Situational Disabilities in Information Systems for Situational Awareness in Flood Situations in Nigeria

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Abstract. Floods are one of the major natural disasters that contribute to the high disaster death rate in the global south, especially in Nigeria. This requires an effort of collaboration from all stakeholders in designing, building, deploying, and maintaining inclusive disaster management systems. This effort can hardly be achieved without the application of universal design principles in designing rescue applications. In this research, we have studied situational disabilities and their effect on situational awareness based on the data collected from victims in Nigeria through a questionnaire with 56 respondents and 5 follow-up interviews. The research work contributed to identifying situational disabilities and their corresponding accessibility barriers based on difficulty experiences collected from the research participants in Nigeria.

Keywords: Universal Design, Universally Designed Rescue Applications, Inclusive Disaster Management Systems, ICT for Situational Awareness.

1 Introduction

Natural Disasters have always affected humans. It remains a fact that we are living in a world where different kinds of severe natural disasters occur and impact the socio-economic sphere of the affected areas [1]. Information Communication Technology (ICT) artifacts are essential in emergency management [2], and their accessibility and usability in a disastrous situation through the application of universal design principles has become a scientific discussion topic [3-8].

Universal Design principles are applied in many areas to ensure that products and services are usable for the broadest possible diversity of users [9]. However, there is still room for improvement when it comes to Emergency Management in flood scenarios to mitigate situational disabilities that might hinder situational awareness [10, 11]. Floods are among the most common natural disasters, with 30-50 million people affected each year [12]. In Nigeria, flood accounts for the most frequently occurring natural hazards, with great consequences on life and property [13]. The causes of floods are both natural and anthropogenic and in the last decades, for instance, many states and cities have witnessed unusual and devastating floods [13].

Research work has shown that individuals in a disaster situation are often unable to access information through the use of technologies in their environment as a

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consequence of situational factors [10]. Situational awareness is an important factor for effective decision-making, especially when it comes to crisis management [14]. In the context of this paper, situational awareness is defined as the ability to be aware of one's surroundings and identify potential hazards or dangers [15]. Individuals in natural disasters can experience state of shock, trauma, or being unable to move to safety or use available technology to seek help due to the dangerous conditions all around them. In these cases, the individual is said to be situationally disabled. Situational disability is a term used to describe the disability-like difficulties that people face when they are affected by situational factors. In a disaster situation, these factors can make it difficult for them to be aware of what's happening around them or to plan the appropriate action to take [10]. Examples include impaired vision in fogged environments, limited mobility in flooded areas, and hearing impairments in noisy areas. These types of disabilities can pose challenges when carrying out certain tasks or navigating spaces. Individuals might not be able to utilize available means like ICT emergency services, warning announcements, and evacuation plans for evacuation or seeking safety in time. Mitigating situational disabilities in the use of ICT devices provides an opportunity to create a more inclusive emergency management system that benefits all users. This work aims at providing an in-depth systematic understanding of the possible situational disabilities experienced by individuals in flood situations, which hinders situational awareness. |It also highlights high-impact scenarios where a universal design approach can be used to enhance situational awareness.

We will examine the ways various factors trigger situational disability and its impact on situational awareness in flood emergency situations in Nigeria through gathered data from flood victims. The core objective of this research work is to identify situational disabilities in a flood situation and study their effect on situational awareness through answering the following research questions.

- RQ1: What are the situational disabilities at play in a flood scenario?
- RQ2: What are the effects of situational disabilities on situational awareness in a flood scenario?

The rest of the paper is organized as follows. Section 2 reviews existing related research works in the research domain. Section 3 focuses on the methodology of the research work. Section 4 deals with the analysis and results of the study. The discussion is covered in Section 5. Conclusion and future works are included in Section 6.

2 Background

2.1 Flood-Related Disaster Situations

According to the global survey conducted by the UN published on 10 October 2013, the top hazards or disaster risks faced by survey respondents were floods, with 54% of all hazardous occurrences [16]. Developing countries are more prone to disasters or hazards due to challenges like poverty, lack of resources, lack of educational opportunities, poor infrastructure, lack of trained manpower, lack of awareness and

knowledge of disaster and mental health [16]. Research has shown that flooding is the most severe and prevalent adverse event and has serious implications for sustainable development [17].

While the world is currently facing the COVID-19 pandemic, disasters such as flooding are still occurring, but limited attention is being paid. The United Nations 2030 agenda for sustainable development calls for a global partnership in addressing these problems. Intending to highlight areas of possible partnership on disaster-risk reduction, Nigeria like most sub-Saharan African nations is prone to perennial flooding and advocates for national cooperation in managing flood risks. Empirical research on the effects of disaster on people, though sparse, confirms that individuals with disabilities are at higher risk of death [18] and injury [19]. The impacts of floods are catastrophic and most times very difficult to forecast with precision and can subsequently leave people uninformed and subject to surprise amid their daily activities [20]. A study by Olajuyigbe (2012) has shown that the major floods in Nigeria are river floods, coastal floods, and urban floods [21]. Among these, river flooding is the most destructive.

The study by Ruin, Creutin [22] has described Flash floods as high-impact, occasionally catastrophic events that result from the intersection of hydro meteorological extremes and society at small space–time scales, generally on the order of hours. It is further stated that flash floods are much localized in space and time, they are very difficult to forecast with precision and can subsequently jeopardize situational awareness. A study by Jonkman and Kelman [23] has shown that the type of flood and especially its space-time dynamics affect the level of harm suffered. According to the study, different types of floods have different impact levels as shown by their different mortality rates. The difference between these two kinds of floods does not just contribute to the magnitude and type of harm they cause but also plays a role in the emergence of vulnerabilities that do not occur with other flooding phenomena such as general flooding [23]. Studies have also shown that extreme flooding events could trap people in their cars or outside. They mostly happen during rush hours when commuters are on the road [24]. On the other hand, large hydrological scales typically cause building damage and prevent individuals from taking action [24].

2.2 Inclusive Disaster Management

The Sendai Framework For Disaster Risk Reduction [1] emphasizes that disaster risk reduction and risk-aware development are instruments to slow the hazard-perpetuating wheel of disaster exposure like a flood. The infusion of disability-related terms and concepts such as accessibility, inclusion, and universal design throughout the SFDRR document was significant. These concepts, which have their origin in disability studies, are used in the SFDRR document to refer to the needs of all in disaster, not only people with disabilities. Additionally, the Disability Inclusive Disaster Risk Reduction (DIDRR) commits to ensuring that people with disabilities have the same opportunity to access emergency preparedness information, participate in emergency preparedness programs in their community, and be included as a valuable stakeholders in all phases (preparedness, response, and recovery) of local community disaster risk reduction [25].

Disaster risk management involves information-driven activities and tasks [26]. ICT has been seen to have played a major role in community disaster resilience plans, and in particular in supporting people with disabilities and other vulnerable groups [27]. Universal Design guidelines can play a great role in DIDRR Initiative in creating ICT for emergency management that can be used by everyone with or without adaptation in many cases such as in flood emergencies. ICT systems and tools should be developed to be more accessible and usable among a wide range of diversified users to the greatest extent possible. A prerequisite for this type of product development process would be giving attention to diversity among users so that the needs of all types of people may be considered in its conception.

From the perspective of Universal Design, research shows that universal design in ICT and Emergency Management context might not only be important for people with disabilities but also to a wide range of stakeholders who may also be affected by situational disabilities caused by social and environmental barriers that can occur during emergencies [10, 11]. Introducing a universal design approach will make it more likely to develop an effective and efficient system, one which supports decision making while at the same time mitigating situational disability. It becomes even more necessary when dealing with complex systems- ones where there is always lots of information changing rapidly, or hard to obtain [15].

2.3 Situational Disabilities in Flood Scenarios

Situational disabilities can include difficulties in obtaining information, making decisions, or taking action. Situational disability can be caused by the physical environment, communication breakdowns, or psychological factors such as stress or fear [28]. Understanding situational disability in flood situations is the first step towards mitigating it and enhancing situational awareness in difficult situations with more ease in the future. Situational disabilities can range from reduced vision to no vision at all in low light environments or blackouts, limited mobility in crowded areas and blocked hearing in noisy areas, etc. These types of disabilities can pose challenges for people when carrying out certain tasks or navigating spaces. Recent studies by Gjøsæter, Radianti [10] have identified that in many cases, especially in disaster situations, people can suffer from a situational disabilities and environmental barriers.

To fully understand the impact of flood disaster and its effects on emergency management, Gjøsæter, Radianti [11] established frameworks that are crucial to analyze the interaction between different stakeholders and tools in different scenarios of a flood and development of such tools to mitigate a situational disability. The role of various stakeholders in a flood scenario differs in needs, methods of interaction with ICT technologies, and environmental challenges, while they all need to attain Situational Awareness. We see stakeholders in form of first responders who are first on the scene, local members of the general public who might be victims affected by a flood, and control room personnel who are in control of observation, recording, and interpretation of data for decision making, and decision makers responsible for allocation of resources, logistics, government agencies and NGOs who are responsible

for pre-post-disaster analysis, offering knowledgeable expertise and allocation of resources.

2.4 Situational Awareness

Situational awareness (SA) originated in military research during World War I and has become one of the key factors in contemporary disaster management [29]. SA can be defined as the cognizance of entities in the environment, understanding of their meaning, and the projection of their status in near future [15]. Endsley [30] has shown that several disastrous incidents were caused by a lack of adequate perception, comprehension, and projection of an action. She further argued that overcoming the challenge of acquisition and understanding information that comes through data is important and can make the difference between success and failure in many situations. Situational awareness is crucial in disaster scenarios and is often difficult to come by due to the challenges in coherently obtaining the necessary information and organizing it.

The fundamental point of gaining situational awareness is familiarity with elements in the environment, as well as understanding what those elements mean [31]. In other words, when people grasp the information they receive and understand its significance-they have gained situational awareness [32]. Situational awareness (SA) is critical to mobilizing a rapid, efficient, and effective response to disasters.

By assessing SA on an individual level [15], in what might be one of her most cited papers, defines SA as the perception of elements in an environment within a volume of time and space. In essence, Endsley claims that SA can only exist if it reflects what has been processed before by an individual since this leads to more understanding of how to respond to new information about a given challenge or event. Furthermore, an individual assessment study by Klein, Calderwood [33] has shown that Short-term and long-term memory are necessary for the speed at which our brain processes information. The basic mechanisms that constitute SA are short-term sensory memory, perception, working memory, and long-term memories which are based on a mental model of SA. This is known, as described by Doyle and Ford [34], to play a vital role in determining what is going on with any given situation - they provide context to what we perceive by defining "*the purpose of a system as well as its functioning*". This definition gives insight into why the psychological aspect of SA is so important: it's because mental models form such an integral part of understanding anything. The activity theory model by Doyle and Ford [34] represents another way to examine SA. This approach combines consciousness with diverse "in-world" activities and subscribes to a process perspective of SA, arguing that the extent to which information-processing methods are involved in achieving SA is dependent on the nature of the task and goals of an individual.

2.5 ICT-Supported Situational Awareness

Recent disasters and crises have shone a spotlight on the role that Information and Communication Technologies (ICT) can play in gaining situational awareness by

connecting people to relevant information, people to rescue workers and resources, and people to people in the immediate aftermath and recovery communication is one of the most important aspects of emergency management [35].

In a case of emergency, communications can be affected in interaction and conversation quality due to connection and noise coming from the background [36], this can have a negative impact on the speech and audio output. Visual distortion can ensue from fog hindering visibility or wetness on the individual palms which in turn can prevent or limit simple mobile device operational gestures. Cold and stiffness of joints limiting simple motoric movements to carry out operations.

On the other hand evidence from a variety of sources indicates that wearable and mobile technologies can lead to distraction and accidents in both the general population and emergency responders [37]. The contradictory nature of wearable and mobile information technologies most times comes with the increased multiple streams of information and the associated reduction of attention to those sources of information due to stress and anxiety [38].

It can be challenging and complicated to maintain sufficient SA levels in an emergency. Gjøsæter et al. [10] examined Endsley's SA-Demons [15] and their relationship with situational disabilities that can arise in a disaster situation and make it more difficult to establish SA by increasing the chance of human error due to usability or accessibility barriers present in the technology.

In large-scale operations such as disaster management, many different parties work collaboratively. In emergency situations, most communication is bound to happen via ICT since agencies may be located over a large geographical area. This means that those who use these types of forms of ICT for their communications receive less information than in face-to-face discussions because implicit or nonverbal cues like body language and environmental stimuli are left out from these events [39].

2.6 Digital Disaster Management: The Case of Nigeria

Nigeria has experienced shocking disasters in recent years, which led to the establishment of the National Emergency Management Agency (NEMA) in March 1999, with the single objective of coordinating disaster management activities in the country. Given the huge impact of natural disasters on society, comprehensive national disaster risk management strategies have been adopted by NEMA in the form of the National Disaster Response Plan (NDRP). NDRP was created for the purpose of processing, structuring, and coordinating an effective response plan for disasters in Nigeria.

Nigeria is one of the countries combating this menace of disaster and has adopted and encouraged the usage of ICT in its NDRP objectives and private partnerships to protect lives and properties among its citizens. This has given rise to a few of many common ICT emergency response platforms that have found their usage in the recent flood disaster that has been witnessed in the country. The advancement of ICT in Nigeria has over the years played an important component in disaster risk management in Nigeria [40]. These ICT tools have been utilized by NEMA and other emergency agencies in all stages of the disaster management cycle.

3 Research Design and Data Collection

In this research work, we have followed a mixture of qualitative and quantitative research methodology in the collection and analysis of the research data [41].

An online survey was conducted among victims of flood in Nigeria. Questionnaires were sent out through email. This study adopts an online questionnaire methodology using SurveyMonkey as an accessible questionnaire tool to accommodate a more diversified groups of participants.

Qualitative interviews were conducted among the victims and individuals who have experienced flooding in Nigeria. This was made possible by NEMA (The Nigerian National Emergency Management Agency). Consent forms for interviews were drawn for participants who consented to be contacted by phone for an oral interview.

The questionnaire was designed based on essential disaster management functionalities through questions about difficulties participants may have experienced in performing a task with an ICT device in a flood emergency scenario. Scales were set to ascertain the level of accessibility of using ICT devices in a flood situation. This task covers visual, audio, speech, cognition, and mobility abilities. The research has been conducted in accordance with the research ethics guidelines stated in "Ethical Guidelines for Research at Oslo Metropolitan University" and "The Nigerian National Code of Research Ethics".

An online survey and interviews were conducted among the victims and individuals who have experienced flooding, this was made possible by NEMA (The Nigerian National Emergency Management Agency). The participants were selected according to NEMA flood emergency records from different backgrounds, economic classes, literacy levels, demography, and age. Questionnaires were sent out through emails. Consent forms for Interviews were drawn for participants who consented to be contacted by phone call for an oral semi-structured interview.

We designed an online questionnaire building on the Short Set on Functioning (WG-SS) from the Washington Group on Disability Statistics that provides questions on functioning and activity limitations for use e.g. in national censuses and surveys. WG-SS builds on a bio-psychosocial model of disability that sees disability as a result of the interaction between a person's capabilities and environmental barriers. Our questionnaire is comprised of thirteen functionality questions in consideration of visual, hearing, speech, mobility, and cognition abilities. The questionnaire starts by explaining in detail what is meant by situational disability for each of the functionality variables in order to clarify the terminology to the participants. The survey participants were given a single answer questionnaire with a likert scale of: *no difficulty*; *Some difficulty*; *A lot of difficulties*; *Cannot do at all*; and in addition the options *Refuse to answer*; *Don't know* were provided. From the total of 100 flood victims that received the questionnaire, 56 participants responded.

The information received from the 56 respondents was coded using a set of relevant categories for further quantitative analysis. Later, the data is analyzed according to the research questions of this work. We have considered the Web Content Accessibility Guidelines (WCAG) 2.0 when we analyze the data. This is because of the rational benchmark provided by the accessibility principles that help us to quantify experienced

accessibility barriers due to situational disabilities in a better and more scientific way. We have also conducted semi-structured recorded interviews with 5 participants for qualitative thematic analysis and interpretation of users' experience in a flood situation and to identify situational barriers of the victims of flood disaster.

In thematic analysis, the first step always involves a careful understanding of the data at hand. Since the data was recorded in an audio mode in this research, data transcription is therefore needed to have a full grasp of the whole audio transcripts in text mode. The Data transcript requires multiple revisions over time to be able to understand and deduce the kind of themes involved in the transcript. We took the recommendation of taking notes at this stage as it can be used in the next stage of deeper analysis to have a better understanding of the research analysis [42].

The participants were all Nigerians and they spoke English; however, some accents were not correctly transcribed Into English. This affects the literal meaning of some sentences, but with careful listening to the audio recording repeatedly during data in this stage of data familiarization, these data errors were corrected thereby enhancing unbiasedness in the data. The texts of all the participants were then read to understand how this data answers the research questions and a basic form of codes were generated.

We then generated codes and searched for themes. The validity of these themes is then determined to see if they connect with data and research questions as suggested in Braun & Clarke (2006). The steps in the evaluation process are to first identify themes or groupings of ideas and opinions throughout the texts. We then refined specific themes into topics that reflect those particular ideas and opinions. Third, we determined whether our arguments pertain to certain concepts across all texts- so-called "generalizations." The final step is making interpretations of what has been found through evaluating each text individually while also comparing them between themselves.

4 Analysis and Results

In this Section, we will present the analysis part of the research work to identify accessibility barriers resulting from situational disability and how this barrier affects situational awareness. The analysis includes both quantitative and qualitative approaches to address the research questions of this study.

4.1 Analysis

This research involved analyzing 15 quotes selected for relevance from the interview text and dividing them into five themes. During this process, related quotes were grouped to form a theme. This was done by how relevant each theme seemed to be when answering the research questions. After grouping all of the themes, some edits had to be made because it became clear that a few quotes did not fit well within its corresponding theme; this was mainly due to understanding what they meant after revisiting their original transcripts and finding out where they belonged to each topic being studied differently afterward as an attempt at verifying how much a specific quote

contributes towards addressing our data-oriented question. Repeated rounds of generating codes for groups and including different revisions have proven fruitful as we are now able not only to classify our data but also to answer more specific questions about the research work.

The responses and opinions were analyzed thematically to shape the pattern of the responses [43]. As a result, 12 codes from the interview text were identified and later divided into three themes presented in Table 1.

Table 1. Themes and Codes.

Themes	**Codes/Quotes from Interviews**
Situational Barriers to ICT usage	Visual difficulties Cognitive Difficulties mobility difficulties hearing difficulties speech difficulties
Effects of barriers on situational awareness	Poor danger identification Poor decision making Poor location-awareness Poor communication
ICT design barriers	Internet issues Device issues System design issues

Participants were asked questions about the situational difficulties they encountered using an ICT device in a flood situation. Responses were affirmative on several difficulties experienced. *Participant 1* responded that: "It was hard to even use my phone at that moment even though I had so much need for it, but it was not easy to see through the phone because of haze from vapor. When I wanted to call my mother, I tried so hard to wipe the phone screen but there was still water on my hands, so it was difficult seeing anything through my phone." This indicates visual difficulties as well as explaining how it can lead to communication difficulties. *Participant 2* responded that: "I experienced a bit of communication difficulty, I was a bit loss of words, and even though I tried and succeeded to put out a call the person I was calling seem not to hear me quite clearly when I spoke. I had to more effort into raising my voice practically I was like shouting on phone to be heard." *Participant 4* similarly stated that: "Even though I tried using my phone often, but I was not able to concentrate or do any task I was used to even to simply search for a phone contact was not so easy. It is somehow difficult, and a lot of echoes were heard from the background and breakings in the conversation, strange noises were obstructing the signals, and the network signal was so much interfering. I was so tensed up that I wasn't able to hear properly because I was struggling to get to safety." These responses highlight issues of poor communication stemming both from cognitive difficulties as well as auditory ones. *Participant 3* also pointed out that: "I was unable to make a call or anything on my phone, my hand was so numb with cold. I had to jump off the car and rush to the

pharmacy to get some gloves to keep my hand warm. As I was not able to hold the phone with my hand, I was unable to make a call with my phone. I was so helpless and disturbed by the scenario. I was very close to having a nervous breakdown. I thought to myself, what if I am in a situation where I am unable to make a call with my phone? What if I am unable to reach anyone?" Here we see the effects of the situation on mobility and dexterity, as well as the psychological pressure and stress of the situation that leads to cognitive difficulties, further supported by *Participant 5* who responded that: "It was raining heavily at the same time it was very hard to say anything as we were both overcome with shock to even hear what was around even to think more of hearing anything with a phone. I was extremely scared; I did not know what would happen next and I was very scared of what would happen to me again."

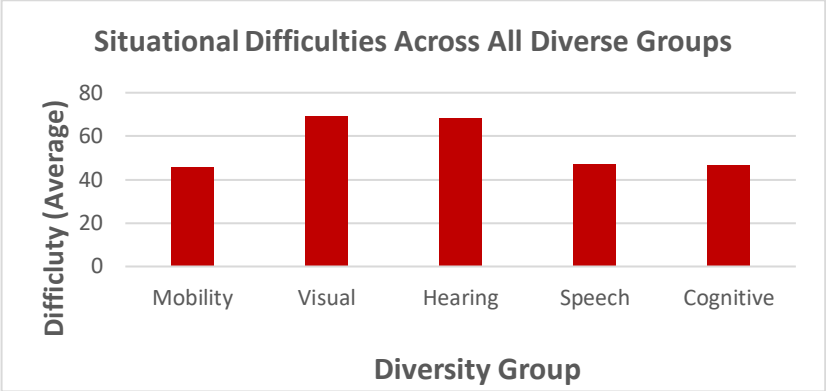

Fig. 1. Situation difficulties across all diverse groups chart.

4.2 Results

The main purpose of the evaluation is to identify situational disabilities and their level of impact on situational awareness. As a result, we analyze the situational difficulties that the respondents experienced based on the level of difficulties across all diverse groups and display the average difficulty rating (as a percentage from 0 to 100%) through the chart in Figure 1.

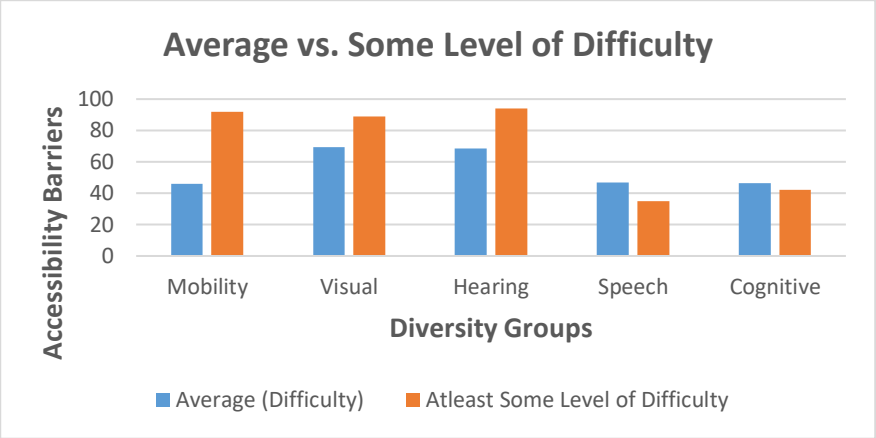

Fig. 2. Average vs. Some level of difficulty comparison chart

However, if we want to answer which diversity group experienced more difficulties (accessibility barriers) or any form of difficulty, we get the result depicted in Figure 2 (difficulty rating shown as a percentage from 0 to 100%).

If we analyze the mobility barriers that the research participants experienced in a flood situation based on the operability accessibility principle, we get the result summarized in Figure 3.

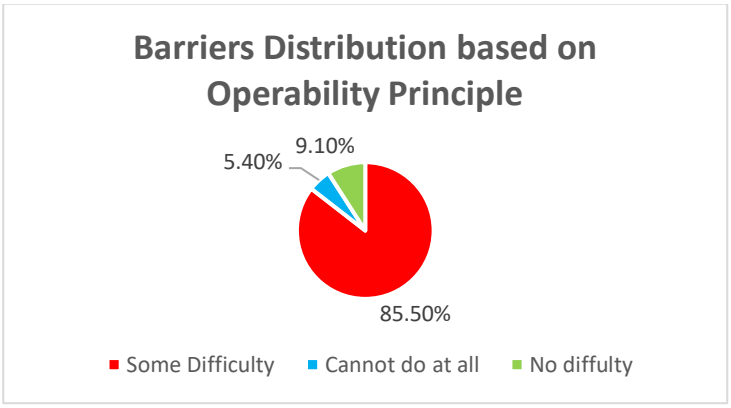

Fig. 3. Mobility barrier distribution based on Operability chart

We analyzed experienced situational disabilities in consideration of operability because of the direct correlation between mobility and the following issues:

- Performing input tasks without a keyboard is often required in a flood situation.
- Performing tasks with enough time.
- Performing simple navigation techniques to find contents that are critical in a flood situation.

We summarize the result of our thematic analysis based on the responses of interviewees in consideration of the thematic codes in Table 1 and see that situational disabilities can lead to difficulties in mobility, hearing, sight, cognition, and speech. This can have significant effects on situational awareness, and can lead to poor danger identification, poor decision making, poor communication and poor location awareness [10, 11].

5 Discussion

We see that people may experience accessibility barriers that are highly related to mobility and hearing. This is because of the environmental change [24] and the stressful psychological condition [28] that resulted from the flood situation. The results depicted in Figure 1, indicate that people may encounter a serious number of visual accessibility barriers because of the situational disability created by the flood. The consequence of it is that an individual interacting with an ICT device in a stressful or dangerous condition and finds it hard to perceive and understand their surroundings situation will be hindered from the overall process of rescuing and response management. This implies that rescue applications should provide interaction with alternative channels including auditory and gestures. Situational disabilities reported that were related to mobility and speech implies that users who were interacting with an ICT device at the time of the flood might have been unable to interact with the device as the channel from the user to the device is interrupted. As a consequence, the need for alternative interaction channels/devices that triangulate the usage of fingers, tactile devices, hand gestures, and speech recognition systems is paramount.

These findings also align with the theory of situational disabilities in disaster situations from Gjøsæter, Radianti [10], and their effects on situational awareness which is further elaborated in Gjøsæter, Radianti [11]. Although these effects are intuitively obvious, they are until now primarily supported by discussions with experts and practitioners. Therefore, this is the first time they are systematically validated by users with experience from a real disaster scenario.

The attainment of situational awareness is not only affected by the ICT device that the user is interacting with but also by the networking infrastructure that the device is connected to, and the design pattern followed to develop the interactive systems or applications. This shows the challenge we are facing to develop an accessible product through universal design principles and reduce the existing digital divide, especially in Nigeria and other Sub-Saharan African countries. The challenge requires the inclusive orchestration among Information Technology infrastructures, interactive rescue systems, and consumer electronic devices used to access the rescue systems.

6 Conclusions

Despite the availability of early warning systems, it is risky to live in an area with natural disasters. The effect of climate change catalyzes the occurrence and severity of natural disasters including floods. Floods are one of the major natural disasters that

contribute to the high disaster death rate in the global south, especially in Nigeria. This requires an effort of collaboration from all stakeholders in designing, building, deploying, and maintaining inclusive disaster management systems. This effort must build on the application of universal design principles. In this research work, we have studied situational disabilities and their effect on situational awareness based on the data collected from victims in Nigeria. This research work contributes in particular with the identification of situational disabilities and their corresponding accessibility barriers based on difficulty experiences collected from the research participants. We also note that these findings are in line with the described effects of situational disabilities in disasters [10, 11].

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