Global Disaster Preparedness Center

RESEARCH PAPER

TOWARDS PARTICIPATORY FLOOD EARLY WARNING FOR EARLY ACTION A SITUATIONAL ANALYSIS OF FLOOD RISK COMMUNICATION IN THE ZAMBEZI REGION, NAMIBIA

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Acronyms

CDRMC	Community Disaster Risk Management Committee
CDRMC	Community Disaster Risk Management Committee
EWS	Early Warning System
FGD	Focus Group Discussion
DMA	Disaster Management Act
DRR	Disaster Risk Reduction
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HEC-RAS	Hydrological Engineering Center River Analysis System
HSN	Hydrological Services Namibia
KII	Key Informant Interview
MAWF	Ministry of Agriculture, Water and Forestry
MET	Ministry of Environment and Tourism
MICT	Ministry of Information and Communication Technology
NASA	National Aeronautics and Space Administration
NamWATER	Namibia Water Corporation
NCRST	National Commission on Research Science and Technology
NGO	Non-governmental Organization
RAISON	Research and Information Services of Namibia
SASSCAL	Southern African Science Service Centre for Climate Change and Adaptive Land Management
UN-SPIDER	United Nations Platform for Space-based Disaster Management and Emergency Response

Abstract

Flood hazards are uniquely complex phenomena with severe implications for those affected, especially rural riparian communities, which rely on the natural environment for their livelihood. As such, developing risk communication strategies that lead to appropriate early action has shifted to the forefront of the global hazard risk reduction agenda. Although research and recommendations for good practice have increased exponentially over the past two decades, several challenges still exist. Empirical evidence suggests that risk communication approaches adopted in developing countries are often 'top-down', bureaucratic approaches that disregard the unique environmental, economic, and social contexts of target communities that drive access to information, response action, and, by definition, end-user needs. Adopting a case-study approach, this study explores the benefits of leveraging existing governmental resources and innate community capacities to develop a bilateral and impact-based flood risk communication system tailored to community needs. The study demonstrates that knowledge of the social, economic, and environmental dynamics within a target community not only defines the appropriate risk communication strategy required but also determines the community's capacity to respond. The study presents several cost-effective, participatory, and people-centred opportunities for systems enhancement and, consequently, long-term resilience building.

Keywords: *risk communication, flood risk, early warning system, participation, integration, situational analysis*

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1. Introduction

Flood risk communication (i.e., risk and preparedness communication and early warning) serves to ensure that upon receiving contextually relevant information, target audiences respond appropriately, taking the necessary actions to reduce the risk (Haer et al., 2016). However, ineffective communication and breakdowns in the structures through which information is transmitted have all been credited as notable components in previously exiguous or failed disaster response efforts, such as the tropical Cyclone Eline in Southern Africa in 2000 (Reason & Keibel, 2004) and the Hurricane Katrina floods in 2005 (Garnett & Kouzmin, 2007). The grounds for failed communication are often varying. At one end of the spectrum, the social and political aftermath of risk transfer guides communication approaches, and at times, the composite dynamic between government, relevant agencies, and civil society directs decision-making (Terpstra et al., 2009). Conversely, the public's failure to accurately interpret the conveyed information also proves to be a significant challenge (Twigger-Ross, 2009). Poor confidence levels and mistrust of authorities providing the information (Basher et al., 2006), misinformation and contradicting information from multi-level media outlets (Martens et al., 2009) all impact community response to risk. Any of these factors or an amalgamation of them serve as prospects for public misinformation and, consequently, compromise resilience-building (Zschache, 2022). Effective risk communication is thus at the forefront of the global agenda to bridge the last mile in (Bradford et al., 2012; Twigg, 2013) hazard risk reduction (Steelman & McCaffrey, 2013).

Many risk communication approaches in rural African communities are founded on the information deficit model, which assumes that target communities lack an understanding of risk and the science behind hazardous events (Demeritt & Nobert, 2014). As such, appropriate responses can be inspired by providing them with increased-quality scientific information (Mowat, 2011). However, this approach fails to recognize that communities are heterogeneous in their interpretation, comprehension, and response to risk information (Twigg, 2013). Therefore, it does not account for the diverse situational (environmental characteristics, location), socio-cultural, and economic elements that impact flood warning response by either impeding or inspiring action from communities at risk from flood hazards. Individuals assess risk information based on their perception of risk and personal judgment (O'Sullivan et al., 2012). This, in turn, is influenced by socio-cultural risk perceptions (how risk is perceived subjectively and how it affects their livelihoods) and their economic capacity to respond (access to resources) (Dula Etana & de Cock Buning, 2021). Moreover, social demographic patterns, communication practices, risk awareness, and perceived hazard impact form part of the larger pool of factors influencing risk information interpretation (Bajracharya et al., 2021; UNU-IAS et al., 2014). The ambivalence with which communities interpret risk highlights a major weakness in adopting the information deficit model approach for flood risk communication. It is, therefore, understandable that authors like Twigger-Ross (2009) and Miceli et al. (2008) report that despite alterations or upgrades to any element in risk communication approaches based on the information deficit model, a significant change in response activity is highly unlikely.

The main question arising from this research is, "Is the current risk communication structure sufficient to enhance flood risk preparedness, response, and mitigation? As such, this research aims to examine the efficacy of flood communication structures by analysing the operations of the early warning system implemented in Kabbe, assessing the gaps, and identifying opportunities for effective flood risk communication, preparedness, response, and mitigation. As previously mentioned, floods are a major threat in Kabbe, recurring each year, with devastating consequences for the most vulnerable communities. Given that these communities have refused to relocate to other areas, urgent strategies are needed to enhance their level of preparedness, response, and mitigation. Flood risk communication is the starting and most strategic point for achieving this goal. As such, this paper presents findings of a hierarchically contextualized situational analysis of Namibia's operational flood early warning system. Adopting a qualitative approach, the researchers conducted key informant interviews with multi-level governmental Disaster Risk Reduction (DRR) officials and focus group discussions with residents from four high flood-risk communities in Isize, Mbalasinte, Kalumbesa and Ihaha in the Zambezi region, Namibia. The study adopted a bilateral approach in assessing the efficacy of risk communication for appropriate early action across the technical, institutional, and socio-cultural components of the formal flood warning process. Recognizing that resilience is multidimensional (Hughes & Bushell, 2013), we also conducted a situational analysis of the target communities' unique social, economic, and environmental capacities to assess their access to risk information from authorities and how this guided them in preparing and responding to impending floods. The situational analysis also identified several opportunities for community engagement that can significantly strengthen risk communication and overall system efficacy.

The paper assumes that by acknowledging, assessing and integrating innate community capacities (social, economic and environmental) or the lack thereof into the design and implementation of risk communication strategies, system efficacy can be significantly enhanced, encouraging appropriate response actions, bridging the last mile by reaching the most vulnerable groups and building overall community resilience. Flood risk and preparedness information and warnings are considered a resource circulating through a network of relevant players and transformed into knowledge that positively influences preparedness and response actions (Baldassarre, 1969). By considering the unique constructs of the target communities, the government can develop systems that address community needs and are technically relevant to the particular environment. By identifying how communities perceive risk, translate risk information, and prepare and respond to flood risk based on risk communication, the study provides a set of easily applicable, cost-effective and contextually appropriate recommendations for improving flood risk communication through establishing participatory flood early warning practices. This approach is consistent with the knowledge systems approach proposed by (Röling & Engel, 1991). The approach explicates the risk communication process more holistically. It offers better solutions to challenges in risk communication as it gives due consideration to the diversity of external factors and knowledge systems that influence response actions.

Moreover, risk communication approaches based on the information deficit communication model adopt one-way, top-down technocratic strategies with minimal community engagement, no feedback mechanism, and thus no way of assessing system efficacy (Tsatsou, 2009). Communities act as recipients of risk information in these systems, and there are no platforms for communicating their needs. While this poses a significant limitation, solely bottom-up or community-driven approaches are notably just as ineffective (Röling & Engel, 1991; Tsatsou, 2009). The proposed recommendations are derivative of a combination of evidence-based systems challenges and the needs of communities at risk, and they incorporate strategies for ongoing collaboration between relevant stakeholders. The results support bilateral risk communication that is neither bureaucratic nor bottom-up but centred around end-user needs (Basher et al., 2006).

2. Literature Review

Although several definitions with unique variables and perceptions exist for describing risk communication, there is a general global consensus that it is the bilateral risk information trade-off between communicators and benefactors. According to McCallum et al. (1991), risk communication can be defined as the resolute exchange of information about the nature, immensity, importance and mitigation of both natural and anthropogenic hazards between interested parties. Perpetuating this rationale, other scholars expand on this definition, emphasizing the relevance of uninterrupted risk monitoring (Bica et al., 2020), risk reduction (Driedger et al., 2020) and multidimensional stakeholder dialogue (Coombs & Holladay, 2022).

As a concept that continuously draws from multiple disciplines in its approaches, several recommendations and implementation strategies for effective risk communication have emerged from research and practice (Mooney et al., 2020). As such, risk communication has evolved significantly over the last 20 years, shifting from linear and instructive approaches to more versatile, integrated, deliberative, and participatory strategies geared at serving end-user needs (Balog-Way et al., 2020). Nowadays, it is common knowledge that public needs and perceptions influence risk mitigation and thus require due consideration as system effectors (Mooney et al., 2020). The normative theory of effective risk communication strongly encourages public prioritization, association, and dialogue between risk management authorities and target communities (Sato, 2015). Renn (2008) highlights the significance of tailoring risk communication to stakeholder needs, arguing that this influences risk perceptions and, therefore, informs preparedness and response actions. This demonstrates that effective communication, or a lack thereof, significantly influences appropriate actions.

Building his work on early risk perception theories proposed by authors like Covello et al. (1986), Fischhoff (2013) is considered an innovator in risk communication research. Being among the first to propose the due consideration and integration of community risk perceptions when designing risk communication approaches, his work aligns with that of numerous researchers (Ayeb-Karlsson et al., 2019; Bajracharya et al., 2021; Ripberger et al., 2015) who believe that effective risk communication is not solely based on science but also acknowledges the complex mix of socio-cultural, economic and environmental dynamics at play. Since then, however, risk communication research has evolved to include recommendations on but not limited to tailoring information to address the needs of target groups, strengthening public risk awareness, defining media roles, etc., for effective public warning (Farber, 2018; McCallum et al., 1991; Munyai et al., 2021; Terpstra et al., 2009).

In as much as risk communication is essential to raising risk awareness and inspiring appropriate preventative actions in vulnerable groups. Similarly, the social, economic, political and environmental constructs of target communities are crucial to developing effective risk communication strategies (Kasperson et al., 2016). Although the scope of practical recommendations for improved risk communication is unlimited, research approaches are often linear, focusing on a single effector of the hazard risk. For instance, Knocke & Kolivras (2007) highlighted the need for risk awareness raising for flash floods through presentations, public training workshops, information pamphlets, etc., to alert the public to existing data, information, and warning sources. Contrastingly, Kreibich et al. (2007) suggested prioritizing preparedness information to drive risk communication for communities living along the Elbe River. The authors found that residents who prepared for floods were better equipped to respond to flood emergencies as part of preparing included household evacuation planning. Meanwhile, Martens et al. (2009) encourage considering the social diversity within target communities to guide risk communication approaches. The authors argue that providing communities with uncustomized risk information proves futile in achieving positive results as their individual circumstances and perceptions ultimately guide their response. Additionally, studies advocating for two-way risk communication approaches have become more prevalent, often governed by different rationales, interpretations of dialogue, and challenges that these approaches should address (Breakwell, 2000; Guan et al., 2021; Sandman, 2006).

From the reviewed literature, it is evident that for risk communication to be effective, different individuals require different approaches with unique stakeholders, networks and exchanges (Steelman & McCaffrey, 2013). However, a common thread has been identified: effective risk communication and the resultant end-user responses are ultimately governed by risk perceptions (Balog-Way et al., 2020), which are influenced by the target communities' social, economic and environmental contexts. Therefore, by acknowledging, analyzing and incorporating the diversity of these spatially unique variables into developing risk communication approaches, governments can assist communities in building resilience against hazards. This study contributes to this body of literature by empirically assessing the efficacy of flood risk communication by analyzing the operational flood early warning system and how it influences flood risk reduction in rural at-risk communities in the Zambezi region, Namibia. The study results provide a foundation for strengthening local flood early warning by capitalizing on innate community capacities for effective risk communication to bridge the last mile.

3. Methodology

3.1. Study Area Description and Hydrological Context

Built on approximately 14,663 km^2 of land mass plagued by annual floods, the Zambezi region (formerly the Caprivi Strip) links Namibia to the Zambezi River basin (Gbagir et al., 2019). The region borders Angola, Zambia, Zimbabwe, and Botswana to the east, along over 130 km of the basin's main tributary, the Zambezi River. The Zambezi region is almost at the bottom of the former Kalahari Basin, an expansive 'sandpit' dominated by sandy and clay loam soils (Mendelsohn, 2007). The area is almost entirely flat, averaging 930m above sea level, with maximum rise and fall approximating 30m from east to west, which is thought to, in some way, contribute to its complex hydrology (Ministry of

Agriculture Water and Rural Development, 1998). Climatic conditions in the region are tropical, deviating from the rest of the country's aridity, and characterized by extreme rainfall events and sporadic dry spells in certain areas. The region also records the highest annual precipitation levels in the entire country, averaging (600mm-800mm/annum) relative to the national average (<250mm/annum) (Mendelsohn et al., 2002).

The eastern section of the Zambezi region, Kabbe constituency, was selected as the study area. The area takes up approximately 5000 km^2 of the entire region and is categorized as a floodplain almost completely enclosed by rivers, i.e. the semi-permanent Linyati-Chobe Rivers to the south and the perennial Kwando and Zambezi to the west and north-east, respectively (Ministry of Agriculture Water and Forestry, 2010). About 1000 km^2 of the area is open water, with the combination of swamps, lakes, and rivers forming the only permanent water features within the Namibian borders (MAWF, 1998). According to the last population census (2011), the area, which comprises the Katima Mulilo Rural and Kabbe north and south constituencies (Figure 1), had a population size of 30,917, all housed on the floodplain, making them vulnerable to flood impact (Namibia Statistics Agency, 2011; United Nations Office for Disaster Risk Reduction, 2019). The majority of the population (91.1%) in the area are Namibian natives belonging to the 'marginalized' Mafwe and Masubia tribes. From an economic, environmental, and social perspective, most of the population depends on the natural environment for their livelihood, with 17% directly involved in farming and about 40% operating small non-farming businesses, i.e. fish vending, tour guides, reed basket weaving, artifact selling, etc. Concurrently, 57% of the households in the area are headed by men, and approximately 83% of the population above 15 years is reported to be literate.
The natural fragility, land degradation, and governing hydro-climatic conditions of Sub-Saharan African countries place floods at the forefront of their developmental hindrance (Aliyu et al., 2023). Moreover, several authors have reported on the continuing surge in flood events and their compounded impacts influenced by climate change over the past three decades, especially around major shared water courses such as the Zambezi (Arinabo, 2022; Ramiaramanana & Teller, 2021; Ziga-Abortta & Kruse, 2023). The increase in flood events is particularly concerning in SSA as over 71 million people in the region are reported to live in both extreme poverty and significant flood risk. These flood events often have detrimental impacts on civil society, the environment, infrastructure, and the economic sector (IFRC, 2021). For instance, the 2019 Indian Ocean cyclone Idai resulted in a devastating level of flood damage previously unknown to Africa. The cyclone affected Mozambique and Zimbabwe, resulting in over 600 deaths, approximately 300 fatalities, and an estimated $1 billion in infrastructural damages (Disaster Emergency Committee, 2019).

Additionally, the 2011 Southern Africa La Niña affected 228,500 people in northern Namibia in its second state of emergency flood in three years, killing 65, displacing 60,000, and causing $ 136.4 million worth of infrastructural damage (Government of the Republic of Namibia, 2009). Over 100,000 people were affected in the study area, with over 9,000 relocations, and 90% of the population in Kabbe, north and south, was severely impacted. Although preceding floods have not been as impactful, the Namibian terrain makes it most vulnerable to the impacts of climate change, and the country has been declared as having the highest population-to-flood risk ratio in Southern Africa (IFRC, 2021).

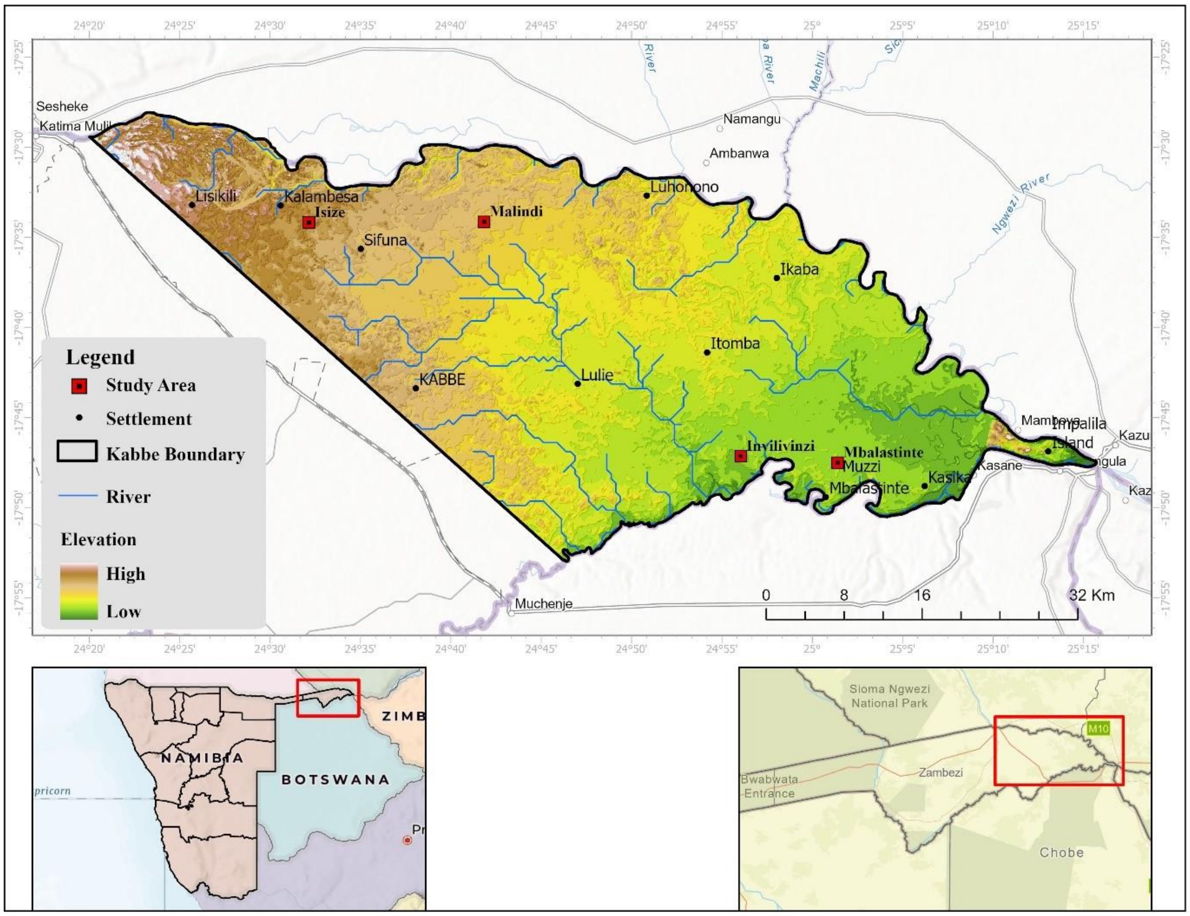

Figure 1. Study area map

3.2. Framework for the Situational Analysis

According to Magis (2010) and Wilson (2012), the capacity of communities to accurately and effectively respond to the impacts of both natural and anthropogenic disasters is governed by a nexus of environmental, economic, and social attributes. As such, the efficacy with which communities respond to unanticipated disruptions by disasters highlights specific aspects of vulnerability. Other than the geographical risk profile defined by the built and natural environment of target communities, economic conditions and social capital in the stages leading to disaster heavily influence the ability of residents and local authorities to consolidate necessary resources and attain coordinated and effective early action (Kim & Marcouiller, 2021). As such, the adoption of risk-reduction planning strategies that meticulously consider the environmental, economic, and socio-cultural aspects of communities at risk of hazard impact are more likely to succeed and are pivotal to effective early action and fostering overall disaster resilience (Berkes & Folke, 1998; Xiao & Drucker, 2013).

Several frameworks with unique perspectives on hazard risk communication and household risk reduction were reviewed to align with the abovementioned concept proposed by Berkes & Folke (1998) and Xiao & Drucker (2013). Thereafter, a modified framework adapted from Alexander (2008) and Bollin et al. (2006) was developed for the study *(Figure 2)*. This framework adopts a systematic view of risk communication and theorizes that effective early warning communication is governed by strong interlinkage between three critical components, namely technical (scientific), institutional (administrative), and socio-cultural, that give due consideration to the social, economic and environmental construct of target communities *(Figure 2)* at the planning through implementation stages of the systems development (Alexander, 2013; Bollin et al., 2006). The framework recognizes that a community's capacity to effectively respond to hazard impact is determined by the combination of endogenous (social, economic, and environmental) factors that define them. Therefore, system efficacy is more attainable if system design is correlated to the target community's innate capacity to respond to natural and anthropogenic shocks (Norris et al., 2008). The framework postulates that inefficacy in any of the three components renders the system inoperable (Alexander, 2013).

The technical element of the flood risk communication process includes hazard monitoring, real-time flood data collection and analysis, flood forecasting, and flood evaluation. The institutional element looks at the administrative structures required to communicate the relevant risk information disseminated through various available media, i.e. the internet, TV, radio, SMS, notice boards, websites, electronic mail, sirens, etc. Finally, the socio-cultural element reviews the incorporation of knowledge of the target communities' risk perception and the different levels of exposure and capacity that influence hazard impact on vulnerable groups. The feedback loop presents an opportunity for officials to liaise with end-users on the early warning system's efficacy, providing a conduit for improvement. Regarding the community's capacity to effectively receive and respond to the disseminated risk information, the environmental component reviews natural and built environment constructs that influence risk and vulnerability, including community perceptions. The economic component looks at the financial investment in the area, which influences residents' access to resources, i.e. communication devices, cars, boats, electricity, money, food, etc., that influence household response capacity. Finally, the social component looks at the local demographic that determines the social capital, i.e. social groups and networks, the ability to accurately translate risk information, etc., of the target area.

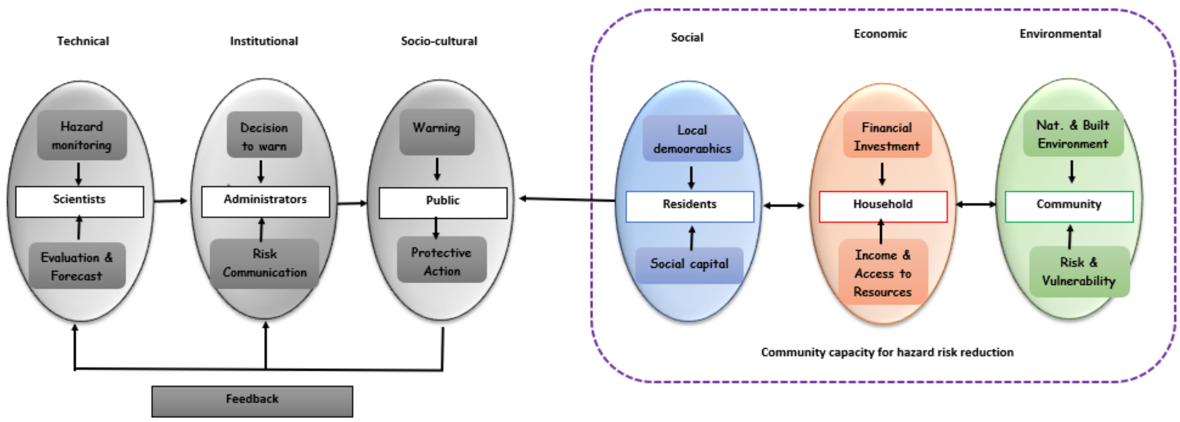

Figure 2. Sustainable early action risk communication framework adapted from Alexander (2008) and Bollin et al. (2006)

3.3. Data collection and analysis

The data used in this study was obtained through an extensive literature review, field visits, and key informant interviews. (KIIs) and focus group discussions (FGDs). Additionally, survey-like information such as household income range, education levels, access to communication media, etc., were posed to FGD participants to measure response capacity. Although the study was primarily qualitative and based on the primary data collected, quantitative secondary data from official government reports was used in certain instances to validate qualitative information. In addition to identifying elements essential to early warning communication, the literature review also provided the research team with an overview of the overall flood risk communication process and the existing structure in the study area. Through the literature review, we developed the KII questionnaire (Appendix I) and identified nine relevant officials at the national (3), regional (1), and local (1) governmental levels, community leaders (3), and a single official from the Namibia Red Cross. Government officials included those from the MAWF, DDRM, MICT, and the Zambezi regional and local authorities. The officials were selected based on their stakeholder expertise and involvement in the flood risk communication process.

Based on the postulate by Chambers (1997), identifying relevant indicators for capacity measurement is most effective when determined with decision-makers and those in charge of implementing action plans. As such, the research team employed the help of a local official, community leaders, and the NGO to select these indicators, which influenced the FGD participant selection criteria. This required that all participants be ≥35 years old, head of a household, and have experience of the 2008/2009 and 2010/2013 state of emergency floods and at least two annual flood events thereafter. Additionally, the FGD questionnaire (Appendix II) was developed with the environmental, economic, and social capacity indicators in mind and survey-like questions such as those mentioned above were posed to all attendees. A total of 178 FGD participants were interviewed, with 82 and 96 male and female participants, respectively.

Data collection took place from November 2023 to January 2024, based on a two-stage data collection process, as follows:

1) Assess flood risk communication and dissemination from the national to community level and determine the feasibility of the system relevant to the target community's needs and capacities through KIIs.
2) To assess the extent of community engagement in the flood early warning and risk communication process and to determine the target communities' capacity to receive and respond to risk communication effectively.

The combination of the data collection tools ensured data validity and increased the study's credibility as KIIs, FGDs, and field observations cross-checked each other. Qualitative data was thematically analyzed, whereas descriptive statistics were used for the qualitative data. The analysis enabled the research team to identify gaps within the existing system while simultaneously identifying conduits for system enhancement through community participation.

4. Study Findings

4.1. Assessment of Flood Early Warning Communication

4.1.1. Technical component: Flood risk monitoring, forecasting and evaluation

At the national and regional levels, flood risk monitoring, forecasting and evaluation by way of rainfall data, monitoring of river flow levels and real-time flood hazard monitoring comprise the technical component of flood risk communication in Namibia. Although its primary role is data collection, the Hydrological Services Namibia (HSN) is the primary agency responsible for warning generation in Namibia. HSN operates several ground stations and collects rainfall, river flow, surface and groundwater levels and forecasting data from a combination of 47 human-crewed, telemetric automatic stations in the study area. In addition to river flow data obtained from their own stations, the HSN includes rainfall and surface and groundwater level information from privately owned stations by the Meteorological Services of Namibia (MSN) and the Namibia Water Corporation (NamWATER) in their flood modelling process. Although the six stations situated in the three major tributaries *(Figure 1)* in the study area have been upgraded, the KIIs revealed poor maintenance and shortages in the number of gauging stations, particularly along minor tributaries situated close to homesteads, as major pitfalls for data availability and effective modelling *(Table 1)*.

Along with the MSN, the HSN provides seven-day numerical weather prediction forecasts based on the COSMO-NWP model. In 2010, the HSN collaborated with various organizations, including the United Nations Platform for Space-based Disaster Management and Emergency Response (UN-SPIDER) and the National Aeronautics Space Agency (NASA) to establish an EWS in the study area that used relevant satellite and ground flow data to identify scenarios for flood modelling using the open access CEOS model. However, the project efforts have been hindered by the shortage of data in most areas and the lack of funds to acquire models appropriate for data-scarce areas. The KIIs revealed that due to these factors, the HSN does not conduct any flood or impact modelling activities *(Table 1)* but is focused on increasing the number of rainfall and river flow data collection stations. It uses projected and real-time data from automatic, telemetric, manually recorded and hydrologically modelled data for early warning generation. The HSN also acquired several hydrological and hydrodynamic models, such as the Hydrological Engineering Center River Analysis System (HEC-RAS) and CREST models, in early 2012, which enabled them to provide lead times on river levels for up to 24 hours before a flood event in the study area. However, the shortage of trained personnel, coupled with the models' drawbacks, e.g. restricted flow dimension modelling, software malfunctions, and multi-variable data requirements, which affect outputs and calibration, have all affected forecasting resource availability for warning generation and, at times, accuracy (Table 1). The KIIs reveal that capacity building is a major requirement within the technical component of the risk communication process. For instance, forecasting activities are only conducted at the national level through collaborative efforts between the HSN, MSN, and NamWater. The KII, with the HSN official, reveals a need for capacity building in that they lack skilled staff for data collection and analysis and software modelling (Table 1). KIIs also reveal a need for data and information sharing among multisectoral agencies that may have the same interest and the limited and ad hoc engagement of academic institutions in the flood warning process (Table 1).

Currently, the HSN generates flood warnings based on forecasting information from the MSN and internal hydrological models [where possible], real-time river depth and flow levels, and rainfall data from internal stations and other partner organizations. In the study area, predefined thresholds for the four major tributaries *(Figure 1)* trigger warnings and alerts from the HSN. However, the coverage provided by monitoring systems does not include tributaries along the residents' homesteads *(Table 1).* Although residents conduct preparedness activities based on indigenous knowledge and skills they have obtained from collaborations with the Red Cross, the KIIs and FGDs reveal a lack of risk knowledge (i.e. risk and vulnerability assessments, knowledge sharing, etc.) activities and poor community engagement. Although the Zambezi is the most flood-impacted area, the unavailability of risk and evacuation maps is concerning. We found that the HSN does not produce the said maps at any governmental level, so this information is not included in the risk communication process (*Table 1*). Furthermore, apart from the generic nature of the warnings and alerts, the KIIs also revealed a lack of resources for the overall early warning process. For instance, sub-national governmental authorities are provided with a single landline and a megaphone for warning dissemination. However, most of these have deteriorated due to poor maintenance over the years. Officials also reported a lack of human resources, transportation, funds for preparedness and response/evacuation training and restricted mandates as major challenges in the process (*Table 1*).

Table 1. Flood risk communication gap summary

Governmental Level	Technical	Institutional	Socio-cultural
National	• Disproportionate distribution of monitoring stations • poor data availability • limitations in data collection • non-specific warnings • inadequate monitoring stations • challenges in flood forecast and early warning validation • poor data-sharing • lack of standardisation in warning formulation • inadequate technical capacity • short lead times • poor knowledge of target communities • lack of community engagement • lack of mass dissemination strategy	• a disintegrated system with several relevant players not involved in the EWS process • Poor definition of roles and responsibilities • Inadequate human resources • Centralised system • Lack of capacity of the local government to come up with its disaster preparedness and response plans • Poor budget allocation strategies • Response-driven system .	• Poor knowledge of the socioeconomic and environmental status of target communities • Written warnings are disseminated in English • Lack of warning standardisation • Warnings are not specific to the end users needs • Lack of appropriate dissemination tools/channels • No feedback loop to assess warning reach and efficacy • Lack of integration of indigenous knowledge • Lack of community engagement
Regional	• no technical capacity (e.g. monitoring & forecasting do not take place at this level) • restricted mandates • existing communication	• Inadequate human resources • Poor coordination between regional and local authorities • Lack of capacity for implementing SOPs • Restricted mandates, e.g., budget allocations	• Lack of community engagement • Lack of preparedness and response training efforts

	structures, e.g. landlines, are not functional • Lack of appropriate warning communication devices (e.g. megaphones, walkie-talkies) • Poor digital connectivity during flood emergencies	occur at the national level despite regional needs • Response driven • Poor community engagement	
Local Authority/ Constituency	• No technical capacity • Lack of communication and response equipment (e.g. mobile phones, sirens, mikes, life jackets, steamer or boat, etc.) • Poor connectivity during flood emergencies • Restricted mandates	• Lack of human resources • Lack of operational capacity, i.e. single staff member department • Lack of coordination among institutions working in DRR at the local level • Poor community engagement	• Lack of community engagement • Lack of feedback loop to determine whether all vulnerable groups receive warnings

4.1.2. Institutional component: Flood risk communication and flood warning decision-making

Following the HSN's generation of the flood warning, impact-based communication relies on effective institutional coordination among relevant multisectoral and multi-level stakeholders. These include an assortment of governmental institutions, NGOs, the private sector, and community organizations and members. This component is responsible for early warning translation from technical to layperson language and warning communication decision-making.

Upon the HSN's generation of the flood warning, the information is sent to the Directorate of Disaster Risk Management (DDRM) for validation and then to the MICT for further dissemination to relevant authorities and target communities through radio and television. In its capacity, the HSN shares rainfall and river level information for monitored rivers and tributaries through its website and email-dispersed bulletin, which comprises a group of subscribers interested in the information. The MSN also shares rainfall data on its website, whereas the MICT disseminates information only through radio and television media. Mass dissemination through telecommunication networks is currently an unexplored avenue. *Table 2* represents flood advisory information mediums from governmental institutions. During the rainfall season (October to March), the HSN provides weekly updates on rainfall and surface water level progressions and daily and twice daily for medium to heavy rains. Real-time river-level for major tributaries can be found on the HSN's website during flood emergencies. This supports river monitoring initiatives and early action and response decision-making at the basin level. The MICT disseminates warning messages to relevant authorities and to radio and TV stations for further dissemination. The MICT has also placed a single toll-free telephone in each constituency, which is used for communicating during the rainfall season and flood emergencies. At the community level, the Red Cross has some ongoing initiatives that support warning dissemination through the use of megaphones, SMS, community volunteers and organisations, and village heads. However, their coverage is often limited as villages are very far apart, and the relevant players are not always easily reachable.

Table 2. Summary of existing governmental dissemination channels

	Method	Communication medium	Frequency	Recipients	Percentage of FGD participants with access
1	Flood bulletins	Phone, email, media	Daily during the rainfall season	Regional offices, municipalities, DRR institutions, subscribed recipients, private sector	3%
2	HSN written warning message/circular	Email, phone	Disseminated during flood situations when rainfall reaches and exceeds threshold level	DRR institutions, municipalities, private sector, media	0
3	River and rainfall watch	HSN and MSN websites, email, phone	Hourly	DRR institutions, private sector, General public	3%

4 Real-time data; information on major rivers	HSN website, email, phone	Hourly	Directorate of DRR, municipalities, emergency respondents	0
5 Weather forecast information and the likelihood of heavy rain	FM radio, television, daily newspapers	Daily	General public	29.5%

Furthermore, regional and local authority officials expressed their concerns that residents may be unable to interpret the scientific terminology in the warning messages. This often creates confusion when communicating flood advisories (varying warning filtering, translations, and interpretations) and resultant responses *(Table 1.)*. The KIIs revealed that the government is unaware of the extent of the reach of flood alerts and whether they have been impactful during flood emergencies. Communication is mostly one-sided, with communities serving merely as recipients without a feedback mechanism. In addition to pointing out issues with digital connectivity during the rainfall season, wind and rainfall damage to power lines and the blockage of roads brought about by high water levels have also posed a major hindrance to flood information communication and dissemination. The KIIs also pointed out the need for DRR personnel at regional and subsequent government levels *(Table 1)*. The HSN currently has one employee at regional and local authority levels, with whom information is communicated for dissemination. Monitoring and forecasting is done only at the national level. This causes delays during the rainfall season, where forecasting and monitoring are required 24/7 for real-time updates *(Table 1.)*.

In terms of decision-making after the MICT disseminates warnings. The regional governor is officially mandated to liaise with officials at the constituency and local authority levels for further dissemination to the public. Local authority officials are required to liaise with the government-founded Community Disaster Risk Management Committees (CDRMCs), NGOs and community leaders for further dissemination. Local authorities are also required to use megaphones, MICT-sponsored telephones, and any other means to disseminate warnings. However, both the KIIs and FDGs revealed the unavailability of resources (i.e. megaphones and vehicles), lack of Standard operating procedures (SOPs) at subsequent governmental levels, restricted mandates, and the unavailability of certain structures (i.e. CDRMCs) as additional hurdles to warning dissemination *(Table 1.)*. Regional, Constituency, and Local Authority KII respondents highlighted the significance of preparedness. Still, restricted budgets and mandates (inability to issue warnings prior to verification and dissemination from the national level) have significantly set back these efforts *(Table 1)*. The need for personnel was also emphasized in this regard, as each administrative level is represented by a single DRR official, which significantly disrupts the communication chain in case of resignations, departmental transfers, etc. *(Table 1.)*. Although the development of SOPs, budgeting, and resource activation should be decentralized to all levels as outlined in the Disaster Management Act (DMA 2012), both the KIIs and FGDs reveal that this is not the case as institutional capacities are lacking in several areas at sub-national levels *(Table 1.)*. The centralized nature of the warning system limits preparedness activities such as awareness raising, evacuation drill training, and even response protocol activation, affecting the last mile of early warning communication *(Table 1.)*. According to the DMA of 2012, the head of the local authority DRMC is expected to communicate flood information and warnings to the Community DRMC for further dissemination to village heads and subsequent communities; however, the KII's and FGD's reveal that these structures are currently non-existent *(Table 1.)*. The study also found that communication structures are primarily vertical (top to bottom), with no official horizontal structures or information sharing at subnational levels *(Table 1.)*.

4.1.3. Socio-cultural component: Efficacy of warning dissemination

The KIIs revealed that due to the lack of a feedback loop, governmental organizations were unaware of the extent of the reach of issued warnings *(Table 1.)*. Furthermore, the lack of knowledge decision-makers have about the target communities also reveals poor knowledge of whether communities can translate or interpret flood advisories and warnings disseminated by the HSN, MICT, and MSN for effective early action and response *(Table 1.)*. Both the KIIs and FGDs also revealed that the warning alerts and modes of communication were inadequate for the target communities (i.e. official warnings and advisories are not tailored to the target communities, and the sources of information do not cater to the rural construct of the target communities) *(Table 1.)*. As such, engaging local communities in collaborative communication systems design would benefit preparedness and response significantly. The FGDs revealed that although communities have taken the initiative and possess internal systems and networks for flood information sharing, warning dissemination, preparedness and response action, these systems are not integrated into the formal system *(Table 1.)*. Although several FGD participants consider radio a popular source of flood information, residents were unaware of the formal flood warning system, how it could serve them, and where to gain access to flood information other than the radio. Poor community engagement and a disregard for the varying social norms and customs of target communities in flood warning were further highlighted by governmental organizations' lack of vulnerability, risk and evacuation route mapping *(Table 1.).* Several studies have emphasized the relevance of social capital in building and strengthening community capacities to forecast, respond and adapt to flood impact. However, at the community level, the study found that the flood early warning system lacked public awareness campaigns, including initiatives that drive preparedness and response, such as local institutional building, networking and social mobilization *(Table 1.).*

4.2. Capacity Assessment for Effective Early Action

According to Buchanan-Smith & Davies (1995), the influence of external factors, i.e., economic, spatial, social, ideological, technical, political, institutional, etc, has long been recognised as drivers of hazard risk communication and warning. As such, if these factors guide disaster communication, it is only fitting that they simultaneously influence community access to information and household response. However, the inclusion of these factors has often been disregarded, especially in third-world countries. The Kabbe Constituency possesses several livelihood capitals that can be used to positively contribute to effective early warning communication and, as a consequence, impact-based early action and community resilience. The study assessed the area's innate environmental, economic and social capacities to evaluate the appropriateness of the existing communication strategy within this rural context. In their interactivity with broader systems, these capacities can define a community's access to information and warning dissemination and strengthen or erode its ability to respond effectively and build resilience against flood disasters. *Figure 3* presents a situational map of the different factors that influence risk communication and overall flood early warning system efficacy. The diagram presents a simplified view of the interactivity between the social, environmental and economic livelihood capacities, the operations of the Early Warning System and natural phenomena that influence flood risk and communication. The situational map assumes that effective DRR planning considers the robustness of each of these variables, including their individual performance, diversity and redundancy. In this instance, the effects of the different variables can be predicted by assessing how individual indicators (e.g. precipitation, assets, education, etc.) can contribute to or diminish effective risk communication. The overlapping circles indicate the basic interactions of the different systems with each other, how they influence each other and, as a result, how these interactions influence flood risk, risk communication and strategy development simultaneously. The sub-sections present the identified capacity indicators influencing flood risk communication and bridging the last mile. Shortcomings in the community's capacity can be considered conduits for participatory system enhancements by tailoring service delivery to community capacities and needs.

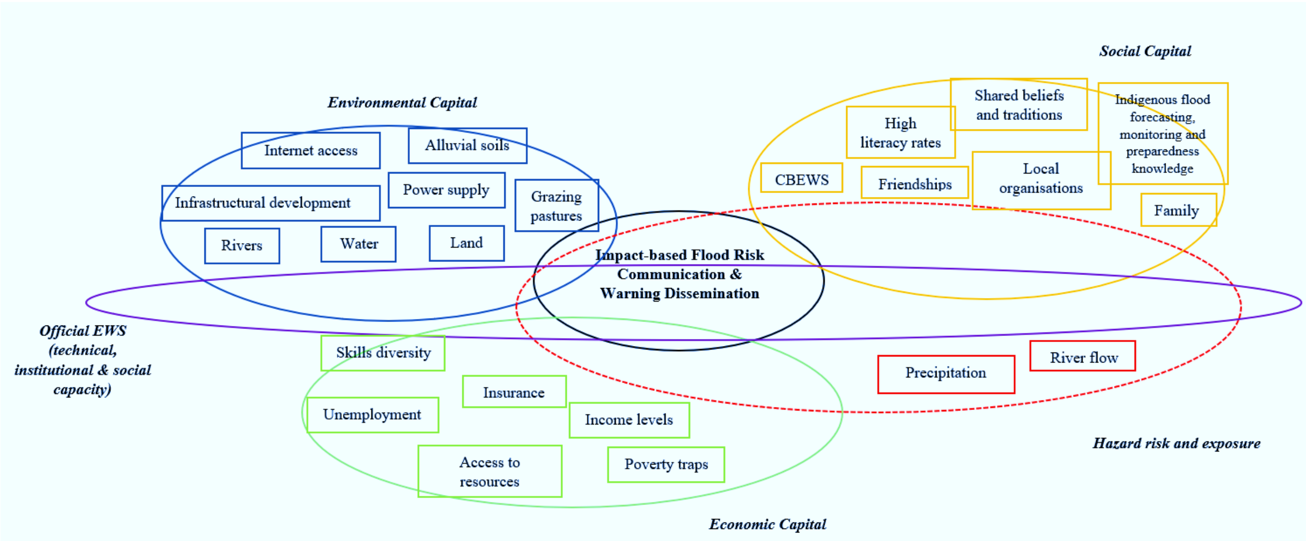

Figure 3. Situational map of the different components affecting flood risk communication and warning dissemination

4.2.1. Environmental Capital

As an area entirely structured on a floodplain, land, water, and woodlands represent the origin of resource flow and the environmental capacity of the study area. Consequently, the majority of the population in the area (87%) (Namibia Statistics Agency, 2011) rely on land and watercourses for their livelihood through farming, fishing, and tourist activities. Land-use changes, woodland resources, and surface water availability influence flood resilience in the area. Based on the study findings, approximately 69% of the FGD interviewees depend on land and watercourses (rivers and wetlands) as sources of income and recreation. The majority (81%) of the FGD participants owned inherited land, whereas the remainder lived on family-owned plots (17%) or land acquired through traditional leaders (2%). As a result of their customary living and the benefits derived from the natural environment, many FGD participants (96%) consider the floodplain to be their ancestral land and refuse to resettle elsewhere, demonstrating the attachment residents have to the area *(Figure 4)*. Furthermore, a majority (66.5%) of participants refuse to relocate to higher ground, while others (13 %) temporarily relocate to secondary homes or relatives in the uplands during the wet season *(Figure 5)*. The FGDs and physical observation both revealed the rich environment of the study area in terms of grazing pastures, alluvial soils, land, rivers, and, as a consequence, wet-proof structures, ethno-based warning systems and innovative fishing and farming techniques during the wet season that assist in flood preparedness and recovery. The study also found that the benefits derived from the environment strongly influenced the risk and vulnerability perceptions of community members, as many (80%) agreed to prefer to focus on the benefits of the floods and not on the devastation caused during a disaster.

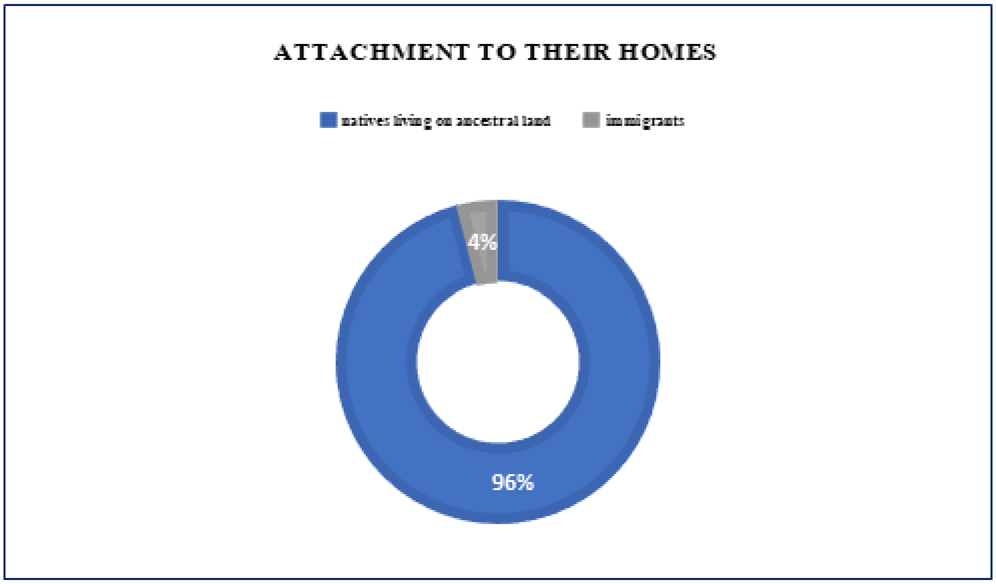

Figure 4. Percentage of residents 'attached' to the floodplain

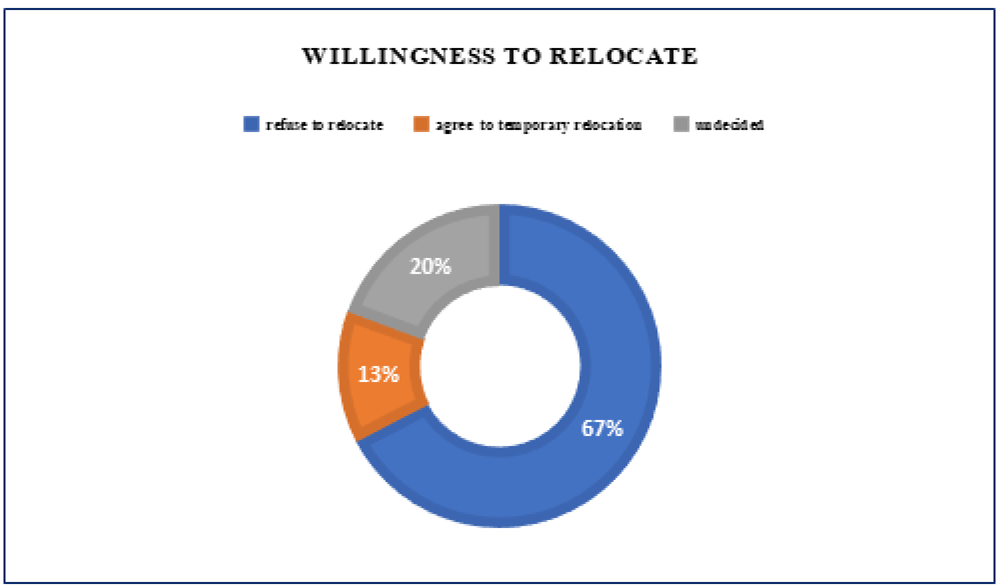

Figure 5. percentage of residents willing to relocate from he floodplain

Contrary to the rich nature of the floodplains, the study found the area's built environment to be significantly poor. For instance, although all the FGD (100%) participants owned a home, very few (37.5%) owned structures built with concrete, and all had no insurance coverage. Moreover, the lack of public transportation services in the area, underdeveloped and limited health facilities, and the absence of tarred roads can significantly influence warning and response activities, including information dissemination. The study found that in the incidence of a flood, very few FGD participants (16.5%) had access to physical safety structures, i.e. schools, libraries, community halls, communication facilities (15%), powered electricity (11%), water supply and sanitation (10%) and health facilities (3%).

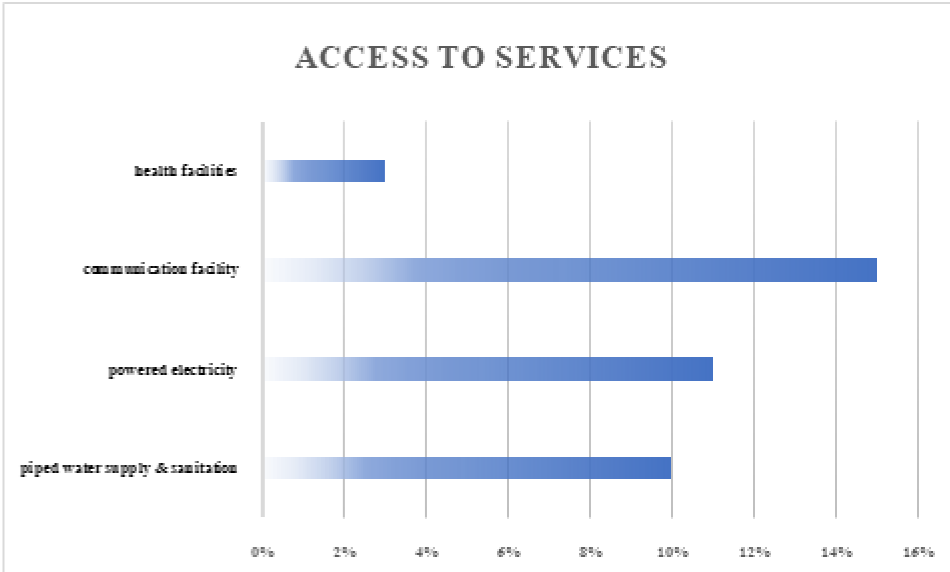

Figure 6. Percentage of residents with access to basic services during a flood emergency

Table 2 presents the percentage of households with access to available HSN communication sources based on the FGD responses. However, all FGD (100%) participants admitted to practicing traditional forecasting (i.e. observing the migration of red ants, birds, fish and wildlife; frothing in rivers, increase in the 'sound' and speed of the flow of river water, concentric rings around the moon, blooming of certain plants, change in the color of river water and the filling of smaller tributaries) and adaptive and absorptive preparedness strategies (i.e. building of raised homesteads and poultry cages before the wet season; building tunnels and concave reed walls around homesteads to divert water, planting early maturing crops, store dried food during dry months etc.) during the wet season. Flood risk information sources include community organizations (e.g. CDMCs, village messengers and social groups) (70%), radio (29.5%), television (29.5%), newspapers (29.5%), social media (14%), and verbal public announcements (82%) *(Figure 7)*. Although not many FGD participants had access to electricity, many owned mobile devices (52%), which they use to share warning, forecasting and monitoring information among themselves.

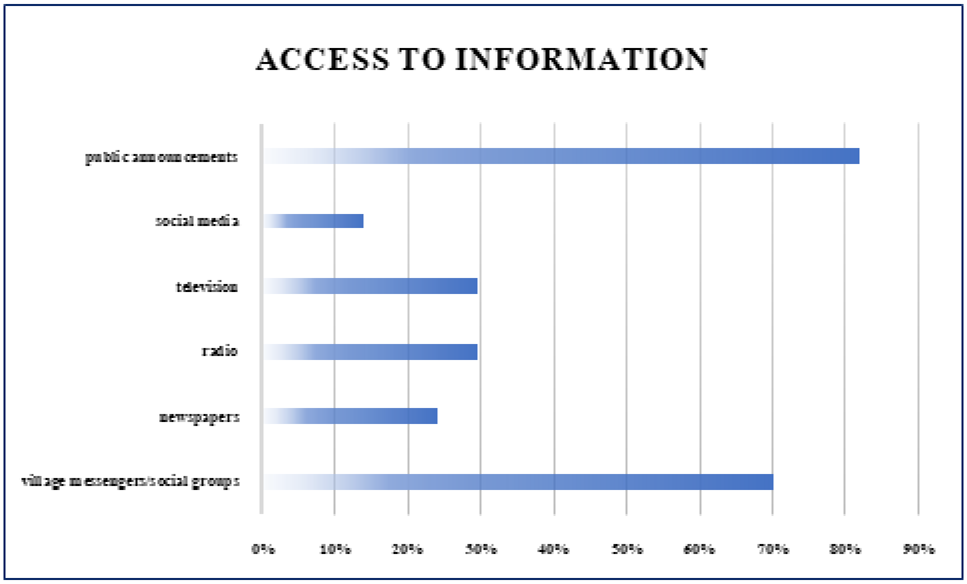

Figure 7. Accessible sources of flood risk information

4.2.2. Economic capital

Although the benefits from the natural environment and floods have been extensively covered in Kabbe, the area is considered to suffer from chronic poverty. Approximately 50% of the population lives below the upper poverty line, largely due to poor economic development in the area (National Planning Commission, 2015). Moreover, although the study found the workforce profile to be quite extensive for the study sample *(Figure 8)*, i.e. communal farmers (44.5%), fishermen (11%), professionals (13.5%), arts and crafts vendors (10%), tour guides (3.5%), and small business owners (6%), the household income range was found to be quite low with only 20.5% of the participants earning upwards of NAD 4 000.00 (USD 218.90). Due to their dependence on the natural environment as their primary source of income, many residents in Kabbe cannot generate enough income to withstand the impacts of atmospheric shocks(Namibia Statistics Agency, 2011). Many youths attempt to move to more developed areas or neighboring farms in the region in search of employment opportunities, which are often limited and pay poorly because of the poor economic investment in the area and high national unemployment rates. However, many FGD participants own assets in the form of natural resources, i.e. poultry (96%), livestock (81%), farmland (60%), land (81%), vegetable gardens (90%), which farmers often barter during flood season to curb food shortages. Many communal farmers have also adopted mixed farming techniques, which in many cases involve share-farming whereby cattle farmers may lend their animals to poor households for draught power and fertilisers for crop production in exchange for human labour or harvest share. Furthermore, community better-offs often share foodstuffs with poorer families or exchange them for manual labour, e.g. planting, weeding, harvesting, ploughing and threshing on their farms.

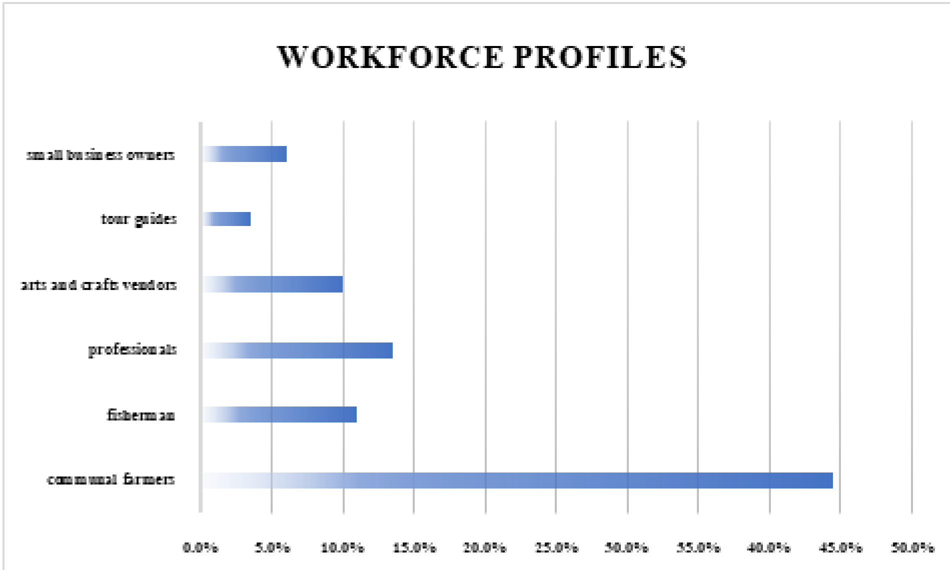

Figure 8. workforce profiles observed in Kabbe

4.2.3. Social Capital

Notwithstanding the economic and environmental challenges that disadvantage many residents in Kabbe, social capital is copious and inventive. This includes formal and informal connections, networks, community organisations, safety nets, social networks, relationships, and trust that people draw upon daily. These include the collaborative Red Cross-established Community Disaster Risk Management Committees (CDRMC), which are primarily responsible for flood risk reduction activities in different communities, volunteer groups that assist in warning dissemination and response action and community feeding schemes that streamline household self-sustenance and risk reduction projects by providing them with food. The study found that the majority of the FGD attendants belonged to at least one village organisation, e.g. fishing groups (11%), farmers associations (52.5%), church committees (24.5%), and village committees (60%) and most liaised with each other regularly. The study also found that approximately (47.5%) of FGD respondents considered these social networks their primary source for flood information and warning, while 100% agreed that it was a popular secondary or tertiary source.

The study also found low migration levels (0%), shared religious and customary beliefs (100%) and similar flood prediction, preparedness, and monitoring practices (100%) to be strong drivers of social capital. In addition to enhancing social cohesion and flood preparedness, flood information-sharing among village dwellers ensures that community early warning systems are activated on time and communities are on high alert to monitor water levels and river flow patterns. Some demographic indicators included a high level of FGD participants (72%) who completed their junior secondary education, many (81%) speaking English as a second language, and a majority (96%) demonstrating a willingness to assist neighbours during a flood emergency. The high level of trust, consideration, and social cohesion among residents, built on years of friendship and familial relations, provides an environment where residents rely on each other, engage with one another, and exchange knowledge, skills, and expertise for dealing with flood risk. Regarding warning interpretation, although most FGD participants speak and read English fluently, many (preferred to receive messages in their native language (56%) agreed to not being able to understand scientific terms felt that and agreed that simple instructions on water level information, what do and how to prepare based on the expected magnitude of the flood would suffice.

5. Discussion

Adopting a situational analysis approach to assess flood risk communication in Kabbe allowed this study to redefine system efficacy as an integrated strategy requiring the prioritisation of local communities. According to Howard et al. (2017) and Henly-Shepard (2019), a community's socioeconomic and environmental construct influences preparedness and response and is essential to building resilience. Therefore, these factors must be considered when planning and developing risk-reduction strategies for target populations. Social capital, i.e., community organisations, social networks, trust, willingness to help, and community-based early warning systems, defines resilience in Kabbe, demonstrating that resilience is in itself contextual. The situational analysis focused on the different interactions between flood risk, formal EWS capacity (technical, institutional, and social), and community capacities (social, economic, and environmental) and how they influence flood risk communication in the study area. The study first assessed the communication structure of the EWS to identify challenges and good practices within the system. Thereafter, we assessed risk communication from the community perspective and identified absorptive and adaptive capacities that assist communities in addressing flood risk in their capacity. This demonstrated that although risk communication is top-down and not community-centred, residents are not merely passive warning recipients. The study identified several community capacity indicators from which the national EWS could benefit by encouraging community participation and prioritisation, especially at the local government level.

Despite the HSN's efforts to acquire and transmit relevant and extensive real-time data through collaborative monitoring strategies with the MSN and NamWater, the study revealed that the inadequacy and uneven distribution of existing hydrometeorological stations along minor tributaries have hindered these efforts. Early warning communication is often delayed by the lack of data from streams and tributaries close to inhabited villages, resulting in elevated losses. These findings correlate with those of Sharma et al. (2018), who reported increased human and property losses along smaller tributaries in Chure, Nepal, during the 2017 monsoon floods. This indicates the need for the HSN to shift its focus from quantity to quality by placing stations and prioritising monitoring at relevant locations along inhabited tributaries. In addition, the system was found to be highly bureaucratic, with decision-making taking place at the national level, a lack of countrywide dissemination of warning messages via popular and spatially appropriate methods such as SMS, and messages not tailored to the target community's location. Warning messages were found to be generic, informing residents of expected rainfall levels and the possibility of floods with poor directives on preparedness and response. Other observable factors contributing to the gap in risk and warning communication include the residents' lack of knowledge of the formal EWS, irrelevant communication mechanisms, and poor accessibility to warnings disseminated from the national level. These were all found to be consequences of community exclusion at various significant stages in systems development and operations.

Risk communication is widely understood to be a two-way process (Sayers et al., 2015). However, the study found that end-users are disregarded as custodians and first respondents of disaster, and messages are generated and communicated in a top-down manner, with end-users as mere recipients of warnings. At the national level, the study found that although the communication structure was more clearly defined in contrast to those at subsequent governmental levels, the system lacks a feedback loop. This indicates that decision-makers are unaware of the extent of the reach of disseminated warnings and lack insight into whether communication methods are attenuated to end-user needs and whether communities understand and can appropriately respond to warnings. To address this gap, local government and partner agencies must develop strategies for integrating target communities' social, economic and environmental capacity information and end-user feedback information to complete the communication and provide appropriate policy formulation and system enhancement information (Chapman et al., 2003).

According to Demeritt & Nobert (2014), effective risk communication often requires multi-level capacity building, which ensures that warning messages are not only disseminated on time but also appropriately contextualised (i.e. clear, concise, and easily understandable). As a consequence of factors such as risk perception, isolation, spatial location, availability of communication channels, literacy, and social networks, end-users have varying access and understanding of warning information (Nygren & Zeidlitz, 2020). The current system requires capacity enhancement by administering participatory preparedness initiatives, awareness-raising campaigns, and appropriate end-user warning response training. Although risk is communicated in the local language via radio and television media, most residents do not have access to these devices. As such, more appropriate methods, such as knowledge products in the form of illustrations, posters and enactments, have a better chance of reaching more residents. Additionally, strategic communication protocols executed by defined actors and robust communication infrastructure are essential to effective risk communication. Therefore, local authorities should collaborate with other DRR organisations and engage communities to co-develop appropriate communication infrastructure and information and education materials.

Although the Disaster Management Act 10 of 2012 stipulates that guidelines and Standard Operating Procedures (SOPs) for early warning response should be developed at all governmental levels, these policies were found to be lacking at all sub-national levels. This indicates the absence of any strategies to improve EW communication, such as tailoring warnings to end-user needs, increasing information access to risk and warning information through the use of appropriate communication tools, identifying and eliminating congestion on information sources, improving lead times on warnings, etc. Furthermore, communication between local authorities needs bridging to ensure collaboration between the formal EWS and community-based systems. Local institutionalisation of community-based systems connects them to the national systems, which can improve overall system efficacy. The formal systems can benefit from community-based systems in that the latter can address the human factor of early warning by catering to divergent individual end-user needs, improving lead times on warning by providing real-time reports from monitoring groups, and providing directives for decision-making and relevant early action.

Moreover, community-based systems are often a product of NGOs and target community partnerships. Many activities essential to the early warning process, e.g. risk mapping, vulnerability assessments, knowledge sharing, response drills, evacuation training, etc., are discontinued when funding is withdrawn. Providing platforms for merging formal with informal systems thus presents a mechanism for capitalising off the skills and knowledge provided by these projects. It ensures sustainability and continuation without the national government bearing initial costs.

The study also found that early warnings failed to address social issues. A study by Snel et al. (2019) found that formulating end-user-specific warnings resulted in higher system efficacy as it caters directly to the needs of various groups within target communities, including women, children, people living with disabilities and other vulnerable groups. The varying levels of individual risk, vulnerability, hazard perceptions, and economic standing within target communities influence how individuals prepare and respond to warnings. As such, several authors advise against adopting a ‘one size fits all’ approach to warning formulation and dissemination (Cole & Murphy, 2014; de Boer et al., 2015; Howard et al., 2017). At present, the system lacks a verification mechanism that ensures warning information reaches the most vulnerable groups within the target communities. Moreover, with a lack of policy-backed communication strategies, it is unclear how the government plans to ensure effective stakeholder participation to ensure that the needs of marginalised groups are addressed as per the Disaster Management Act, 10 of 2012.

The study revealed that creating platforms for community participation at the constituency level could assist in developing needs-based infrastructure and risk knowledge programs that can significantly improve governmental and community response capacities. Furthermore, residents’ knowledge of previous flood disasters can be incorporated into designing and implementing evacuation plans and drills, further strengthening response capacities. Empirically, response capacities can only be tested during the occurrence of an actual hazardous event. As such, authors like Auliagisni et al. (2022) and Sayers et al. (2015) encourage the use of past experience to guide the development of contextually appropriate strategies that build local awareness and consider the socioeconomic and environmental contexts of the target communities, thus bridging the last mile.

The study presents a limitation in that the results are based on the experiences and perceptions of residents from a single constituency, Kabbe. To allow for large-scale impact-based system enhancement, similar assessments that capture other dimensions of flood preparedness, i.e. political, evaluate the efficacy of the identified Indigenous coping and adaptation strategies and the extent of flood impacts and identify additional social, environmental and economic indicators for resilience assessments will need to be applied on a wider scale to improve the methodology. The recommended research will serve to accumulate baseline data that can be used to develop appropriate risk reduction strategies in flood-prone communities.

6. Recommendations

By assessing early warning communication based on the process overview provided by multi-level flood DRR officials and the views and opinions of individuals living in high-risk areas, the study developed a 'picture' for guiding effective flood risk communication. Although the HSN and MSN provide flood risk information (albeit through similar means), at present, dissemination requires significant improvement. It appears that the dissemination of appropriately contextualised information endeavoured to assist target communities in better mitigating and responding to risk is inadequate. Furthermore, the EWS was found to be highly centralised, excluding several valuable players, thereby negating the multidimensional nature of the risk communication process while simultaneously disregarding the unique construct of the target communities. The study participants observably possessed great knowledge of flood risk and were often prepared based on information from community-based sources, e.g., volunteers, CDMCS, flood monitoring groups, community networks, etc., without governmental involvement. Overcoming this divergence will ensure effective dissemination and response from individuals and communities alike. By analysing the influence of systems operations and community capacities to assess risk communication efficacy, a sizeable scope of guiding recommendations for strengthening the system emerged. These are summarised as follows.

6.1. Develop and raise awareness of current flood information sources

In addition to indigenous knowledge and practices passed down through generations in target communities, the study revealed a multiplex of information reservoirs (both practical and theoretical) that can aid flood risk communication and, consequently, appropriate preparedness and response. Organisations such as the Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Ministry of Environment and Tourism (MET), National Commission on Research Science and Technology (NCRST), and Research and Information Services of Namibia (RAISON) that provide services relevant to DRR work (e.g. risk mapping, risk information, research outputs, climate and hydrological information etc.) and can serve as important sources of information to early warning operations and target communities were found to be completely disintegrated from the system. Based on the study's evidence, poor collaboration can be credited to the lack of a multisectoral strategic approach to DRR and the bureaucratic nature of the system that fails to prioritise communities. Identifying, integrating and raising awareness about the varying sources of information, e.g. organisations, brochures, websites, knowledge-sharing campaigns, etc, provides a conduit to assist target communities in addressing flood risk more appropriately, given that it is more likely to influence self-motivated behavioural changes. Local authorities can collaborate with NGOs, the private sector, local organisations, and community leaders to create programs and platforms for raising awareness. The study identified several contextually appropriate methods for endorsing the available information sources, including the use of mass media (newspaper, radio and television), telecommunication services (mass SMS dissemination by collaborating with local service providers), distribution of information brochures via local access points, e.g. police stations, health clinics, schools, council offices, community centres etc. Furthermore, message resonance can be strengthened by scheduling awareness raising for these information sources to concur with the anniversaries of previous floods or periods before the rainfall season.

6.2. Build on existing knowledge and data systems

The existing reliance on technological-based information systems subverts the existence of abundant and valuable information networks, especially in developing countries where access to electricity, technology, and the internet is limited. However, experience reveals that even the most basic and cost-effective systems can be effective. Often founded on existing databases with modest data collection practices, i.e. manual recording and real-time observation, they can still furnish specified information to target audiences that inform impact-based decision-making. At the local level, governments can exploit these systems by merging them with formal systems and supporting local data systems (e.g. providing tools, materials, equipment, training and volunteers, etc., to support local data collection and information management systems, monitoring initiatives, and information dissemination efforts). This will ensure continuity and compensate for instances when technology may fail. Some opportunities identified towards this end included identifying data and information sources and expanding on them using existing resources and agencies, fostering opportunities and developing platforms for multisectoral knowledge sharing and information exchange, decentralising data and information management by expanding on sub-national systems and exploring the possibility of infrastructural development to increase internet availability, e.g. telemetric stations, connectivity towers, internet linked radio stations etc., in target communities.

6.3. Institutional capacity building

Effective risk communication and the overall early warning process will require significant capacity building on all levels. At the national level, adequate amounts of skilled personnel, appropriate technologies (i.e., flood modelling software), multidisciplinary information-sharing between intergovernmental agencies and the private sector and defined operation standards are required. The same is required for sub-national capacity building in the form of developing both institutional and technical operation structures to allow for forecasting, monitoring, knowledge sharing, risk communication and warning dissemination at these levels. Developing data and information-collecting systems at the local level will serve to link target communities to relevant authorities. To this end, the study found that DRR strategies would benefit greatly if governments ensured that local staff are qualified experts and are granted the authority to spearhead risk reduction efforts at their administrative levels. This would provide an objective lens or more appropriate perspective for overall DRR governance and strategy implementation. Capacitating local authorities with the necessary skills and mandates would mean that more strategic approaches would be adopted to address hazard risk (i.e. the development of recommendations and plans that outline contextually appropriate DRR plans, including technical and infrastructural needs); communities will be prioritised, monitoring and evaluation at the local level will ensure that any possible challenges are addressed before causing significant damage, and in cases where funding is inadequate the most critical activities will be prioritised. In the case of Kabbe, the study found that many of the officials were not DRR experts, which in part explained why they viewed communities as mere warning recipients.

6.4. Develop knowledge-sharing partnerships

Although the current EWS is characterised as centralised, with information generated, packaged and passed down from the national level, communication flow in this direction is lagging. The horizontal flow of information is poor in that several relevant stakeholders (see 6.2 above) are omitted from the system. Effective risk communication and warning dissemination require balanced horizontal and vertical communication, which allow for feedback loops that provide authorities with the necessary information required for the development, implementation and 'quality control' of communication systems, allowing the swift identification and neutralisation of any unexpected gaps. By providing multi-level platforms, either through workshops, skills development training, public inquiries, etc., for multidisciplinary knowledge exchange, the government can develop community knowledge partnerships to tackle poor connectivity and information literacy issues and integrate practical local solutions and knowledge that directly benefit target communities. This strategy can replace the outdated 'top-down' information 'supply' approach to a participatory system with two-way communication at every level.

6.5. Formulate clear and concise risk, preparedness and warning messages tailored to end-user needs

Although risk communication is based on a complex relationship of individual risk perception, situational, affective and cognitive factors, literature reveals that the average person's thought process is binary (i.e. a flood will or will not occur), which highlights the necessity of clear, concise and easily understandable risk messages tailored to the end-users needs. Despite the situational high literacy levels in the study area, those with access to official information sources could not interpret many scientific and probabilistic terminologies used to communicate risk, hence the preference for local sources. The study found that employing non-technical personnel to formulate clear, concise and targeted risk messages tailored to end-user needs may better convey risk information to these communities. Relating expected flood magnitudes, impacts and outcomes to previous flood events through audio narrations, visual reenactments, and imagery can also be useful in generating appropriate actions. Some initiatives identified to this end include engaging and collaborating with community focal persons and groups, NGOs and all relevant stakeholders to develop materials (i.e. pamphlets, plays, songs, radio excerpts etc) and use the local language and appropriate methods (i.e. radio, face to face meetings, private-public FGDs) for information exchange, create feedback loops (e.g. places, websites, toll-free numbers where residents can provide information and make inquiries).

6.6. Clearly define institutional roles, responsibilities and boundaries for information sharing and ensure public awareness

Flood resilience is often a consequence of high levels of preparedness. The study revealed high levels of preparedness among community dwellers, which stemmed from their knowledge of their high-risk environment and past flood experiences. This highlighted the innate ownership communities have of flood risk and their acknowledged responsibility to mitigate risk without simply relying on or delegating it to authorities. Although officials acknowledged the need for improved community engagement, a strong willingness for collaborative action to improve flood risk communication and reduction was observable among members of the public (i.e. FDG participants). This was quite surprising given that EW systems should be community-centred and that, other than a good understanding of the use of emergency services during a flood emergency, the roles and responsibilities of authorities in the process were relatively unknown to the public. Therefore, a clear definition of policy-backed individual, community and institutional roles, responsibilities and boundaries should be publicised (using contextually appropriate platforms such as those mentioned in section 6.5) to promote effective risk communication and develop effective flood DRR partnerships. Once these roles have been clearly defined and engraved within the consciousness of the target community, a further recommendation, which is the dissemination of flood preparedness information and the benefits thereof, can now be easily implemented. Using the same platforms to continuously publicise sources of information, residents can access this information through previously mentioned access points (see Section 6.1) (i.e. police stations, schools, community halls, etc.). Furthermore, though the study area is quite underdeveloped, the use of social media for mass information dissemination was also suggested, as many residents have relatives with access to the internet and cell phones in the more developed areas in the region, and others commute to the city daily where they may gain access to this information, and by collaborating with local authorities and NGOs, volunteer groups may be provided with the tools to access this information to disseminate within their communities.

6.7. Ensure equitable access to information

Although the rapidity of information transfer over long distances has rapidly increased over the past decade, evidence of its inaccessibility to all has been equally observable, highlighting existing social, environmental and economic disparities. Although individuals in the case study area had very similar socio-cultural backgrounds, communities are often heterogeneous and made of individuals from various social, economic, demographic and environmental profiles. These factors influence the channels through which end-users can and would prefer to receive risk communication. Cellular phones and radios are more accessible in the study area. A recommendation is, therefore, that national and local governments use multiple appropriate channels to ensure that flood risk information is extensively disseminated and bridges the last mile. Although advances in telecommunications technology have provided an extensive scope of social networks that can be used to this end, these are not always appropriate, especially in rural areas with little infrastructural development (e.g. inadequate powerlines, no internet services) and a vast minority owning smartphones. However, mass dissemination can still be achieved within this context by issuing internet-based information via SMS through telecommunication providers (governments can collaborate with service providers to aid in disseminating risk information at selected times), by distributing flyers at local community clinics, schools, and police stations, by using internet-linked community radio stations with a publicised flood information 'news' schedule and by enlisting trained community volunteers.

6.8. Develop communication links between authorities and the public

In any successful early warning system, communication channels must be established between relevant local DRR authorities and the public to ensure a people-centred approach. These will allow the integration of local flood knowledge and mutually beneficial participatory preparedness and response training efforts that would otherwise be impossible. Although such channels are encouraged in the Disaster Risk Management Act 10 of 2012 and the Disaster Risk Management Policy (2009) and were observable between communities and the Namibia Red Cross, communities have no direct link to local DRR authorities. However, some have reported sharing or inquiring with the regional officer about flood information in their personal capacity. Creating a direct link between communities and authorities leads to positive interactions and dialogue between relevant stakeholders, building trust. This can be achieved if local DRR authorities participate in or contribute to the development of community development organisations, engage and collaborate with existing ones and host public information-sharing events.

The Section 6 recommendations are considered essential to improving flood risk communication, and their flexibility makes them adaptable to other hazards. Moreover, they do not only apply to the study area but are transferrable elsewhere.

7. Conclusion

Although a global consensus to place communities at risk at the centre of early warning systems from the policy development to implementation stages has been reached, the same is yet to be empirically realised. This is particularly evident in developing countries in Africa where the adopted technocratic strategies have resulted in 'supply type' systems where DRR authorities serve as suppliers of risk information and target communities are viewed as passive receivers, not as the primary respondents to hazards. As a concept, effective risk communication and the resultant strategies are influenced by an extensive body of political, environmental, scientific and social disciplines pervaded by knowledge relations. Failure to consider these distinct dynamics in characterising risk communication can result in conflicting recommendations on what the process should entail.

In that regard, the case of Kabbe, detailed above, is no different. Despite numerous attempts to improve flood forecasting and impact-based warning through technical improvements and several partnerships with local and foreign agencies, shortages in data and the resultant poor risk analysis have hindered several stages in the EW process, including, perhaps the most important- risk communication. The sustainable early action risk communication framework (Figure 2) adopted in this study views risk communication as a multidisciplinary and integrated process centred around the target community's needs. It is based on the principle that effective risk communication is a product of a robust system of interconnected activities and that any disconnect at any point within the system hinders its efficacy. On the technical front, while the HSN seeks to significantly improve warning generation by increasing data collection stations and securing funds for spatially appropriate flood forecast and impact modelling technology, these plans still seem far off in the future. However, several cost-effective and participatory opportunities exist to this end (e.g. collaborating with community-based groups for location-based real-time and historical data collection and information, integrating local forecasting and preparedness practices into the technical information and partnering with communities to develop appropriate communication channels). These can be exploited to improve risk information dissemination and ensure that the most vulnerable groups are reached.

Similarly, the institutional component of the system could benefit from substantial capacity-building, beginning with a well-publicised, transparent and policy-backed definition of roles, responsibilities, and service remits for relevant EWS stakeholders at all governmental levels. A clear definition of roles would foster the development of relevant collaboration networks and strengthen coordination, especially at regional and local government levels. Open access to information is directly correlated to personal freedom, and the more aware the general public is of their information rights, the easier it will be for them to communicate their needs. This can serve as a conduit to ignite and strengthen a sense of community within government- tailoring information to end-user needs and developing a sense of responsibility in target communities to collectively consolidate, coordinate, and appropriately communicate their needs. Risk communication strategies require two-way information flows to positively exploit these opportunities, thereby developing new and strengthening existing institutional structures. Effective flood warning dissemination will also require appropriate budget allocations and expanding institutional DRR portfolios from single staff members to departments with increased qualified personnel serving in that capacity daily. Based on the empirically-backed study findings, warning dissemination among institutions is often hindered by poor digital connectivity, e.g. breakdowns and disruptions of communication networks, damage to powerlines and cell towers and road damage (i.e., megaphones are a form of warning dissemination). The compounding effects are that lead times are shortened, and warning dissemination reach is restricted based on the rural context of the study communities. The idea of consolidating electronic, mass media and local information systems to address persistent challenges in risk communication presents an unparalleled opportunity. The opportunity lies in empowering communities to take self-motivated, appropriate actions to protect their livelihoods by ensuring increased access to information.

The Report of the Midterm Review of the Sendai Framework (UNDRR, 2023) strongly advocates for community-centric early warning that prioritises the unique needs of target groups and their ability to interpret and appropriately respond to the warnings.

However, warning formulation and dissemination in Kabbe is not based on giving due consideration to the socioeconomic and environmental constructs of the target communities, which makes access to official early warning communication a serious challenge for many. Although individuals within communities may fundamentally share similar information needs, the meaning and relevance may differ to different groups, as many often experience diverging microenvironments. Thus, apart from ensuring that risk and warning information is clear and concise, authorities also need to ensure that language barriers are breached, information is easily understandable, appropriate communication channels are used and the most vulnerable groups (i.e., people in higher risk zones, those with disabilities, the elderly etc.). Based on this study's findings, capitalising on socio-cultural community capacities through participatory initiatives can assist in transcending many existing barriers that affect the last mile in warning dissemination. However, this can only achieved by adopting a flexible and decentralised strategy that integrates contextual diversity in information management and communication. Merging formal technocratic systems with more flexible and informal community-based initiatives at the local government level presents an opportunity to build on and capitalise off existing networks to improve the dissemination of information tailored to end-user needs.

In conclusion, risk communication has evolved expeditiously, and along with it, recommendations for research and best practice have been made (Boholm, 2019; Wardman, 2008; White et al., 2010). To bring some order to this burgeon of contrasting analyses and guidelines, this report outlines several recommendations for effective risk communication centred around community needs, prioritisation and participation. To effectuate this integration, disaster risk reduction authorities will need to devise the most appropriate mechanism, as best practices are subjective in that no single practice is a cut above the rest. From the study findings, we can deduce that although all the components (i.e., technical, institutional and socio-cultural) require significant enhancements for effective flood risk and warning communication, assessing the social, economic and environmental capacities of target communities or lack thereof to guide systems design and implementation provides an excellent opportunity to strengthen the system. By including communities in the co-development of early warning systems, governments can develop systems with appropriate communication channels that ensure the most vulnerable groups are reached, formulate messages that include risk and preparedness information, strengthen risk knowledge and build response capacities.

Furthermore, the global community and national governments need to labour tirelessly to revise policies, strategies, and practices that are bureaucratic, create institutional barriers and disregard socio-cultural diversity to bridge the last mile.

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