ZAMBIA INFORMATION COMMUNICATION TECHNOLOGY (ICT) JOURNAL

Volume 7 (Issue 1) (2023) Pages 57-62

Assessing Automated Flood Disaster Alert Systems in Zambia: Case of Mbeta Island in Sioma, Western Province

Cliford Siatala[a], Jameson Mbale[b]

Copperbelt University, Kitwe, Zambia
[a]csiatala@gmail.com; [b] jameson.mbale@cbu.ac.zm

***Abstract* - Globally, as the advancement and mainstreaming of Technology become more perversive, ICTs have become agents of change transforming the way we conduct and perceive human activities to sustain and promote the quality of life. It is also no surprise that today's technology pros control everything from telephone system to software compliance and disaster recovery that seem to become sole candidates for change. For instance, todays ICTs have been integrated in modern lifestyles and has become perversive in everything from telephone networking, automated security systems, software compliance and backups to disaster recovery platforms and Internet of Things. Additionally, one may argue that it is no longer feasible or rapidly becoming obsolete to solely rely on manual systems to predict potential threats such as natural and man-made disasters. Thus implementing early warning systems, communities play an important role in leveraging ICTs potential to generate warning hazards through automated systems that escalates emergency notifications to rescue and mitigation teams. Using a positivist approach with methodological triangulation at data collection and analysis, this study assessed automated flood disaster alert systems in Zambia with specific reference to Mbeta Island in Sioma. The study was informed by Unified Theory of Acceptance and Use of Technology (UTAUT) theoretical framework with questionnaires and interviews as measurement instruments to assess factors that led to the adoption of the alert system installed in Mbeta Island. Study findings showed varying impact of independent variables: Effort expectancy 6.2%, Performance expectancy 11.8%, Facilitating conditions 4.4% and Social influences 2.6% respectively. The total impact showed there were factors left out in the implementation of the alert system and that there is a need to adopt a new and robust disaster mitigation system that would allow for integration of community needs and everyday challenges in relation to natural and man-made disasters.**

Keywords: ICTs Automated Disaster System, Zambia, Sioma, Mbeta Island, Disaster Recovery, GIS remote Sensing.

1. INTRODUCTION

Entering the fourth industrial revolution, Mankind has witnessed the rapid rate at which technology has transformed the way we conduct and perceive human activities in an endeavor to sustain and promote the quality of life. While it is also possible to use it in enhancing business processes and functions, todays ICTs has been integrated in modern life styles and is becoming pervasive in everything from telephone networking, automated security systems, software compliance, and backups to disaster recovery platforms and Internet of things. [1] Numerous scholars argue that the emerging avenues such as Wi-Fi, devices with ready Internet connectivity, the cloud and big data has created a conducive environment to nurture the development of effective and efficient processes that may improve many aspects of life. [2] Similarly, emerging interest and research in business and artificial intelligence systems integrating ICTs have become mainstream tools in achieving or creating optimized, efficient and effective services. Given the increased attention to natural disasters with possible relationship to climate change, various economies, organizations or institutions have embarked on the creation of deliberate policy frameworks that are promoting funding for research on uncovering new knowledge to act as key components in adoption and integration of ICTs. Studies by Singh et al [3] argues that ICTs mediated systems have become useful in early detection and prediction of disasters, communication and dissemination of information on disasters. This is being argued to act as an effective platform for information exchange and sharing among people and with government and non-government agencies in time of disasters especially with known possibilities in modern geographical information systems (GIS), remote sensing and satellite-based communication systems.

Further, studies [4] argue that ICTs have become key in risk reduction in entities such as companies, organization or communities through the use of mobile cellular networks coverage [5]. Also, big data analytics have emerged as a powerful set of inference platform necessitated by technologies that allow for swift execution of commands or interventions from a sea of data to address and mitigate disasters. [6]

The importance of timely disaster warning systems in mitigating negative impacts on communities or societies can never be underestimated. For example, developed countries have created systems with robust predictability to enable reduction in loss of life due to disasters compared to their counterparts in developing countries. A key reason for this has been the implementation of effective disaster warning systems and evacuation procedures in developed countries and the absence of such measures in developing countries especially African countries [7]. In implementing early warnings systems, communities play an important role in the use of ICTs in realizing potential warning hazards that can be reported through automated and integrated systems that escalates emergency notifications to appropriate local government authorities, rescue units and mitigation teams [8]. While it is possible for people to predict disasters in communities, it is within their control to report early warnings of disasters to mitigation teams before such potential threats turn into real disasters. [9]

II. LITERATURE REVIEW

Currently, there is an increasing literature on a number of studies that have been done on emerging systems that are intended to process disaster information. These systems aggregate disaster information in order to streamline notification, response and recovery efforts [10]. Among them include

- ✓ Integrated Public Alert and Warning System (IPAWS)
- ✓ Global Disaster Alert and Coordination System (GDACS)
- ✓ Emergence Alert System (EAS)
- ✓ Real-Time Early Response System (RTERS)

For instance, the Integrated Public Alert and Warning System (IPAWS) leverages its relationships with state and local Government agencies, universities, researches, broadcast stations and two-way radio dispatch. IPAWS system is capable of linking alerts of disasters related information on Tornado, Hurricane, Tsunami and earthquake information from universities, research partners and local government authorities. These alerts are processed at alert system group (ASG), a research partner that sends alert information directly to local FM radiobroadcast stations for public awareness. Alerts are delivered to the American people through the media such as TV, web widgets, FM, AM, satellite radio, web browsers, websites, and digital analogy. [11]

The United Nations in collaboration with the European Commission maintained a Global Disaster Alert and Coordination System (GDACS). GDACS Corporation established partnerships with scientific monitoring organizations and aggregates worldwide disaster information following a natural disaster. The primary users of GDACS system are governments and disaster response organizations. However, there is no direct process in place for individuals to receive GDACS alert notifications. Users access disaster information on the GDACS website worldwide [12]

The EAS system is an emergence system that uses broadcasters, cable television systems, wireless cable systems and satellite digital service providers to send alerts. EAS system is designed in such a way that it utilizes the direct broadcast satellite service providers to make their communications facilities available to the President during a national emergency. Maity et al [13] explained that state and local authorities deliver important emergency information such as amber alerts and severe weather warnings targeted to specific geographical regions or areas in the US. Maity further stated that the EAS system generalized notifications at a national level whereby information filtered up to higher level and also transmitted through a variety of means and mediums for public safety. According to Maity the EAS system was designed to issue notification alerts information through available communication facilities to the local authorities and the President of the United States.

Real time early response systems (RTERS) incorporated real time information as feedback data for closing control loop and for generating real time situation assessment. RTERS arose as a useful tool for supporting people in their decision making process during natural disasters. RTERS's design integrated a component of decision support systems (DSS). The DSS systems collect real time information from sensors around the world, process that information and make suggestions that allows the accomplishment of decisions by decision makers in disasters. The system is customized to help in emergence situations and provided a real world environment representing human behaviour. The systems representations of the real world are fundamental tools in RTERSs because they help to estimate and to predict scenarios for making decisions. [14]

III. METHODOLOGY

The study was informed by positivist approach complemented by methodological triangulation during data collection and data analysis. Additionally, the nature of the study necessitated use of case study method to allow for probing the study area from different perspective. Also, the study utilised none-probability sampling specifically snow ball to select respondents for questionnaires and purposive sampling on selecting respondents for interviews.

Furthermore, in order to ensure a systematic assessment of the study area, it was necessary to outline the logical structure of the inquiry including the scope that indicated a broader perspective of the research project. Additionally, the study considered a number of relevant steps critical to an empirical inquiry such as identifying a sampling criteria, data collection instruments, data analysis, validity and reliability, among other things. The summarized circle of the study design is shown in Figure1 below. [15]

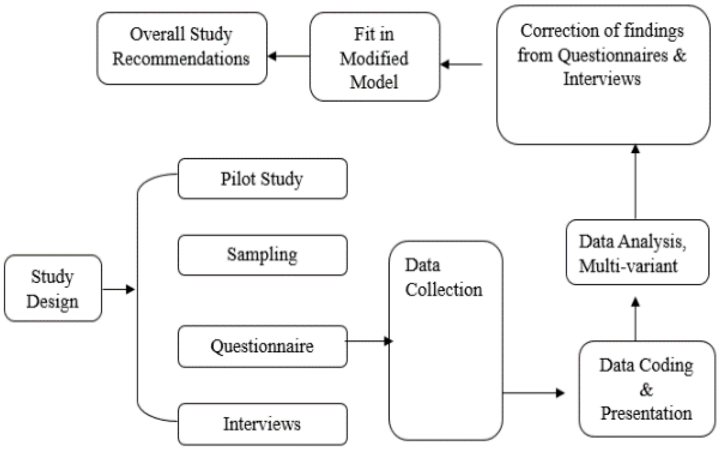


Figure 1 Research Circle

Source (Yin, 1994; Babbie & Mouton, 2001; Creswell 2009)

IV. STUDY FINDINGS

The study was focused on establishing the relationship of the five variables (Independent variables) where four were analyzed quantitatively using frequencies and percentages to establish their impact on the dependent variable while the fifth one was qualitative that was measured through one to one interviews. From the study, Table 1 below shows the summarised findings based the evidence collected and inferences drawn.

Variable	Output	Reason
Effort Expectancy	43 (65.1%) of respondents disagreed that in terms of perceptions the automated flood alert system was clear and understandable	Since 2017 Mbeta Island had not experienced flooding. Surrounding communities had not seen the system in operation
Performance Expectancy	46.5 (69.4%) of respondents disagreed that the automated flood disaster alert system would become useful	
Facilitating Conditions	46.5 (69.4%) of respondents disagreed that AFDAS had necessary infrastructure to support its use	The study showed gaps in the system lack of robustness in incorporating a dedicated interface or tools that would allow for interacting with the system
Social Influences	73 (71%) of respondents disagreed that the automated flood disaster alert system had changed their farming processes	As Mbeta Island had not experienced flooding since 2017, hence communities' consequently their difficulties in appreciating it

The study findings were further analysed using regression. This was critical to establish the appropriate impact or relationship of each independent variable on the dependent variable. However prior to regressing the data sets were tested for normality in determining the impact of all variables in the study shown in Table 2 below:

Variable	R Square	Sig Value
Effort Expectancy	**.062**	**.040**
Performance Expectancy	**.118**	**.001**
Facilitating Conditions	**.044**	**.050**
Social Influences	**.026**	**.032**

V. CONCLUSION OF THE STUDY

Natural and man-made disasters are wide spread and reflect vulnerabilities and susceptibility of people affected when the early warnings of impending disasters are ignored.

The study findings availed a number of gaps and potentail areas for improvement in ensuring that the adopted system is alerting communities and DMMU on impending disasters such as floods, agricultural droughts etc. Also, it was established that leveraging the potential of ICTs for information sharing, escalation and handling warnings and disasters was critical.

Further, mechanisms to respond to disasters via resource coordinators such as DMMU ought to be alerted by effective and user-friendly information channels. Swift responsive systems have now become a hallmark of efficient relief to mitigate the impact of disasters in the 21st century. Thus, it must be pointed out that communities encountering disasters must display a greater level of knowledge and skills of systems implemented to present their challenges in order for them to appreciate such facilities.

VI. CONCLUSION AND RECOMMENDATIONS

According to study findings and the emerging picture from the empirical evidence, there is need to adopt a new and robust disaster mitigation system that would allow for integration of community needs and everyday challenges in relation to natural and man-made disasters.

In consistent with the findings, there is need for embarking on improving of the existing automated flood disaster alert system to ensure that it becomes more robust. Such a system must integrate new features to improve interaction with the community. The following recommendations were made:

- There is need for a drought early warning disaster system that should incorporate Geo-sensing that detect environmental humidity, soil moisture levels and temperatures that consequently help in predicting agricultural droughts. The geo-sensors equipment uses IOT (internet of things) digital humidity temperature (DHT) sensors fitted with a GSM network equipment microcontrollers that automatically send pre-coded message to the AEWDAS system when humidity and temperature levels reaches a critical threshold over a period of time alerting DMMU and other stakeholders for mitigation measures. See system architecture below.

- Secondly, there is need for flood early warning disaster system that incorporate geo-sensing that detect water levels when it reaches a critical threshold to predicting floods using water level flood sensors distributed in the flood prone areas. The Geo-sensing equipment fitted with GSM industrial IOT (internet of things) microcontroller module which automatically sends pre-coded flood notification messages to the system for critical water levels alerting DMMU and other stakeholders for mitigation measures. See system architecture below.

- Thirdly, the system should be able to escalate early warning alerts from ADAS App on user mobile devices in surrounding communities for hazards. The system should aggregate, process and escalate early warnings and disasters into responder alerts for rescue and mitigation.
- Responder alerts incorporate GPS location google maps and real time GPRS locations of the reported disaster/hazard marking a notifying device as a beacon in the location of the disaster or the early warning

- Fourth, the system should be able to process notification messages for any disaster type (e.g. fires, livestock or community disease outbreaks, traffic accidents, terror attacks, droughts, agricultural pests) reported through Adas app mobile platform that integrates server based AEWDAS alert processing system at DMMU

- Fifth, the system should leverage toll free GSM network platform infrastructure for the local communities to access the system without user costs to relay disaster notifications to AEWDAS system. For instance in far flung rural areas where there may not be network installations, utilizing deployable specialized satellite mobile phone technology that can establish stand-alone communications capabilities for use in disasters where local infrastructure is damaged or does not exist for interoperable and priority-sensitive communication to AEWDAS be accessible through indunas or headmen in times of disasters.

- Sixth, the system should be able to alert the public of impending disasters by disseminating and sharing alert information suitable to the public by LDMC, DDMC and DMMU for awareness, public information and facilitate resource allocation in affected areas and information to stakeholders (i.e. NGOs, aid organizations, LDMC, DDMC, DMMU, Cooperating partners, donors, Funders and stakeholders from national coordinators to emergency responders and general public)

- Seventh, the system should be able to interoperate and provide a database pool of disaster related information for other purposes. It should be able to share online information with other systems wishing to pull online information related to disasters for instance research websites, data mining systems, Online Analytical Processing systems (OLAP), big data analytical systems for disaster information and other purposes.

ACKNOWLEDGEMENTS

The Authors would like to acknowledge the support of the Director Disaster Management and Mitigation Unit (DMMU) Regional Coordinators and field engineers from Zambia Information and Communication Technology Authority (ZICTA) who participated in this research.

REFERENCES

[1] Vermesan, O., & Friess, P. (2015). *Building the Hyperconnected Society-Internet of Things Research and Innovation Value Chains, Ecosystems and Markets* (p. 332). Taylor & Francis.

[2] Kaluarachchi, Y. (2022). Implementing data-driven smart City applications for future cities. *Smart Cities*, *5*(2), 455-474

[3] Singh, J. P., Dwivedi, Y. K., Rana, N. P., Kumar, A., & Kapoor, K. K. 2019. Event classification and location prediction from tweets during disasters. *Annals of Operations Research*, *283*(1), 737-757.

[4] Rani, S., Bhambri, P., & Kataria, A. (2023). Integration of IoT, Big Data, and Cloud Computing Technologies. *Big Data, Cloud Computing and IoT: Tools and Applications*.

[5] Cao, Yinghui, et al. "Warning dissemination and public response in China's new warning system: Evidence from a strong convective event in Qingdao City." *Journal of Risk Research* 25.1 (2022): 67-91.

[6] Iqbal, M. H., & Soomro, T. R. (2015). Big data analysis: Apache storm perspective. *International journal of computer trends and technology*, *19*(1), 9-14.

[7] Perera, D., Seidou, O., Agnihotri, J., Rasmy, M., Smakhtin, V., Coulibaly, P., & Mehmood, H. (2019). Flood early warning systems: a review of benefits, challenges and prospects. *UNU-INWEH, Hamilton*.

[8] Phiri, A., 2015. Creating a model in community based Disaster risk management for informal settlements: a case of Kanyama Settlement, Lusaka-Zambia (Doctoral dissertation).

[9] Pulwarty, R. S., & Sivakumar, M. V. (2014). Information systems in a changing climate: Early warnings and drought risk managment. *Weather and Climate Extremes*, *3*, 14-21. Information management.

[10] Pacheco, C., & Cipriano, A. 2015. Design of Real Time Early Response Systems for Natural Disaster Management Based On Automation and Control Technologies. International Journal of Environmental and Ecological Engineering, 9(3), 725-733

[11] Purvis, L. K., Jortner, J. N., Arpin, B. K., Ramos, B. J., & Glaser, R. F. (2007). *Integrated Public Alert and Warning System (IPAWS)* (No. SAND2007-4767P). Sandia National Lab.(SNL-CA), Livermore, CA (United States); Sandia National Lab.(SNL-NM), Albuquerque, NM (United States).

[12] De Groeve, T., Vernaccini, L., Annunziato, A., Van de Walle, B., & Turoff, M. (2006, January). Global disaster alert and coordination system. In *Proceedings of the 3rd International ISCRAM Conference, Eds. B. Van de Walle and M. Turoff,, Newark* (pp. 1-10).

[13] Maity, et al. 2016 "*Status of disaster risk reduction in the Sub-Saharan Africa region*. The World Bank).

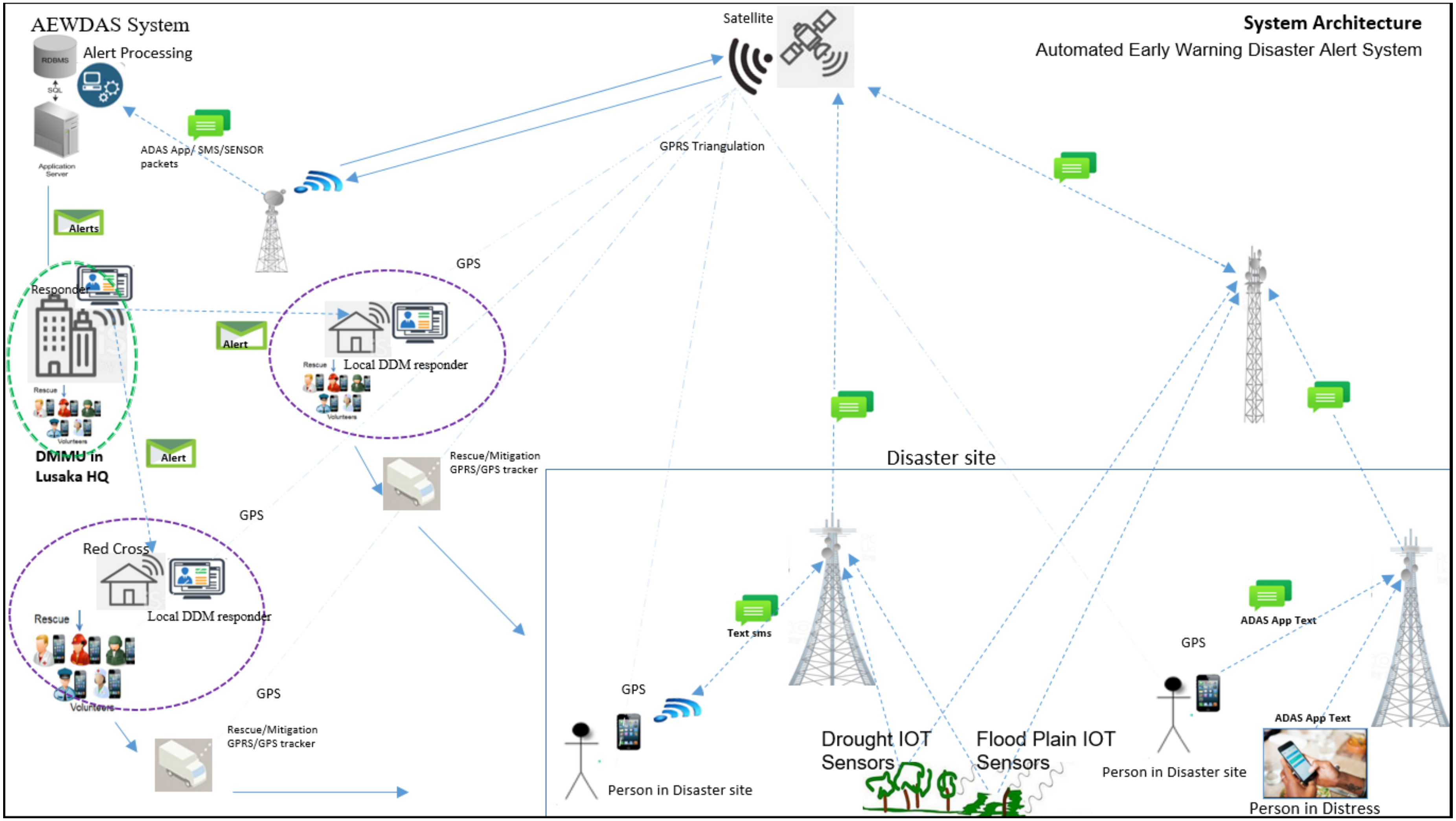
[14] J. R., Eichhorn, A., Smith, S., Sterle-Contala, M., & Cooperstock, J. R. 2014. Real- time emergency response: improved management of real-time information during crisis situations. Journal on Multimodal User Interfaces, 8(2) 161-173.

[15] Creswell, J. W. (2009). Mapping the field of mixed ethods research. *Journal of mixed methods research*, *3*(2), 95-108.

[16] Veil, S. R., Buehner, T., & Palenchar, M. J. 2011. A work-in-process literature review: Incorporating social media in risk and crisis communication. Journal of contingencies and crisis management, 19(2), 110-122.

[17] Kelvin, O. K., & Innocent, K. 2012. ICT in Disaster Risk Reduction: The Kenyan Experience. *International Journal*, *4*(2).

[18] Samarajiva, R. 2010. Leveraging the budget telecom network business model to bring broadband to the people. *Information Technologies & International Development*, *6*(SE), pp-93.


AEWDAS System
Alert Processing
ADAS App/ SMS/SENSOR packets
Alerts
Responder
DMMU in Lusaka HQ
Alert
Satellite
GPRS Triangulation
GPS
Local DDM responder
Rescue/Mitigation GPRS/GPS tracker
Red Cross
Rescue
Volunteers
System Architecture
Automated Early Warning Disaster Alert System
Disaster site
Text sms
ADAS App Text
Drought IOT Sensors
Flood Plain IOT Sensors
Person in Disaster site
Person in Distress