in application development and the App design is discussed. The paper ends with a discussion, conclusion, and directions for future work.

DISASTER MOBILE APPLICATIONS AND USABILITY

A well-designed disaster mobile application has the potential to improve response and recovery in a disaster situation. However, if the technologies were not adequately employed, it poses significant risks to the users of the application as it compromises the safety of the users (Büscher et al., 2016). It is important to ensure that users can effectively interact with the application even during stressful emergency situations (Sarshar et al., 2015).

Usability ensures that the mobile application assists the users in achieving their goals by making the application do what it is intended to do (Mcnamara & Kirakowski, 2006). With disaster mobile applications, usability results from designing user interface elements that allow users to receive and share critical information for efficient decision making (Sarshar et al., 2015). Usability attributes vary with different applications as the applications are developed with unique features for varying contexts. Also, usability criteria evolve continually with the rapidly changing needs of the end users and accelerated technological developments. Hence, new dimensions of usability are being continually introduced in literature (Alturki & Gay, 2019). More recently, with the increase in the number of mobile applications that serve multiple purposes, there has been significant research interests in identifying and evaluating the usability dimensions of such mobile applications.

Due to the nature and scope of various disaster management mobile apps, there is limited consensus among them on the dimensions of usability. For most of the applications, the usability guidelines were drawn from the International Organization for Standardization's (ISO) seven general principles, Nielsen's ten usability heuristics, or Shneiderman's eight golden rules. Alturki and Gay (2019) conducted a systematic literature review on usability attributes of mobile applications. They identified and summarized usability attributes from 18 published and peer-reviewed journal articles. Satisfaction, effectiveness, efficiency, learnability, simplicity, usefulness, errors, understandability, and attractiveness were frequently mentioned in these articles, together with attributes such as memorability and cognitive load. These were general guidelines for any mobile application that were developed for use.

Tan et al. (2020) proposed usability guidelines for disaster mobile apps from the end user's perspective to improve the usability of such applications. Their elaborate scoping review identified three overarching themes from literature: present information effectively; develop a non-complex interface and build trust. They also revised the wording in these themes to reflect insights on the frequency of use. The revised themes were making critical information salient, considering cognitive load when designing the interface and building trust, and anticipating the level of interaction.

From the above discussion it is evident that there is limited consensus among the researchers on the specific usability attributes that must be included in disaster management mobile applications. Also, there are limited studies that evaluate usability from the user's perspective. It is obvious that the usability dimensions vary with the scope and the purpose for which the mobile apps are developed for. Hence it is posited that the usability attributes that will enhance the user interface in iĀwhina may vary than those identified from literature. This paper elaborates on the process the researchers adopted to identify the most promising usability attributes for iĀwhina.

THE DESIGN PROCESS

The development of iĀwhina went through three stages. The first stage was to analyse relevant existing literature to identify and clarify the main features of mobile applications. In the second stage, an initial concept was developed and evaluated in an informal usability study. The feedback from the second stage was used to develop a protype that will go through a formal usability study in the third stage. The first two stages are presented in this paper. The process used to develop the iĀwhina app is illustrated in **¡Error! No se encuentra el origen de la referencia.**.

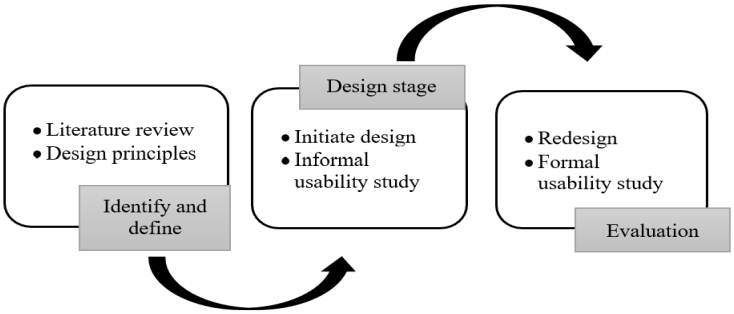

Figure 1. A graphical representation of the application development stages.

Stage one: Identify and Define

In stage one, in-depth literature review was conducted to enable a broad assessment of the studies that discussed built-for-disaster-purpose mobile applications. Even though it is contended in literature that research on new disaster technologies focus more on capabilities and functionalities than on interface issues such as usability (Tan et al., 2020; Tan et al., 2017), it is considerably harder to decide what features should be offered in the application when it is known that the victim would use the application only in emergency situations. The features identified from literature review are tabulated below (Table 1).

Table 1: Summary of Features for Disaster Mobile Applications

Feature	Explanation	Example studies
Receive disaster-related information	The user receives information from the authorities. Information may include notifications about the situation or information for raising awareness.	(Anta et al., 2021; Arslan et al., 2021a; Frigerio et al., 2018)
Share location	The application enables sharing the location of the victim. The purpose of sharing could be to rescue or collect information.	(Tan et al., 2019; Tundjungsari & Sabiq, 2017; Widagdo et al., 2021)
Broadcast information to others	The user can broadcast information to people around. The broadcasted information could be a request for help or offering help or a service.	(Fabito et al., 2016; Sciullo et al., 2018; Tundjungsari & Sabiq, 2017)
Rescue support	The application can assist rescue operations with algorithms or smart phone capabilities.	(Berawi et al., 2021; Han & Han, 2018; Ludwig et al., 2014)
Send SOS	The application contains a button that is specifically included to send requests for help.	(Gupta & Katarya, 2020; Mody et al., 2020)
Geo-fence	The application creates a local network around the victim to create a small community.	(Gupta & Katarya, 2020; Mody et al., 2020)
Communicate offline	The application offers the ability to communicate even when there is no cellular network.	(Balaji et al., 2017; Gunaratna et al., 2015; Tundjungsari & Sabiq, 2017)
Show safe routes	The application considers data collected during the disaster to show safe routes for users to follow.	(Hyoungseong et al., 2015; Tundjungsari & Sabiq, 2017)

Voice-call	Users can make voice calls using the application when the cellular network is down.	(Gunaratna et al., 2015)
Show disaster/safe zones	The application shows safe and dangerous zones for the user.	(Adeel et al., 2019; Arslan et al., 2021b; Auferbauer et al., 2015; Erdelj et al., 2017)

Few other features such as chatting, sharing location, reporting to authorities, supporting rescue operations, Real-time updating of disaster information were also identified (Arslan et al., 2021a, 2021b; Oganiza et al., 2019; Sukhwani & Shaw, 2020; Tundjungsari & Sabiq, 2017)

More recently, disaster mobile applications use offline communication technologies that use ad hoc networks to communicate between devices, even when the communication infrastructure is unreliable/completely cut off. Regarding offline communication, the review indicated that Wi-Fi technology is the most established and commonly used technology that enabled offline communication in disaster applications. Wi-Fi is a group of wireless network protocols built on the IEEE 802.11 family of standards. These protocols are frequently used for Internet access and local area networking of devices, allowing nearby digital devices to communicate via radio waves. These are the most widely used computer networks in the world. They are used in home and small office networks to connect desktop and laptop computers, tablet computers, smartphones, smart TVs, printers, and smart speakers through a wireless router to connect them to the Internet. This network technology also provides wireless access points in public locations like coffee shops, hotels, libraries, and airports to provide the public Internet access for mobile devices.

Stage two: Design Stage

Two primary questions guided the design stage: What are the suitable user interface design elements that can be used to develop a mobile application that will connect the community in a catastrophic disaster situation? And how to enable ordinary citizens in the community to provide and receive support/help from each other immediately after the disaster? The support/help offered will be sharing or offering food, medicines, psychological support, and the like.

Based on the overarching themes on usability guidelines that emerged from the literature review, an informal usability inquiry through a focused group discussion with 4 participants (three men and one woman aged 28, 30,40 and 43 years) was conducted to gather information on the target users' preferences of the usability attributes that could be included in the application. All participants were invited to the session in person to discuss the features and the design attributes. This provided an understanding of the design elements to include in the initial design of the application. The initial finding was that there are functional concerns due to the lack of functional clarity on what to do and the participants were unsure of how to request or accept support. They also requested a conversation function between the victims and the rescuers and emphasized on user-friendliness as an important criterion.

The concept behind the application was also informally discussed with two industry experts. They work in a well-known design agency in Wellington, New Zealand, as user experience designers and have a combined experience of more than 20 years between them. In the meeting, the main pages to be included in the App and ways to improve user experience was discussed. The experts emphasized on the simplicity of design, user trust in the application and flexibility of design as key attributes.

The information obtained through these processes guided the researchers to propose the initial user flows, including the main tasks and the user events. Each element was evaluated and ranked to reduce the risk of overflowing the screen.

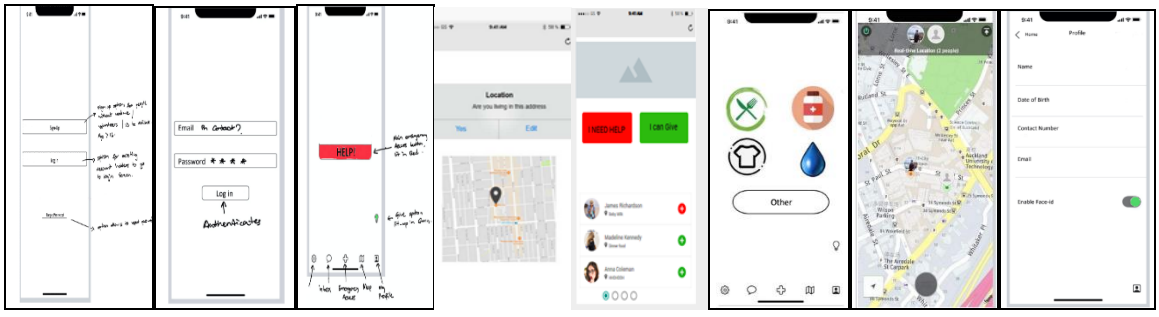

Figure 2: the initial design created for the medium-fidelity prototype.

The wireframes were then created using lean UX design. First prototype was designed using Figma, and the first version of the wireframe is shown in figure 2. Another version of the wireframe was reconstructed after using stamp and Emotes feature by Figma as shown in figure 3. This allowed the participants to evaluate the design and the user flow using 8 inspect elements. Visual feedback worked well for both real-time and asynchronous collaboration, allowing to vote among several concepts and receive feedback from both the researchers and the designers.

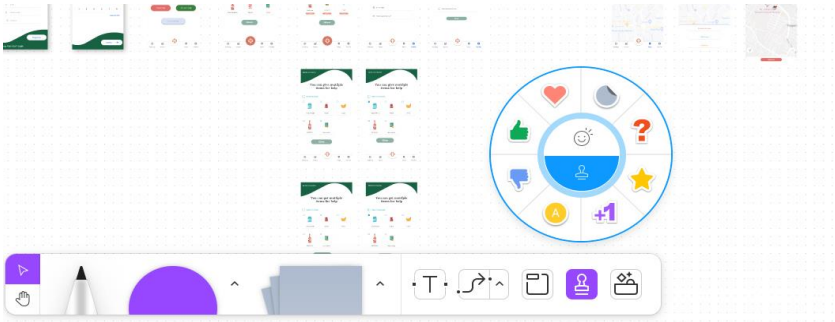

Figure 3: Stamp and Emotes Figma Features.

The third version has 8 main pages. In Page 1, the Splash Screen, Registration, and Login Screen are first seen by users who download the App and log in for the first time. The application allows the user to sign up or log in or to reset passwords if they already have an account. The log-in screen will not appear for users who have already signed in. In page 2, the Main Screen provides the user functionalities. The main feature in this page is seeking or providing help, along with settings, inbox, emergency access, map, and profile tabs. In page 3, Location Detection Screen will appear for first-time users to verify the user location, which is critical in this application. In page 4, the Help Screen 1. Clicking on the help button takes the user to give or request for help. In pages 5 and 6, Help Screen 2, clicking on the help button takes the user to a screen with graphical illustrations where they can easily identify their needs, which in turn sends a request to a helper. In page 7, the Map Screen is displayed to a 'helper' to provide the location of the emergency service required. It is also displayed to the person seeking help so they could view where their helper is located. In page 8, the Profile Screen contains details of the users such as name, DOB, phone number and email address. These details can be updated by the user as required.

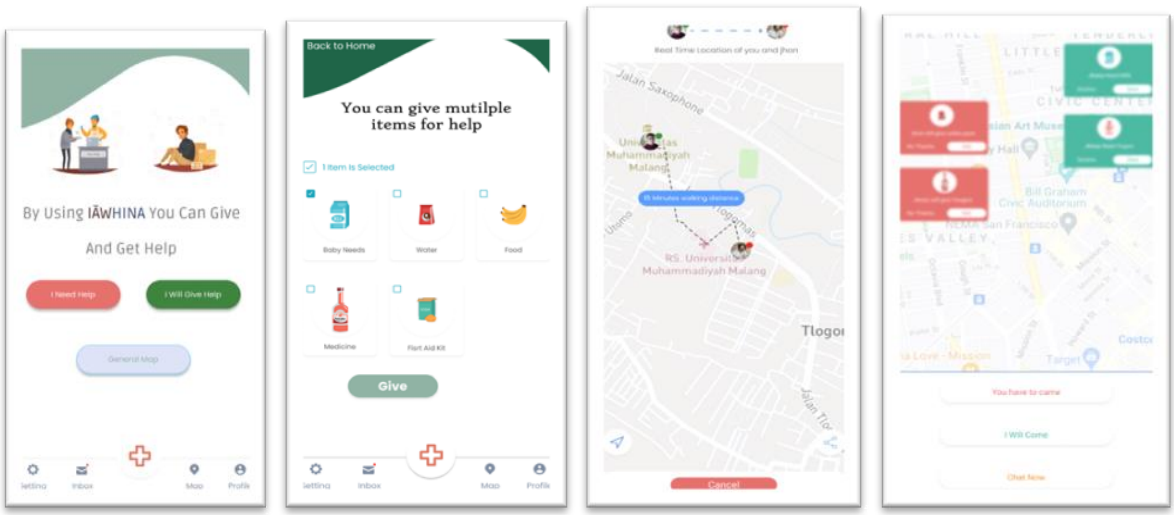

Figure 4: Example of iĀWHINA final draft pages.

Stage 3: Evaluation

This stage is in progress. A formal usability study with a sample of new users will be conducted to fine-tune the design elements to enhance the usability of the application. The goal is to conduct semi-structured interviews with 18 individual users. Ethics approval has been obtained to conduct the study.

CONCLUSIONS AND FUTURE WORKS

With the development of the App, we hope to equip the community with an offline tool that can facilitate communication among members in a neighborhood, enabling them to support each other until the arrival of emergency support services and/or the restoration of the communication infrastructure. Hence, this application helps in the response phase of the disaster management cycle.

Like most of the other studies related to built-for-disaster-purpose applications, the importance of functionality for an application is recognized in this study. This study also highlighted the need to align functionality with an uncompromising focus on usability. Enhanced usability of disaster management mobile applications certainly leads to saving lives and reducing costs. Therefore, designing such an application should be user-centered and should provide a satisfactory user experience.

Among the many usability principles reviewed, it was concluded that reducing cognitive load, increasing learnability, user friendliness and enabling effective information delivery were the most prominent usability principles for mobile applications in the context of disasters. Through iĀwhina users have the fastest way to get or provide help/support. This makes sense in a disaster situation where users panic and are desperate to survive. Therefore, a minimalist user interface is recommended for such applications. In terms of features, reverting to the most basic communication features is essential. A simple feature such as enabling an SOS call makes a big difference. However, the most significant feature that must be in the application is the ability to work in an offline mode. Users wanted a reliable application with less fancy features. The Wi-Fi protocol is a promising technology that could be used to provide offline communication when communication networks are unreliable/interrupted.

Future work concerns implementing the recommendations that were obtained from this study. Further usability tests will be conducted, and the App fine-tuned before it is published in Android and/or iOS operating systems. The published application will serve as a valuable research tool to understand how to build effective communication systems during disasters. Finally, in relation to the application itself, further work is needed on accessibility features of the application. The application could be extended to include an efficient user interface for adults with physical and mental limitations.

REFERENCES

Adeel, A., Gogate, M., Farooq, S., Ieracitano, C., Dashtipour, K., Larijani, H., & Hussain, A. (2019). A survey on the role of wireless sensor networks and IoT in disaster management, *Geological disaster monitoring based on sensor networks*, 57-66. https://doi: 10.1007/978-981-13-0992-2_5

Ahmad, N., Rextin, A., & Kulsoom, U. E. (2018). Perspectives on usability guidelines for smartphone applications: An empirical investigation and systematic literature review, *Information and Software Technology, 94*, 130-149. https://doi.org/10.1016/j.infsof.2017.10.005

Alexander, D. (2002). Principles of emergency planning and management. Oxford University Press.

Alturki, R., & Gay, V. (2019). Usability Attributes for Mobile Applications: A Systematic Review, *Recent Trends and Advances in Wireless and IoT-enabled Networks*, 53-62. https://doi.org/DOI: 10.1007/978-3-319-99966-1_5

Andersen, P. A., & Spitzberg, B. H. (2020). Myths and Maxims of Risk and Crisis Communication, *Handbook of Risk and Crisis Communication*, Routledge. https://doi.org/https://doi.org/10.4324/9781003070726

Anta, V. L. P., Liestyo, I. A., & Warnars, H. L. H. S. (2021). Mobile Application for flood disaster in Jakarta, *International Conference on Artificial Intelligence and Smart Systems (ICAIS)*, 506-510. doi: 10.1109/ICAIS50930.2021.9395799

Arslan, D., Dincer, S. F., & Kirci, P. (2021a). A Mobile Application About Earthquake to be Used Before and After a Disaster, *IEEE 4th International Conference on Advanced Information and Communication Technologies (AICT)*, 84-87, doi: 10.1109/AICT52120.2021.9628969

Auferbauer, D., Ganhör, R., & Tellioglu, H. (2015). Moving Towards Crowd Tasking for Disaster Mitigation, *12th International Conference on Information Systems for Crisis Response & Management (ISCRAM)*, Kristiansand, Norway.

Azad-Khaneghah, P., Neubauer, N., Miguel Cruz, A., & Liu, L. (2021). Mobile health app usability and quality rating scales: a systematic review, *Disability and Rehabilitation: Assistive Technology*, 16,7, 712-721. https://doi.org/10.1080/17483107.2019.1701103

Balaji, V., Akshaya, A., Jayashree, N., & Karthika, T. (2017). Design of ZigBee based wireless sensor network for early flood monitoring and warning system, *IEEE Technological Innovations in ICT for Agriculture and Rural Development (TIAR)*, 236-240. https://doi: 10.1109/TIAR.2017.8273723

Berawi, M. A., Leviäkangas, P., Siahaan, S. A. O., Hafidza, A., Sari, M., Miraj, P., Harwahyu, R., & Saroji, G. (2021). Increasing disaster victim survival rate: SaveMyLife Mobile Application development. *International journal of disaster risk reduction*, 60. https://doi.org/10.1016/j.ijdrr.2021.102290

Büscher, M., Becklake, S., Easton, C., Kerasidou, X., Oliphant, R., & Peterson, K. (2016). ELSI Guidelines for Networked Collaboration and information Exchange in PPDR and Risk Governance. *Information Systems for Crisis response and Management (ISCRAM)*, Rio de Janeiro, Brazil.

Erdelj, M., Król, M., & Natalizio, E. (2017). Wireless Sensor Networks and Multi-UAV systems for natural disaster management. *Computer Networks, 124*, 72-86. https://doi.org/10.1016/j.comnet.2017.05.021

Fabito, B. S., Balahadia, F. F., & Cabatlao, J. D. N. (2016). AppLERT: A mobile application for incident and disaster notification for Metro Manila, *IEEE Region 10 Symposium (TENSYMP)*, 288-292, https://doi: 10.1109/TENCONSpring.2016.7519420.

Frigerio, S., Schenato, L., Bossi, G., Mantovani, M., Marcato, G., & Pasuto, A. (2018). Hands-on experience of crowdsourcing for flood risks. An android mobile application tested in Frederikssund, Denmark. *International journal of environmental research and public health*, 15,9, 19-26. https://doi: 10.3390/ijerph15091926

Gunaratna, G., Jayarathna, P., Sandamini, S., & De Silva, D. (2015). Implementing wireless Adhoc networks for disaster relief communication, *8th International Conference on Ubi-Media Computing (UMEDIA)*, 66-71. https://doi: 10.1109/UMEDIA.2015.7297430

Gupta, A., & Katarya, R. (2020). Social media based surveillance systems for healthcare using machine learning: a systematic review. *Journal of Biomedical Informatics*, 108, 1-13. https://doi.org/10.1016/j.jbi.2020.103500

Han, J., & Han, J. (2018). Building a disaster rescue platform with utilizing device-to-device communication between smart devices, *International journal of distributed sensor networks*, 14, 3. https://doi:10.1177/1550147718764284

Hyoungseong, P., Si-bum, C., & Dongseag, K. (2015). Development of a smartphone application for disaster response, *OCEANS 2015-MTS/IEEE Washington*, 1-4. doi: 10.23919/OCEANS.2015.7404627

Ludwig, T., Siebigteroth, T., & Pipek, V. (2014). Crowdmonitor: Monitoring physical and digital activities of citizens during emergencies, *International Conference on Social Informatics.* https://doi.org/10.1007/978-3-319-15168-7_51

Mcnamara, N., & Kirakowski, J. (2006). Functionality, usability, and user experience: three areas of concern, *Interactions*, 13,6, 26-28. https://doi.org/https://doi.org/10.1145/1167948.1167972

Mody, V., Mody, V., & Parekh, S. (2020). Distress–an application for emergency response and disaster management, *International Conference on Smart Electronics and Communication (ICOSEC)*, 830-836. doi: 10.1109/ICOSEC49089.2020.9215288

Oganiza, O. P., Reselva, M. P., Vicencio, J. P. V., Casim, R. C., & Subia, G. S. (2019). iMALERT–an Emergency Response Mobile Application Using Geo-Location for Palayan City Disaster Risk Reduction and Management Office, *International Journal of Advanced Engineering, Management and Science*, 5,7, 446-453. DOI:10.22161/ijaems.573

Pipek, V., Liu, S. B., & Kerne, A. (2014). Crisis Informatics and Collaboration: A Brief Introduction, *Computer Supported Cooperative Work (CSCW)*, 23, 4-6, 339-345. https://doi.org/10.1007/s10606-014-9211-4

Quarantelli, E. L., Lagadec, P., & Boin, A. (2007). A Heuristic Approach to Future Disasters and Crises: New, Old, and In-Between Types, *Handbook of disaster research*. Springer.

Sarshar, P., Nunavath, V., & Radianti, J. (2015). On the Usability of Smartphone Apps in Emergencies, *Human-Computer Interaction: Interaction Technologies*, 765-774. https://doi.org/10.1007/978-3-319-20916-6_70

Sciullo, L., Fossemo, F., Trotta, A., & Di Felice, M. (2018). LOCATE: A LoRa-based mObile emergenCy mAnagement sysTEm," *2018 IEEE Global Communications Conference (GLOBECOM)*,1-7, doi: 10.1109/GLOCOM.2018.8647177.

Sukhwani, V., & Shaw, R. (2020). Operationalizing crowdsourcing through mobile applications for disaster management in India. *Progress in Disaster Science, 5*. https://doi.org/10.1016/j.pdisas.2019.100052

Tan, M. L., Prasanna, R., Stock, K., Doyle, E. E., Leonard, G., & Johnston, D. (2020). Understanding end-users' perspectives: Towards developing usability guidelines for disaster apps, *Progress in Disaster Science*, 7. https://doi.org/10.1016/j.pdisas.2020.100118

Tan, M. L., Prasanna, R., Stock, K., Hudson-Doyle, E., Leonard, G., & Johnston, D. (2017). Mobile applications in crisis informatics literature: A systematic review, *International journal of disaster risk reduction*, 24, 297-311. https://doi.org/10.1016/j.ijdrr.2017.06.009

Tan, M. L., Prasanna, R., Stock, K., Hudson-Doyle, E., Leonard, G., & Johnston, D. (2019). Enhancing the usability of a disaster app: exploring the perspective of the public as users. *ISCRAM*, valencia, Spain.

Tundjungsari, V., & Sabiq, A. (2017). Android-based application using mobile adhoc network for search and rescue operation during disaster, I*nternational Conference on Electrical Engineering and Computer Science (ICECOS)*,16-21, doi: 10.1109/ICECOS.2017.8167124

Wang, C., Du, W., Chen, Z., Chen, N., & Wang, W. (2018). An Event Modeling Software for Natural Disasters: Design and Implementation, *26th International Conference on Geoinformatics*, 1-4, doi: 10.1109/GEOINFORMATICS.2018.8557045.

Widagdo, J., Putra, D. D., Syihabuddin, B., Juhana, T., Mulyana, E., & Munir, A. (2021). Android-based Disaster Management Application for After-Disaster Rapid Mobile Assessment, *IEEE International Conference on Internet of Things and Intelligence System (IoTaIS)*, 201-204, doi: 10.1109/IoTaIS50849.2021.9359695.