

EVALUATING THE INFLUENCE OF MODERN-DAY EARLY WARNING SYSTEMS ON FLOOD EMERGENCY RESPONSE: A Case Study of Communities around Likangala Watershed, Mwambo village T/A Mwambo, Zomba.

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11 June 2024

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DECLARATION

I, Vanessa Mnenula, do declare that this is my own work submitted to Ndata School of Climate and Earth Sciences of the Malawi University of Science and Technology in partial fulfilment of the requirements for the Bachelor of Science degree in Disaster Risk Management. No one has ever done this study in any university.

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ABSTRACT

The research examined the impact of modern-day early warning systems on the efficacy of flood emergency responses. Utilizing a mixed methods approach within a case study design, the study explored how early warning system contribute to the preparedness and agility of emergency response teams in flood-prone areas. Data was collected through the use of a questionnaire administered to a purposive sample of 30 respondents, encompassing those involved in disaster management and affected community members. The findings suggest that modern-day early warning system significantly enhance the timeliness and effectiveness of responses to flood emergencies, thereby reducing potential loss and damage.

Keywords: **modern-day, early warning system.**

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LIST OF ACRONYMS

ACPC	Area Civil Protection Committee
CBEWS	Community Based Early Warning Systems
DCPC	District Civil Protection Committee
DoDMA	Department of Disaster Management Affairs
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EWS	Early Warning Systems
FEWRS	Flood Early Warning and Response Systems
FEWS	Flood Early Warning Systems
GIS	Geographical Information System

GoM	Government of Malawi
KPIs	Key Performance Indicator
MVAC	Malawi Vulnerability Assessment Committee
NGOs	Non-Government Organizations
PCEWS	People Centered Early Warning Systems
RCMRD	Regional Centre for Mapping of Resources for Development
UNDP	United Nations Development Program
UNISDR	United Nations International Strategy for Disaster Reduction
VCPC	Village Civil Protection Committee
WMO	World Migration Organization

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CHAPTER 1: INTRODUCTION

1.1 Background

Floods are among the most frequent and devastating natural disasters that affect millions of people worldwide every year. Flooding, an overflow of water beyond its normal confines, can occur due to various factors such as heavy rainfall, snowmelt, storm surges, dam failures, or river overflow. It can have severe impacts on human lives, health, property, infrastructure, and the environment (Pauw, Thurlow, & Seventer, 2010) . Floods can cause significant economic repercussions as they impact key industries and sectors like agriculture, fishing, food crops, health, labor, and tourism. Power and communication loss is common during floods, affecting livelihoods and safety access. Disaster Risk Reduction (DRR) is a proactive approach to minimize risk by identifying and addressing its root causes. It's an integral part of sustainable development and requires the involvement of all societal sectors. The primary focus of DRR is to decrease vulnerability and exposure since we cannot control the intensity of natural hazards. Disaster Risk Management (DRM) is the practical application of DRR strategies. It encompasses actions that aim to achieve risk reduction (Nott, 2006) . DRM is not just about managing disasters but also about implementing programs that lower disaster risk. Early warning systems (EWS) are crucial for disaster risk reduction and management. They provide the necessary capabilities to generate and share warnings in a timely manner. EWS have evolved from basic sirens and radio broadcasts to sophisticated systems utilizing advanced technologies like remote sensing, GIS, hydrological models, communication networks, and mobile applications. As one measure of disaster risk reduction and management, community-based flood early warning systems were installed in different rivers across the country. The Community-Based Flood Early Warning System (CBFEWS) in Zomba and other flood-prone districts in Malawi was established by the Regional Centre for Mapping of Resources for Development (RCMRD). This project was contracted by UNDP to support the Government of Malawi (Stepanyan, 2014) . The project targeted the flood-prone districts of Karonga, Rumphi, Nkhata-Bay, Nkhotakota, Salima, Dedza, Zomba, and Phalombe. It aimed to support the Department of Disaster Management Affairs (DoDMA) in its mandate and efforts

towards disaster risk reduction and building community resilience to climate shocks such as flood and drought (Chinguwo & Deus, 2022).

However, the effectiveness of modern day EWS in influencing flood emergency response is not well understood. There are many factors that affect how people perceive, interpret, and act upon flood warnings, such as their level of awareness, trust, risk perception, preparedness, social norms, and coping capacity (Mwape, 2015). Moreover, there are many challenges and gaps in the design, implementation, and evaluation of modern day EWS, such as the lack of coordination, participation, feedback, and learning among different actors involved in the EWS process.

Therefore, this research proposal aims to evaluate the influence of modern day EWS on flood emergency response. The main research question is: How do modern day EWS affect the decision-making and actions of different stakeholders in flood emergency response?

1.2 Problem Statement

Floods represent one of the most frequent and devastating natural disasters worldwide, impacting millions of individuals annually. Flood Early Warning Systems (FEWS) play a pivotal role in mitigating flood risks by delivering timely and accurate information to authorities and at-risk communities (Molinari, Menoni, & Ballio, 2013). The success and influence of FEWS in flood emergency response are contingent on a multitude of factors, including technical performance, institutional arrangements, communication channels, public awareness, and the capacity of stakeholders involved in the process (Misomali, 2014).

Zomba district, located in Malawi, is particularly vulnerable to floods, experiencing recurrent and severe inundations leading to loss of life, displacement, property and infrastructure damage, livelihood disruption, and environmental degradation. The 2015 floods, in particular, left a significant impact, with Zomba district being among the hardest-hit regions. According to the Malawi Vulnerability Assessment Committee (MVAC), Zomba district was among the worst affected districts by these floods, which affected over 1.1 million people and killed 176 people nationwide. In response, initiatives were launched to establish and enhance FEWS, including the Community-

Based Flood Early Warning System (CBFEWS) project by UNDP and RCMRD and the Tropical Cyclone Freddy Response Plan by DoDMA. These efforts aimed to bolster flood resilience within the district. However, the 2015 floods revealed several shortcomings in the existing FEWS in Zomba district, such as a lack of coordination, communication, participation, feedback, and learning among stakeholders involved in the FEWS process (Department of Disaster Management Affairs (DoDMA), 2015).

Despite these initiatives and observed weaknesses, there has been a dearth of systematic and comprehensive evaluations of these FEWS and their influence on flood emergency response in Zomba district. Previous research has predominantly focused on the technical aspects of FEWS, such as data collection, transmission, analysis, and forecasting. For instance, a study on community-based early warning systems in Malawi by Chinguwo and Deus(2022) emphasized the need for improvements in risk knowledge, technical monitoring, warning services, dissemination, communication, and response capabilities. Additionally, another study by Teule, Couasnon, Bischiniotis, Blasch and Homberg(2019) underscored the gaps in early warning systems, particularly in the 'technical' aspects (e.g., monitoring equipment quality, forecasting capability, dissemination channels), which hinder effective EWS implementation, especially in developing countries. In 2019, it was reported that only 26% of monitoring stations in Africa met the WMO requirements, highlighting the challenges faced in monitoring and forecasting floods in the region (World, 2019).

However, limited attention has been given to the social, institutional, and behavioral elements of FEWS, including dissemination, communication, perception, and utilization of flood warnings by different actors. Furthermore, there is a gap in understanding how FEWS interact with other factors affecting flood emergency response, including resource availability, coordination mechanisms, preparedness measures, and coping strategies.

To address these gaps, a comprehensive evaluation of FEWS, considering both technical and non-technical aspects, is imperative for enhancing flood resilience and emergency response in Zomba district.

Therefore, this research proposal aims to evaluate the influence of modern-day early warning systems on flood emergency response in Zomba district.

1.2 OBJECTIVES

1.3.1 Main objective

The main objective of this study is to assess the impact of modern-day early warning systems on flood response to communities surrounding Likangala River.

1.3.2 Specific Objectives

a) To assess the effectiveness of the current early warning systems in reducing the loss of lives and property during floods.

b) To evaluate the efficiency of modern-day early warning systems in providing timely and accurate flood warnings to communities at risk.

c) To identify the critical failure factors of modern-day early warning and response systems for floods.

1.4 Research questions

The study will be guided by the following research questions:

a) How effective are the current early warning systems in reducing damage to life and property during floods?
b) How efficient are modern-day early warning systems in providing timely flood warnings to communities at risk?
c) What are the critical failure factors of modern-day early warning systems during floods?

1.5 Significance of the Study

This study will be beneficial in the sense that it will improve flood response in collaboration with other relevant studies since it will provide insight into the current EWS in Likangala river as well as the effectiveness of the systems in reducing flood damage to property and livelihoods and this information can be used by policy makers and stakeholders on the need to invest in EWS to improve response in Likangala river. The study will also identify the factors affecting the effectiveness of the current early warning systems and provide recommendations on how to improve them.

CHAPTER 2: LITERATURE REVIEW

2.1 Early warning system in Malawi

United Nations International Strategy for Disaster Reduction (UNISDR) defines early warning systems (EWS) as 'an interrelated set of hazard warning, risk assessment, communication and preparedness activities that enable individuals, communities, businesses and others to take timely action to reduce their risks' (UNISDR 2015). Responding to the Hyogo Framework for Action priority area 2 on knowing the risk and taking action, the government of Malawi instituted the development of EWS through its National Disaster Risk Management Policy of 2015. Priority areas 2 and 3 called for the establishment of a comprehensive system for disaster risk identification, assessment and monitoring, and development and strengthening of a people centered early warning system, respectively (GoM 2015b) and finally the Malawi National Flood Early Warning System (FEWS) was established.

2.2 Impact of early warning systems

Floods are one of the hazards that affect the way of life of a society or community and leads to environmental, human, economic, and material losses. EWS are essential in reducing the impact of floods. This literature review aims to provide insights into the assessment of the impact of modern-day early warning systems on flood response.

A structured literature review and interpretive structural modeling analysis conducted by Dutta and Basnayake (2021) identified a clear gap in the completeness, appropriateness, and understanding of a warning message at the local level, which affects the effectiveness of flood early warning and response systems (FEWRS). The study highlighted the importance of translating warning into concrete local action, even in countries with effective capacities for forecasting, detecting, and monitoring.

Prevention Web (2019) identified communication and dissemination as a critical component of early warning systems. Effective early warning and early action are contingent on information being communicated to stakeholders in ways that are accessible, understandable, and useful. However, communication barriers, social and cultural stigma, lack of accessibility of infrastructure, and the absence of effective social

safety nets continue to prevent communities from accessing timely early warning and risk information.

2.3 Community-based early warning system

Assessment of community-based flood early warning systems in Malawi was conducted by Fetahi (2022). The study aimed to assess the need to improve the current manual system of the community-based early warning system. The study identified the challenges faced by early warning systems, including short lead times available for early warning and action, which hinders the effectiveness of community-based early warning systems. Within local communities, EWS are sometimes referred to as CBEWS (Smith, Brown , & Dugar, 2017) or people-centered early warning systems (PCEWS) (UNISDR, 2006) . Therefore, CBEWS for floods are there to help local communities in using available resources to efficiently prepare and respond to floods event (Smith et al. 2017).

The literature cited supports the theoretical argument that early warning systems are essential in reducing the impact of floods. The literature also highlights the challenges faced by early warning systems, including short lead times available for early warning and action, which hinders the effectiveness of community-based early warning systems. The literature review also highlights the importance of effective warning creation and dissemination in reducing the impact of floods. The literature review identifies the need for an effective flood early warning system to reduce the impact of floods

CHAPTER 3: METHODOLOGY

3.1 Research design

The research design used for this study was a mixed-methods approach, combining quantitative and qualitative research methods. The study used a survey questionnaire to collect data from respondents and a semi-structured interview to collect data from key stakeholders. The data collected was analyzed using statistical software. The study identified the strengths and weaknesses of the current early warning systems in reducing the impact of floods and provided insights into the challenges faced by early warning systems in reducing the impact of floods. The results of the study will be useful in improving the current early warning systems and reducing the impact of floods in the future.



Figure 3.1: Research design

3.2 Study Area

The study was conducted in the southern region of Malawi: communities around Likangala Watershed in Ronald and Mteche Villages, T/A Mwambo in Zomba which is located 37 miles (60 km) northeast of Blantyre. Likangala River originates at Zomba Mountain in southern Malawi and flows through both urban and rural areas before it flows into Lake Chilwa, a wetland of international significance. The river has a length of

50 km and flows along varying topography between elevations of 1265 m and 790 m above sea level. Its catchment covers 756 km is located between latitude 15°22′–15°30′S and longitude 35°15′–35°37′E.

This area was selected for the study because geographically it is located in the low lying areas and the major river Shire River runs through these districts. According to the Malawi disaster profile on floods (GFDR, 2019) (GoM, 2019) was based the intensity and frequency of occurrence of floods in those districts.

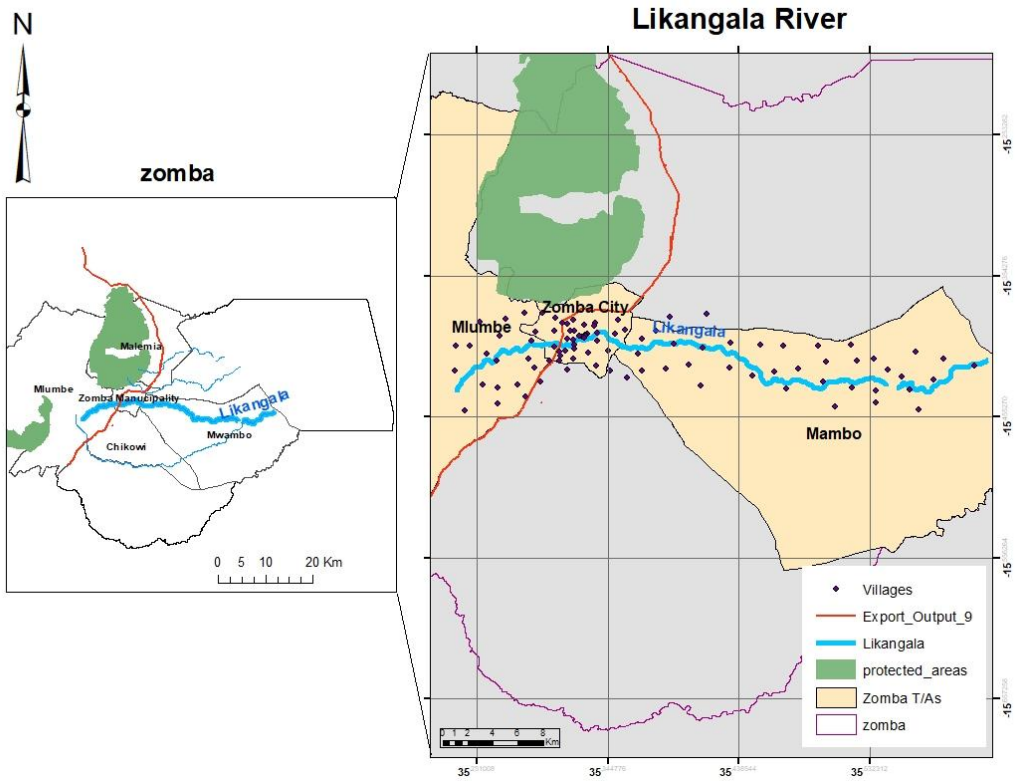


Figure 3.2. Map of study area

3.3 Data Collection

For a better and clear understanding of what really happens when a disaster happens, focus group discussions were conducted within the selected communities and non-probability purposive sampling was be used. This sampling technique 'does not need underlying theories or a set number of key informants' (Tongco, 2007). The researcher decides on whom to interview on the basis of their experience and knowledge in the particular field (Creswell & Creswell, 2017). The key informants (KIs) in this research were those members who knew much of the occurrence and were proper representation

of the entire population. Participants or informants included members of District Civil Protection Committee (DCPC), Village Civil Protection Committee (VCPC) and Areal Civil Protection Committee (ACPC). Members of the committees are from government agencies, departments and NGOs.

3.4 Data Analysis

The first process in data analysis was to clean the data that was gathered. One of the methods that was used was through visual representation of the data in either graphs, charts or other visual aids to clearly show and help identify the patterns and trends in the data, making it easier to compute and analyze. Another procedure was to condition and preparation the data and this involved cleaning and transforming raw data into information that was suitable for analysis, deleting duplicates, correcting errors and filling in gaps were done in this stage.

To analyze the specific objective "To assess the effectiveness of the current early warning systems in reducing the loss of lives and property during floods," a combination of qualitative and quantitative research methods was used. The methodology involved a review of literature on early warning systems for floods, case studies of communities that have implemented modern-day early warning systems, surveys and interviews with stakeholders involved in flood emergency response, and statistical analysis of data on the impact of floods on human life and property. One method that was used to analyze the specific objective "To evaluate the efficiency of modern day early warning systems in providing timely and accurate flood warnings to communities at risk" was to assess the sensitivity of the warning system to provide a notification within a meaningful time window, the cumulative sensitivity leading up to an event, the characteristics of the warning staying on until the event occurs, and the distribution of warning times and the burden of additional warnings throughout monitoring that may or may not be associated with the event of interest. To analyze the specific objective "To identify the critical failure factors of modern-day early warning and response systems for floods," the factors influencing the efficiency of message dissemination, including the credibility of the source, were assessed.

3.5 Materials and Methods

Materials such as questionnaires were used to gather information from relevant stakeholders and those affected by flooding activities.

Phone calls were of importance to communicate with people who assisted in gathering information.

Consent to answer questions and conduct interviews with people of interest was a vital step.

CHAPTER 4: RESULTS OF THE STUDY

4.1 Chapter Overview

This chapter highlights the research results and discussion of data collected from the field. The main objective of the study was to assess the impact of modern-day early warning systems on flood response to communities surrounding Likangala River. Data was collected using questionnaires as the data collection instruments whose presentation and interpretation is given below through the use of frequency tables, bar graphs and pie charts.

4.2 Questionnaire Response Rate

Questionnaire response rate is the proportion of the questionnaires returned after they have been issued to the respondents. Table 4.1 below shows the response rate

Table 4.1: Questionnaire Response rate

Respondents	Questionnaires Issued	Questionnaires returned	Percentage
DCPC	20	18	90
VCPC	10	9	90
ACPC	10	10	100
Total	**40**	**37**	**280**

Out of 20 DCPC, 10 VCPC and 10 ACPC members sampled during the study, 18 DCPC, 9 VCPC, and 10 ACPC members participated in the interview discussions. The return rate was 90% for DCPC members, 90% for VCPC members and 100% for ACPC members, it was therefore deemed adequate for data analysis.

4.3 Demographic Information

4.3.1 Gender

The table 4.2 below shows that the research targeted everyone in the target population regardless of their gender.

Table 4.2 Gender of respondents

Gender	Number of respondents	Percentage
Male	17	46%
Female	20	54%
Total	**37**	**100%**

From the table above, we can see that a majority of the participants were females, accounting for 54% followed by males accounting for 46% thereby giving a total of 100%. Studies show that Women are usually more affected during floods than men. Therefore having them as a majority of respondents put weight on the data collected.

4.3.2 Age.

The respondents were requested to indicate their age. The results are shown in Table 4.3 below

Table 4.3 Distribution of respondents by age

	DCPC		VCPC		ACPC	
Respondents age (Years)	Frequency	%	Frequency	%	Frequency	%
19-22	0	0	3	30	1	10
23-30	5	25	2	20	2	20
31-40	10	50	4	40	4	40
41-50	5	25	1	10	0	0
51-60	0	0	0	0	3	30
Total	**20**	**100**	**10**	**100**	**10**	**100**

From table 4.3 above we see that majority of the respondents were between 31-40 years represented by 50% for DCPC, 40% for VCPC and ACPC. This implied that they have been living in the area for a long time and witnessed floods several times and the assumption therefore is that they have experience on flood early warning systems and therefore they were a reliable source of information for the study.

4.3.3 Education level

Table 4.4 shows the education level of the respondents.

Education level	Frequency	Percentage
Primary	18	49%
Secondary	10	27%
Tertially	9	24%
Total	**37**	**100%**

The table above shows that a majority of the respondents', 49% reached primary level, followed by 27% who reached secondary level and 24% reached tertiary level. Therefore the respondents were able to read and write, hence they were able to understand and follow the discussions.

4.4 Presentation of findings.

The findings of the study were guided by the research objectives as indicated in chapter one. Descriptive and inferential statistics were used to analyze the data and the findings are presented in Tables and figures.

4.4.1 Effectiveness of Current Early Warning Systems

The study asked the respondents to state how familiar they were with the early warning systems currently in place for floods in their community. And the findings are presented in the figure 4.1.

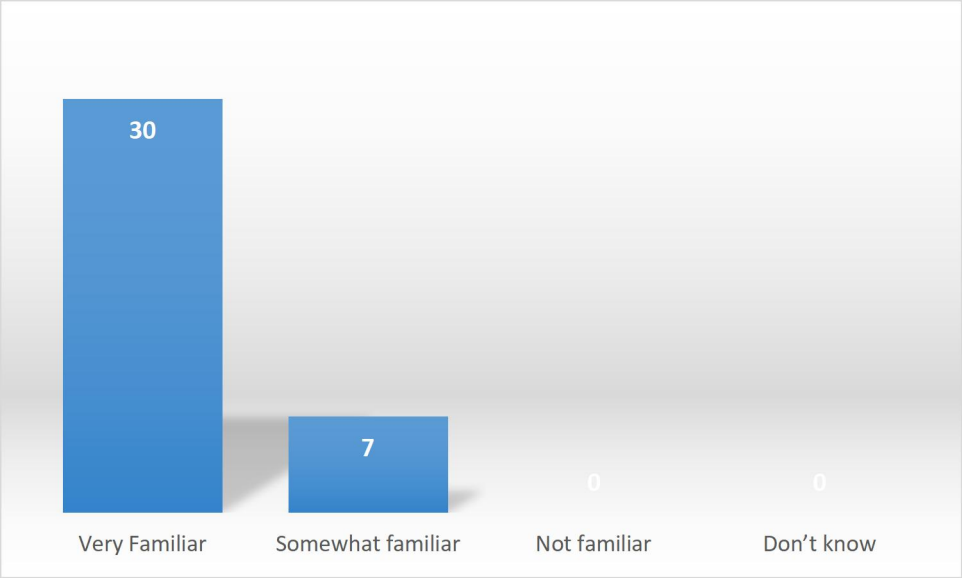


Figure 4.1: Familiarity with early warning systems

As shown in the figure 4.1, 81% of the respondents said they were very familiar with the early warning systems currently in place for floods in their community. And 19% of the respondents said they were somewhat familiar with early warning systems. Therefore, the study concluded that most of the respondents were familiar with flood early warning systems in their community. The respondents were further asked if they have ever received a flood warning through the current early warning systems in their area and the findings are presented in figure 4.2.

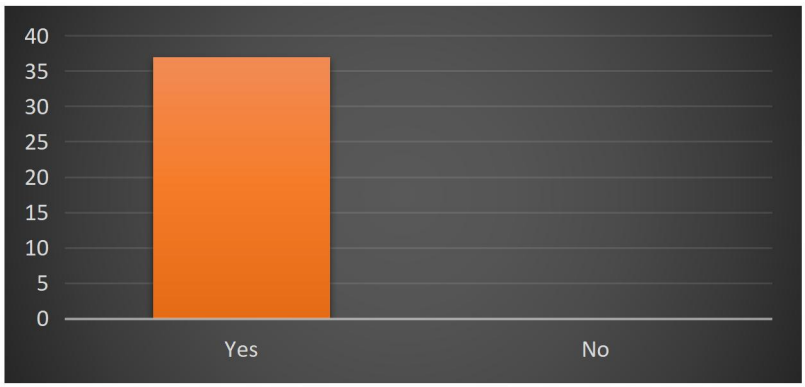


Figure 4.2: Presence of flood warnings through current early warning systems

The findings showed that all the respondents had ever received a flood warning through the current early warning systems in their area.

The study also sought to evaluate how effective was the early warning system in terms of Reducing loss of lives and damage to property during floods. The findings are presented in figure 4.3.

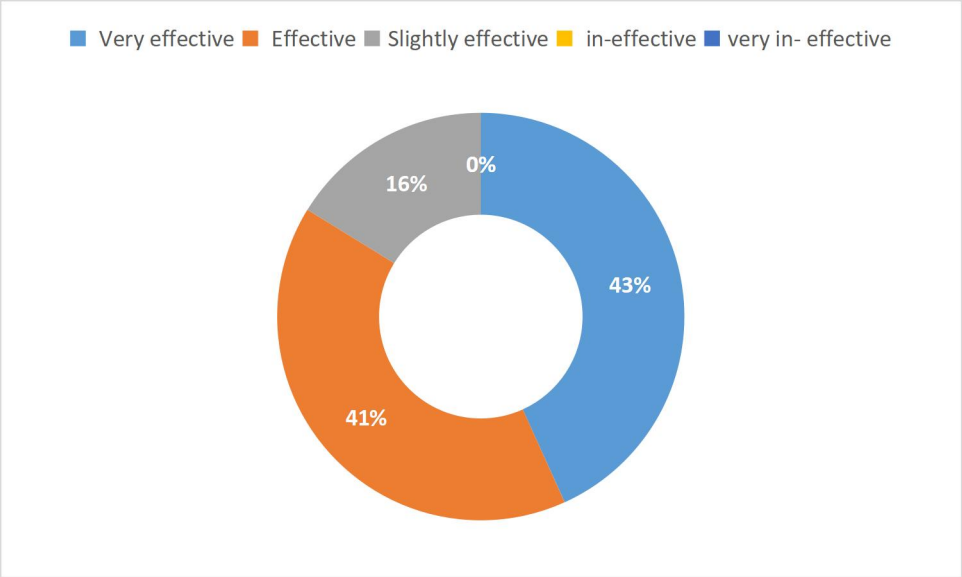


Figure 4.3: Effectiveness of flood early warning system.

As seen from the figure above, the majority of respondents represented by 43% said the early warning system was very effective in reducing loss of life and damage to property, this was followed by 41% of the respondents who said the system was effective. And finally 16% of the respondents said the system was slightly effective. Upon further study it was revealed that after receiving flood warnings, those people living in flood prone areas are told to move to high areas, safe routes are communicated to community members which they can take during floods and children are told to stay home and not to cross rivers without adult supervision.

4.4.2 Efficiency of Modern-Day Early Warning Systems

The study asked the respondents to indicate how quickly they receive flood warnings after the system was activated and the findings are summarized in figure 4.4.

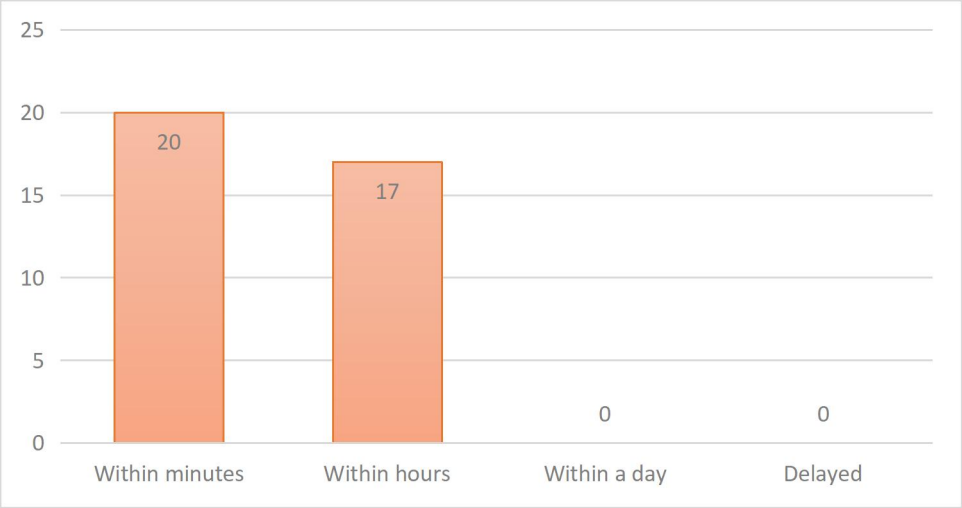


Figure 4.4: Efficiency of flood warning system.

The study revealed that 54% of the respondents received flood warnings within minutes after the system was activated while 46% of the respondents said they received it within hours. Therefore, the study conclude that community members receive flood warnings quickly after the early warning system was activated. The researcher asked the respondents to determine how accurate were the flood warnings provided by the early warning system and the findings are presented in figure 4.5.

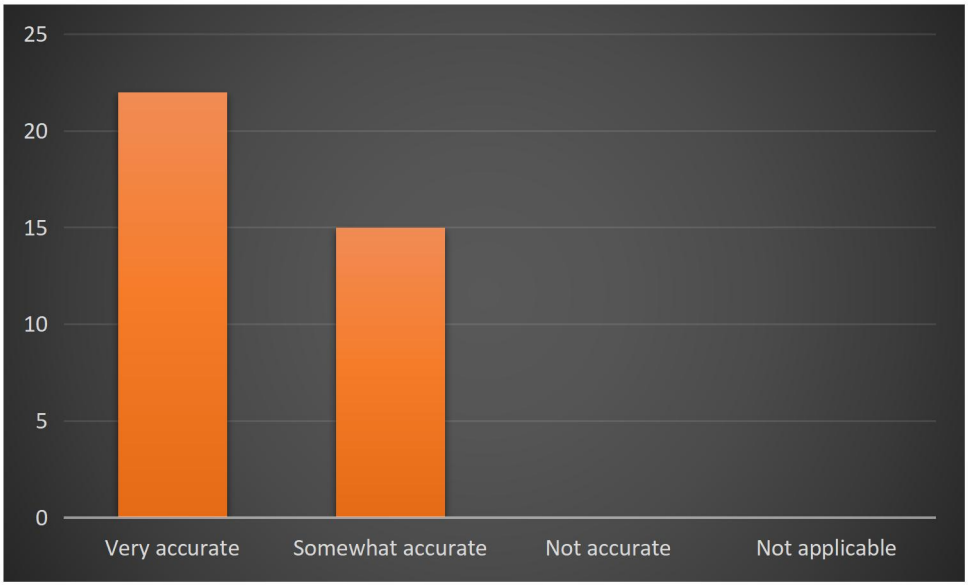


Figure 4.5: Accuracy of early flood warning system.

The findings revealed that 59% of the respondents thought that the warnings were very accurate and 41% of the respondents thought the warnings were somewhat accurate.

The research participants were further asked to identify ways that they thought could improve the efficiency of the early warning system. The findings are summarized in table 4.5.

Table 4.5: Ways of improving the efficiency of flood early warning system

Respondents	Opinions
VCPC	More river line gauges that show water levels should be installed
ACPC	Communication strategies should be improved from the department of climate change and met services - the forecast must reach the communities
DCPC	Utilisation of community radios to disseminate EWS information

The study also wanted to find out from the respondents on how confident they were in the efficiency of modern day early warning systems aimed at reducing the loss of lives and property during floods. The findings are presented in figure 4.6.

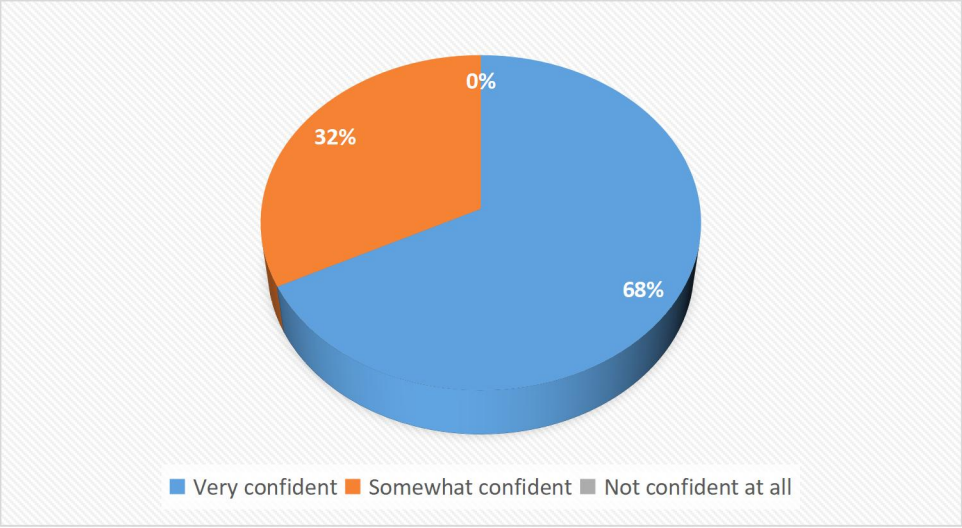


Figure 4.6: Confidence in modern day early warning systems.

The findings found that 68% of the respondents are very confident in modern early warning system and only 32% said they are somewhat confident. In general, the results shows that people are confident in modern day early warning systems.

4.4.3 Identification of Critical Failure Factors

The study asked the participants if they have ever experienced any failures in the early warning system during a flood event and their responses are summarized in figure 4.7.

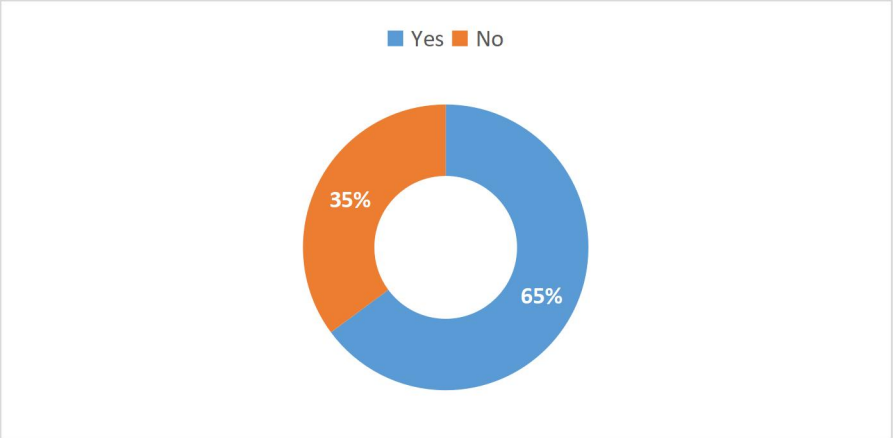


Figure 4.7: Failure in the early warning system.

The majority of the respondents represented by 65% said they have ever experienced failure in the early warning system during a flood event while the remaining 35% said that they have never experienced any failure. Upon further investigation the following were found to be the critical factors contributing to the failure as presented in table 4.6.

Table 4.6: Factors contributing to failure of modern-day early warning system

	DCPC		VCPC		ACPC	
	F	%	F	%	F	%
Lack of community awareness	4	20	1	10	2	20

Insufficient infrastructure	3	15	2	20	2	20
Communication gaps	6	30	4	40	4	40
Inadequate funding	4	20	2	20	1	10
Technological limitations	3	15	1	10	1	10
Total	**20**	**100**	**10**	**100**	**10**	**100**

From the study, lack of community awareness was seen as a factor contributing to failure of modern day early warning system as 20% of DCPC members, 10% of VCPC and 20 % ACPC stated. Insufficient infrastructure was also identified as a contributing factor as 15% of DCPC, 20% of VCPC and 20% of ACPC stated. Communication gaps was seen as another factor represented by 30% of DCPC, 40% of VCPC and 40% of ACPC. The respondents also identified Inadequate funding as another factor represented by 20% of DCPC, 20% of VCPC and 10% of ACPC. Finally Technological limitations represented by 15% of DCPC, 10% of VCPC and 10% of ACPC was seen as another contributing factor.

The study asked the participants on what should be done to improve the early warning systems and table 4.7 summarizes the respondents' opinions.

Table 4.7: Improvement on early warning system

Respondents	Opinions

VCPC	Communities should be properly sensitized about modern day early warning systems. Proper channel of communication should be established to ensure that early warnings are accessible and able to reach everyone
ACPC	Enough funding should be provided to ensure that the early warning teams are properly equipped for instance rain coats, boots, megaphones
DCPC	The early warning team should be trained on how they can operate early warning equipment

CHAPTER 5: DISCUSSION OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1. Introduction

This chapter outlines the summary of findings and the discussions of the research findings. The chapter also presents the conclusions of the study based on the findings and recommendations. The study's overall objective was to assess the impact of modern-day early warning systems on flood response to communities surrounding Likangala River.

5.2 Summary

This section outlines the review of the findings of the study. The section concentrates on the research objectives which were to assess the effectiveness of the current early warning systems in reducing the loss of lives and property during floods, to evaluate the efficiency of modern-day early warning systems in providing timely and accurate flood warnings to communities at risk, and to identify the critical failure factors of modern-day early warning and response systems for floods.

5.2.1 The effectiveness of the current early warning systems in reducing the loss of lives and property during floods

The study was assessing the effectiveness of the current early warning systems in reducing the loss of lives and property during floods. The study findings revealed that 81% of the respondents were very familiar with the early warning systems currently in place for floods in their community. And 19% of the respondents said they were somewhat familiar with early warning systems. The study also found all the respondents to have ever received flood warnings through the current early warning systems in their area. The study further revealed that the majority of respondents represented by 43% said the early warning system was very effective in reducing loss of life and damage to property, this was followed by 41% of the respondents who said the system was effective. And finally 16% of the respondents said the system was slightly effective. This is in context with the observation made by Nott (2006) who said that early warning system greatly improves disaster preparedness and reduces loss of life and property.

5.2.2 The efficiency of modern-day early warning systems in providing timely and accurate flood warnings to communities at risk.

The study found that 54% of the respondents received flood warnings within minutes after the system was activated while 46% of the respondents said they received it within hours. The findings further revealed that 59% of the respondents thought that the warnings were very accurate and 41% of respondents thought the warnings were somewhat accurate. The study further identified the following as ways that they thought could improve the efficiency of the early warning system; more river line gauges that show water levels should be installed, communication strategies should be improved from the department of climate change and met services - the forecast must reach the communities, and utilisation of community radios to disseminate EWS information. The study findings also found that 68% of the respondents are very confident in modern early warning system and only 32% said they are somewhat confident. This concurs with the findings of the study done by Sene et al., (2017), who found that modern day early warning systems are more reliable because they use modern technological advancements

5.2.3 The critical failure factors of modern-day early warning and response systems for floods.

The findings of the study revealed that the majority of the respondents represented by 65% said they had ever experienced failure in the early warning system during a flood event while the remaining 35% said that they had never experienced any failure. Upon further discussions with the respondents it was discovered that lack of community awareness was seen as a factor contributing to failure of modern day early warning system as 20% of DCPC members, 10% of VCPC and 20 % ACPC stated. Insufficient infrastructure was also identified as a contributing factor as 15% of DCPC, 20% of VCPC and 20% of ACPC stated. Communication gaps was seen as another factor represented by 30% of DCPC, 40% of VCPC and 40% of ACPC. The respondents also identified Inadequate funding as another factor represented by 20% of DCPC, 20% of VCPC and

10% of ACPC. Finally Technological limitations represented by 15% of DCPC, 10% of VCPC and 10% of ACPC was seen as another contributing factor

5.3 Discussion of findings

5.3.1 Effectiveness of Current Early Warning Systems

It was concluded that early warning systems are very effective in reducing loss of life and damage to property (Drobot et al., 2007)

According to Parker (2012) early warning systems help to reduce economic losses and mitigate the number of injuries or human loss of life to a disaster, by providing information that allows individuals and communities to protect their lives and property.

A further study conducted by Pandey (2023) highlighted that an effective early warning system is capable of saving many lives and reducing damage by 30% if activated 24 hours before the event.

5.3.2 Efficiency of Modern-Day Early Warning Systems

Floods alerts provided by early warning systems (EWS) are an important element of comprehensive flood risk management strategies. The purpose of EWS is to provide information on expected flows and water levels prior to the actual occurrence of a flood peak and generate alerts in order to take preventive measures for avoiding damages (Dutta, 2018).

Further it was found that reliable forecasts are a basic requirement for warning system operators and responsible authorities to take robust decisions. The evaluation of the efficiency of modern-day EWS according to Thieken (2021) is basically related to the question whether a reliable alert can be set off with sufficient lead time to complete preventive measures.

On the same line, Dutta (2018) concurred that for the EWS to be efficient, the decision about a flood alert has to trade off the prolongation of the warning lead time and the decrease of forecast reliability. In this context, it is important to bear in mind that a successful warning will bring about (socio-) economic benefit whereas a false alert leads to (socio-) economic loss.

5.3.3 Identification of Critical Failure Factors

The research concluded that critical failure factors associated with flood warning and response systems are broadly related to policies concerning, and governance aspects within, warning generation, the behavior of communities in responding to early warnings, and weaknesses in associated tools and technologies used in communicating early warnings and responding (Kumar et al., 2020).

Basher (2006), argues that capturing critical failure factors affecting flood warning and response systems can provide opportunities for making corrective measures and for developing a more advanced and futuristic system for early flood warnings.

5.4 Conclusion

As one of the major natural hazards Malawi faces is floods, this study aimed at assessing the impact of modern-day early warning systems on flood response to communities surrounding Likangala River. Through this study, it was observed that modern day early warning systems are very effective in reducing loss of life and damage to property during floods. The study also observed that modern day early warning systems are very accurate and they give flood warnings in time. Unfortunately, like any other system, modern day early warning systems are prone to failure as well.

Despite proper consideration on issues surrounding EWS, it has been discovered that operational bureaucracy poses a serious threat to effective running of EWS. Heavy reliance on donor project funding that has limited life span is one contributing factor. Another is vandalism of river gauges, which in turn has a bearing on the system as it becomes expensive to maintain and run. In addition, the participants recommended that there is need for continual trainings on CPCs in areas of interpreting and using early warning messages because the committees change from time to time.

The long-term goal for disaster risk management in Malawi is to sustainably reduce disaster losses in lives and in the social, economic and environmental assets of individuals, communities and the nation. Therefore the results of this study will help policy makers to identify gaps and fill these gaps to ensure a nation resilient to disasters

5.5 Recommendations

In order to improve the situation, the researcher made the following recommendations based on the research findings

1. Increase funding to sustain what is already there, as most of the EWS rely on project funds.
2. Capacity building of CPCs to properly manage the systems in terms of interpretation and making use of early warning messages.
3. Improve the technology used in monitoring floods. Locally available, modern and advanced technologies/equipment have to be used.

5.6 Recommendations for further studies

1. The study can be replicated in other areas that are affected by floods in the country.
2. There is need to focus on a study on how bureaucracy affect the effectiveness of running EWS.

REFERENCES

(n.d.).

Basher, R. Global early warning systems for natural hazards: Systematic and people centred. 2006, 2167-2182

Chinguwo, D. D., & Deus, D. (2022). Assessment of flood early warning system in Malawi. *Jàmbá: Journal of Disaster Risk Studies 14(1)*, 2.

Creswell, J., & Creswell, D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches, 4th Edition.* Thousand Oaks: Sage Publications.

Department of Disaster Management Affairs(DoDMA). (2015). *Malawi Floods : Department of Disaster Management Affairs (DoDMA) and United Nations Office of the Resident Coordinator, Situation Report No 8.* Lilongwe: DoDMA.

Drobot, S.; Parker, D.J. Advances and challenges in flash flood warnings. *Environ. Hazards* 2007, 7, 173-178.

Dutta, R.; Basnayake, S. Gap assessment towards strengthening early warning systems. Int. J. Disaster Resil. Built Environ. 2018, 9, 198-215

GFDR. (2019, July 24). *Disaster Risk Profile*. Retrieved from Malawi: https://reliefweb.int/sites/reliefweb.int/files/resources/malawi_low.pdf

GoM. (2015). *National disaster risk management policy 2015,.* Lilongwe: Government of Malawi.

GoM. (2019, July 24). *Malawi 2019 floods post disaster needs assessment report (PDNA), p. 109,*. Retrieved from Government of Malawi: https://reliefweb.int/sites/reliefweb.int/files/resources/Malawi%202019%20Floods%20Post%20Disaster%20Nee

Gruffet, A. (1995). Hydro meteorological, impacts and Management of Extreme floods. . *Paper presented at a workshop on long term social and economic impacts of extreme floods* (p. 14). Coloradon Springs: USA.

Kumar, S.; Jain, S.K.; Gurrapu, S. Challenges and recent developments in flood forecasting in India. In proceedings of the Roorkee Water Conclave, Roorkee, India, 26-28 February 2020

Lumumba , M. P., & Izadkhah, Y. O. (2009, MAY 21). Management of floods in Malawi: case study of the Lower Shire River Valley. *Disaster Prevention and Management*, pp. 409-503.

Misomali, J. (2014). *Emergency Management In Malawi: A Work in Progress With a Strong Foundation,*. Retrieved from http://www.ndr.mw:8080/xmlui/bitstream/handle/123456789/1241/Emergency%20Management%20in%20Mala

Mwape, A. (2015). Quantifying Vulnerability of Rural Communities to Flooding in SSA. A contemporary Disaster Management Perspective Applied to the Lower Shire Valley, Malawi . *International Journal of Disaster Risk Reduction*, 12.

Nott, J. (2006). *Extreme Events : A Physical Reconstruction and Risk Reduction Assessment.* New York: Cambridge University Press.

Pauw, K., & Thurlow , J. (2009). Economic Losses and Poverty Effects of Droughts and Floods in Malawi. *International Food Policy Research Institute*, 3.

Pauw, K., Thurlow, J., & Seventer, v. (2010). Droughts and Floods in Malawi: Assessing the Economywide. *International Food Policy Research Institute 44*, 7.

Parker, D.J.; Priest, S.J. The fallibility of flood warning chains: Can Europe's flood warnings be effective? Water Resour. Manag. 2012, 26, 2927-2950.

Pandey, C.L.; Basnet, A. Challenges and prospects of Flood Early Warning Systems; A study of Narayani Basin. Asian J. *Water Environ. Pollut.* 2023, 20, 17-24

Sene, K., Piper, B., Wykeham, D., McSweeny, R., Tych, W., & Beven, K. (2017). Long-term variations in the net inflow record for Lake Malawi. *Hydrology Research 48(3)*, 851-866.

Smith, P. J., Brown , S., & Dugar, S. (2017). Community-based early warning systems for flood risk mitigation in Nepal. *Natural Hazards and Earth System Sciences 17(3)*,, 423-437.

Stepanyan, M. (2014). *Learning study on DIPECHO programming in Malawi funded by DG-ECHO over the period 2007-104: Community resilience in focus – Chikwawa, Salima and Nsanje Districts*. Retrieved from European Commission – Humanitarian Aid,: https://europa.eu/capacity4dev/file/73559/download?token=K_3tm7XD

Tongco, M. (2007). Purposive sampling as a tool for informant selection. *Ethnobotany Research and Applications 5*, 147.

Thieken, A.H.; Performance of the flood warning system in Germany in July 2021-Insights from affected residents. EGUsphere 2022, 1-26

UNISDR. (2006). Developing early warning systems: A checklist. In *Third International conference on early warning.* Bonny, Germany.

World, M. O. (2019). Accelerating Life-saving Action, Maximising Finance Effectiveness - Climate Risk and Early Warning Systems for Least Developed Countries and Small Island Developing States. *Climate Risk and Early Warning Systems - Annual Report 2019*, p. 12.

APPENDICES