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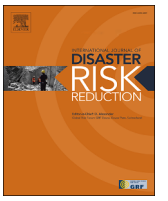

Improving flood early warning systems in Kabbe, Namibia: A situational analysis approach

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ABSTRACT

The social, economic and environmental construct of communities formulates the core of the resilience capacity paradigm, which requires great consideration when developing, implementing and strengthening early warning systems. Though several guiding principles are documented in research, no single method for assessing community resilience exists, and complexities in quantifying capacities are often exacerbated by the diversity of probable hazard occurrence, interconnections between social, economic and environmental components, and difficulty in variable selection to gather data. By implementing a situational analysis approach, this study details an exploratory investigation into the socioeconomic and environmental constructs of rural high flood-risk communities to identify capacities that may be enhanced for improved flood risk reduction through participatory early warning system approaches. The perception is that, in the face of a disaster, even the most vulnerable communities possess some resilience, and this should be exploited for effective, long-term sustainable disaster reduction. The critical question then is: what social, economic and environmental capacities are available to communities to improve early warning system efficacy while building resilience against flood risks and improving their standard of living? The study reveals multiple options that form effective conduits for tailoring flood early warning systems to the exactitude of target community needs.

1. Introduction

Understanding and acknowledging communities as intricate systems with distinct socioeconomic and environmental characteristics and dynamics has become a guiding principle for disaster risk reduction planning [1,2]. The pitfall of implementing internationally standardised early warning systems (EWS) in rural settings, disregarding community dynamics, forms a significant challenge in system efficacy. Disaster risk knowledge, preparedness, organisational response actions and capabilities, and interpretation, are shaped by socio-cultural beliefs, personal experience, sentiments and values, and economic, environmental and societal dynamics [3] which are seldom considered in EWSs development. The composite flood disaster risk interlinkages that pierce through the ever-changing domains of hazard, vulnerability, exposure and capacities formulate the amalgam of factors dictating EWS efficacy—indicating that the development of successful disaster risk reduction strategies is nearly impossible without the acknowledgement, understanding and integration of the local context [4]. Researchers like Kim and Marcouiller (2021) point out that even the most vulnerable communities possess some capacity to cope with disasters- and enhancing these capacities can equip communities to address long-term disaster needs and minimise risk.

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Rural, remote communities, especially those dependent on the natural environment for their livelihood, such as the farming communities in the Sahel, often exhibit higher degrees of vulnerability against flood hazards [5,6]. Flood early warning systems present opportunities for flood impact reduction for these vulnerable communities -achievable only if there are no disruptions in systems operations from risk detection to the emergency response stage [7]. Several studies have highlighted gaps in EWSs [8–10], emphasising that improved flood risk reduction requires tailored community-centric and participatory approaches that consider the socioeconomic and environmental context of the target communities. These systems would consider and integrate community dynamics into FEWS operations by collaborating with communities for hazard risk detection, monitoring and flood mitigation, warning communication and dissemination, facilitating and expediting emergency response planning and response [11].

Recently, several studies have focused on the unique characteristics of rural communities as a source of embedded capacities forming pathways for improved EWS operations. For instance, Kelman and Glantz [12] identified higher education and literacy levels as a community-embedded capacity that enabled them to effectively detect and respond to natural hazards. Udu-gama [13] emphasises that tailoring warning communication methods according to accessibility and relevance to target communities extends the degree of reach of warning information. Additionally, Cutter, Ash and Emrich [14] found that social capacity drives rural resilience and the socio-cultural dynamics of these communities present several benefits for preparedness, response and recovery. Johnson et al. [15] documented place attachment, trust, cohesive efficacy, income diversification, access to communication technologies and positive human-environment interactions as capacities against flood hazards in rural communities.

The inadequate political, social, and economic resources available to governments in the global south tend to compromise DRR planning. As such, FEWSs implemented in most developing countries tend to be technocratic, inadequately financed response-driven efforts that result in unpreparedness and poor emergency response against floods [16]. With increasing flood risk and as a response to the gaps in these end-to-end EWSs approaches, several studies [12,17–19] have proposed community-centred EWSs approaches that are cost-effective and ensure DRR sustainability and efficacy by basing systems design and operations on local capacities.

This study contributes to existing literature on participatory EWSs by exploring rural communities' social, economic and environmental conditions for capacities that can be enhanced to improve EWSs operations and build community resilience, ultimately improving flood risk reduction.

1.1. A conceptual framework for situational analysis

Though structurally interchangeable across different geographies, a community's ability to attain prosperity, survival and prolonged viability is uniquely defined by the availability of resources and how effectively they are used to achieve desired outcomes [20]. Community capacity can be defined as the existing interlinkages between structural resources, human capital and social capital and how they may be leveraged to better or preserve a community's welfare [21]. It is typically a product of social (i.e. community organisation, social interaction), economic (employable skills, economic diversity) and environmental indicators (infrastructure, modes of communication) and the main driver of resilience within communities (Cutter and Derakhshan 2020; Ross, 2014).

The capacity-building paradigm sees communities as the focal point when dealing with the challenges associated with the impacts of a hazardous event [22]. Addressing local socioeconomic and environmental concerns ensures system efficacy by allowing the exploitation of innate capacities while simultaneously creating pathways for community engagement [23]. Moreover, it equips members with knowledge and skills, further strengthening their capacity to contribute to development initiatives [24,25]. Though no definitive method for developing such systems exists, several common concepts can be adopted from social and participatory EWS literature [26]. Among these is the concept of situational analysis.

Moving beyond Morse et al. [27] constructivist approach, this study expands on Clarke's [28] definition of situational analysis as a situation-based (i.e. context-based) research tool that uses grounded theory methodologies to identify and define social, economic and environmental worlds and action scenarios. By providing a comprehensive framework for evaluating multiple relationships and interlinkages that influence activities (in this case, FEWS efficacy) [28], situation analysis provides DRR systems developers and policymakers with critical data and information on internal and external factors influencing system efficacy. Situation analysis provides a unique multi-dimensional understanding of the target phenomena and visual presentation of data to aid information translation and knowledge transfer activities. It allows the reader to grasp the complexity of a situation by demonstrating how the interaction of varying components influences outcomes [28].

To improve community capacities and assist governments in measuring vital elements of their situational disaster risk, Bollin et al. (2003) developed a community-based indicator system [29]. Indicators are community characteristics that directly affect capacity and influence resilience, whereas metrics refer to measurable variables related to community capacities [30]. For instance, as an indicator of community capacity, literacy levels are thought to directly influence the ability of a community to translate and apply warning information for successful hazard response. However, community literacy is not directly measurable but may be assessed based on metrics and consolidated to characterise community literacy levels (e.g. level of education obtained). The framework proposes a methodology for use at the local government and community level to guide decision-makers in their efforts to minimise and manage disaster risk [25]. Additionally, the framework (Fig. 1) categorises key elements of risk management into components of hazard, exposure, vulnerability, and capacity measures. The framework helps define disaster risk drivers and identify appropriate resilience indicators under the relevant categories for capacity quantification.

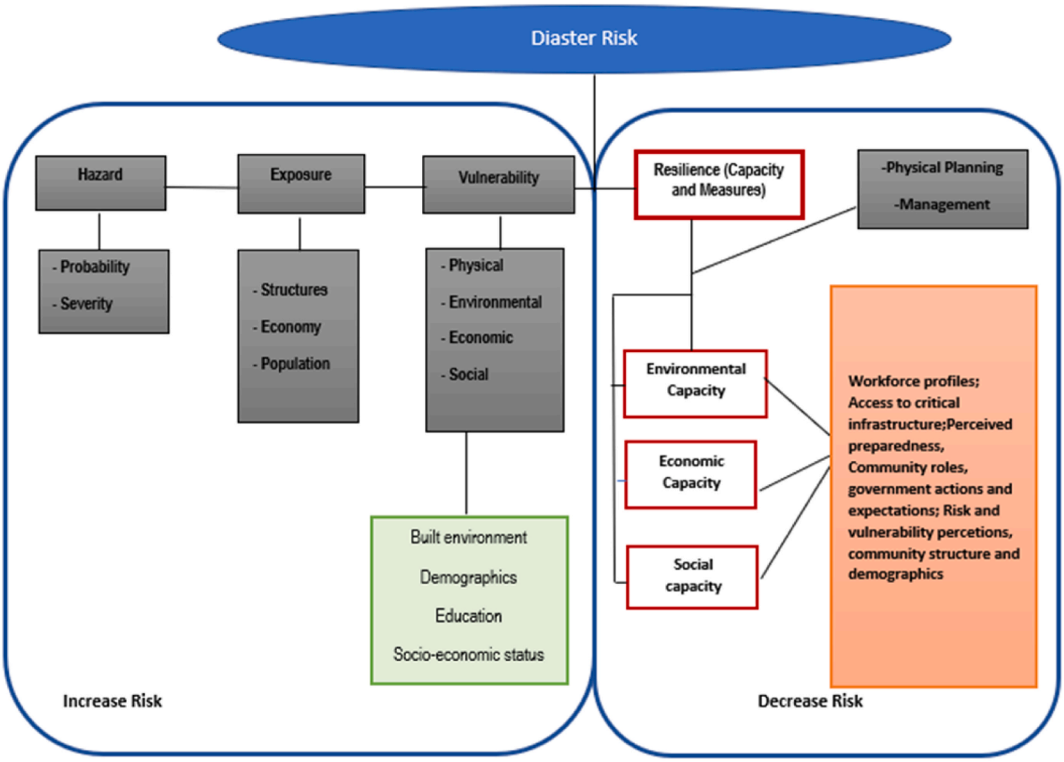

Fig. 1. Situational analysis conceptual framework. Modified from (Bollin et al., 2003).

2. Methodology

2.1. Study area and background

The study area for this research was the Kabbe constituency (Fig. 2.), the most flood-prone area in Namibia. With its entire surface area made up of a floodplain, Kabbe is subject to frequent flooding. Seasonal riverine- and flash floods are the most common floods in Kabbe, the former occurring most frequently between October and April [32]. Located in northeastern Namibia, this uniquely placed area is almost entirely enclosed by perennial rivers. The Zambezi River borders Namibia from Angola, Botswana, Zambia and Zimbabwe east of Kabbe. In contrast, the Linyati and Chobe Rivers border Kabbe in the south and the Kwando River in the west [31]. This unique geographical location of Kabbe, coupled with its rural nature (89%) and high annual rainfall levels (700–900 mm) increases its susceptibility to flooding.

The Zambezi wetland/floodplain dominates the hydrology of Kabbe constituency (Fig. 3). During the rainy season (September–April), riverine flooding often occurs when the Zambezi River fills up, overflowing its banks and pushing against the Chobe-Linyati channels. Heavy rains in the upper lands of Angola often fill up the Kwando River, which then pushes back on Chobe-Linyati, flooding this entire flat area. The high precipitation causes flash floods in the area. During the flood season, the outbreak of waterborne diseases such as malaria and cholera are common in Kabbe [34,35] (see Fig. 4).

After disaster-level floods in 2009, the Ministry of Agriculture, Water and Forestry and several support agencies established a flood early warning system for forecasting, monitoring and response [36]. Though, in theory, the FEWSs operations cascade down to the regional level through the replication of Disaster Risk Management Committees (DRMCs) at regional and local levels, empirical evidence suggests that the system is active on an ad-hoc basis, disintegrated, response-driven, and highly technocratic [37]. Moreover, regional and local authorities are poorly capacitated to carry out flood preparedness, mitigation, and response activities and warning alert systems do not match end-user needs, severely limiting dissemination [13,38]. With the ensuing flood disaster occurrence in 2011, system fallacy alerted several institutions to call for the strengthening of EWSs in the country [39]. As flood events annually plague Kabbe, displacing communities and disrupting livelihoods, the need for adequate flood DRR mechanisms that strengthen adaptive capacity have become a matter of national urgency [40–42].

Flood vulnerability is parallel to resource accessibility in Africa's remote, rural subsistence farming communities, as these are the principal means by which people sustain their livelihood. In Kabbe, for instance, the area's rural nature ensures that the majority of the population, 89% are directly and indirectly dependent on the natural environment for their sustenance. The primary income sources in Kabbe are livestock and crop farming, wages, and pensions [43]. Approximately 52% of revenue in the area is from agricultural activity [44,45]. Additionally, only 25% of the residents have access to safe water, 11% to electricity and 89% have no access to sanitation. The entire population of Kabbe (over 14 000 people) was affected during the floods in 2009, and over N$ 290 million was incurred in economic loss due to ineffective early warning [35,46,47]. The flood was the worst the area had experienced in the previ-

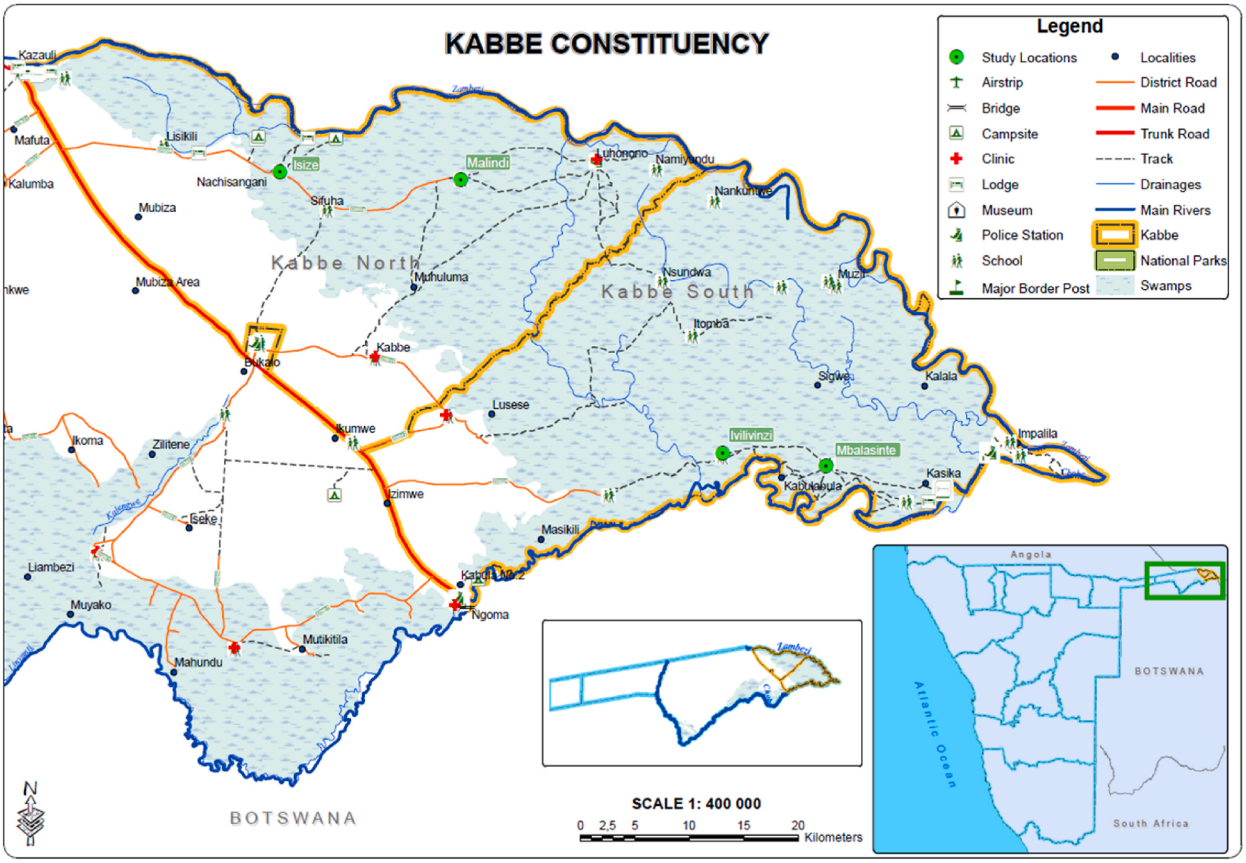

Fig. 2. Location of Kabbe Constituency. Self-illustrated using [31].

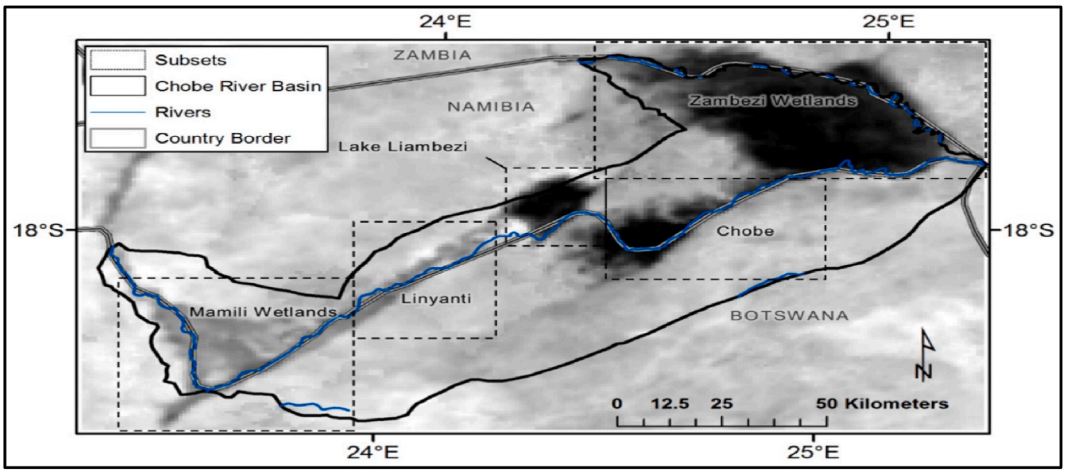

Fig. 3. Hydrological make-up of Kabbe constituency. Source [33].

ous decade, drawing attention to the significance of effective DRR planning on a national scale [36–38]. The flood impacts were exacerbated by compounding factors like food and water scarcity and the outbreak of waterborne diseases [48]. Floodplains an as areas of great significance to rural communities, offer favourable conditions for settlement and resources for sustainable livelihood support [49]. However, flood hazard remains an increasing threat in these environments [33]. Four villages in Kabbe were selected for the study- Isize, Malindi Mbalasinte and Invilivinzi (Fig. 2). Although communities in Kabbe are often equally affected by floods, the major floods in 2009, 2010 and 2011 hit these communities the hardest [48].

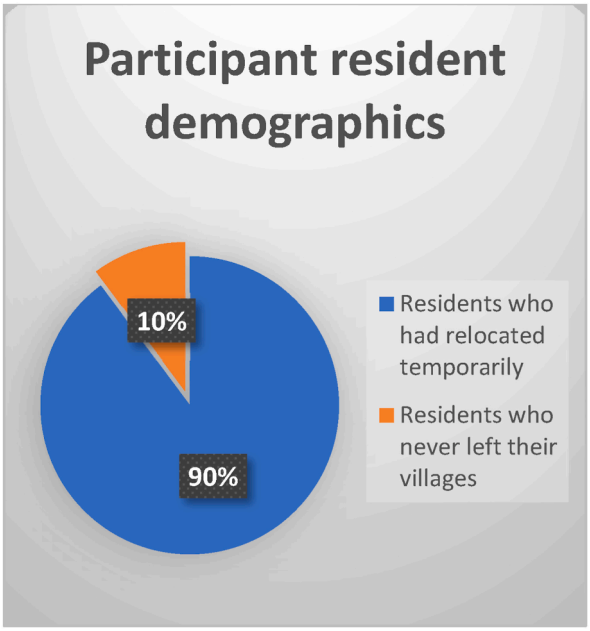

Fig. 4. Residence demography.

2.2. Situational analysis approach and data collection

The situational analysis was designed as a planning tool, which documents the current capacity and scope of flood risk management to provide recommendations on its future strategic directions relative to the remote and rural context of Kabbe. The method was found most suitable as it provided a comprehensive framework for considering the multiplex of social, economic and environmental relationships and connections that influence flood early warning in the area [28]. According to Barquet and Cumiskey [50]; selecting socioeconomic and cultural indicators for a situational analysis is more effective when developed with decision-makers and action plan overseers. During the month of June 2022, the research team conducted nine key informant interviews (KIIs) with officials and technical staff from the Ministry of Agriculture Water and Forestry, Zambezi Region Disaster Management Committee, Kabbe South, Kabbe North Local Authority, Namibia Red Cross and village heads. The interview questions included: What are the benefits and challenges faced in operating the FEWS? What is the extent of reach of early warning message communication? What is the level of community engagement across all FEWS components? What initiatives have communities taken in flood DRR? The initial KIIs identified social, economic and environmental vulnerability and community capacity indicators, cross-referenced with suggestions by Gillespie-Marthaler et al. (2019) for the situational analysis (Fig. 1, orange box).

The empirical work done in the secondary data collection phase formulates the focus of this paper. Following the KIIs, two focus group discussions (FGDs) (Table 1) with purposively selected participants were conducted in each case study village (Fig. 2). The participant selection criteria encompassed being a resident of the case study area, 35 years and above in age, and residents had to be the head of a household. It is noteworthy that all inhabitants of Kabbe belong to the Balozi tribe.

Most FGDs were gender-balanced, providing an overview of the experiences and perceptions of both genders in dealing with floods. Fifty-nine (59) FGD participants equating to 59 households, were selected; these included village heads, farmers, fishermen, vendors, nurses, teachers, and community volunteer group members. A conceptual framework adapted from Bollin et al. (2003) (Fig. 1) was developed using indicators identified during the KIIs to conduct a location-based situational analysis by quantifying community resilience (Fig. 1, using indicators based on the themes highlighted in green, red and orange). The study highlighted, "What resilience looks like for the people of Kabbe", and FGD interviews were formulated to cover the following topics. Firstly, awareness and extent of participation in the formal FEWS, 2) an overview of ongoing community flood DRR activities, 3) an investigation of target communities' socioeconomic and environmental capacity and 4) assessing community perceptions on flood risk and vulnerability. The objective was to identify socioeconomic and environmental community resilience capacities that can be enhanced to improve FEWS operations in Kabbe. Thematic analysis was used to analyse the data, and descriptive statistics used to present the study results.

Table 1
Focus group discussions.

Isize	#respondents	Malindi	#respondents	Mbalasinte	#respondents	Invilivinzi	#respondents
FGD1	8	FGD1	8	FGD1	7	FGD1	7
FGD2	7	FGD2	8	FGD2	8	FGD2	6

n = 59.

3. Results

The FGDs provided an extensive and multi-dimensional perspective of current community vulnerabilities and capacities as respective gaps and opportunities for community-level flood resilience. The categorical measurement of the indicators was based on the developed conceptual framework (Fig. 1) (highlighted in red, green and orange). Within the vulnerability component, indicators were captured as categorical variables measured through questions regarding education, built environment, demographics, and socioeconomic status. The resilience component was measured through categorical variables and composite indices for various environmental, economic, and social capacity indicators, including workforce profiles, public awareness programmes, coping and adaptive capacity, public participation, awareness, and perceptions of preparedness, risk and vulnerability identified through the KII's.

Thirty-three male and twenty-six female respondents participated in the focus group discussions (n = 59). Of the participants, 28.8% were below 40 years of age, 59.3% were 40–55 years old, and 11.8% were above 55 years old. All the respondents headed a household, with 55.9% male and the remaining 44.1% being female heads.

3.1. Community structure and demographic profile

All FGD participants were natives of the study villages belonging to the Balozi tribe; 90% of the residents had spent all their lives in the floodplains with short-term migration for work, school etc., while 10% had never left the area (Fig. 5). The demographic profile of Kabbe has remained relatively the same, with residents revealing that visitors are mainly tourists who do not settle in the area. The region's relatively stagnant socio-cultural and demographic structure indicates great potential as resources, knowledge and social networks remain embedded in the community. Over eighty-one per cent (81.3%) of residents revealed sharing of food, fishing and even farming techniques as long-standing traditions in the area. Residents demonstrated high levels of trust, cohesion and inclusion among themselves, with 73% of women involved in community garden schemes. In contrast, fishermen and subsistence farmers consult each other on seasonal fishing expeditions and farming practices. The literacy level (Fig. 5) among the study participants was found to be relatively high, with (15%) having reached or completed tertiary, secondary (54%), and primary (17%) levels of education, while 14% never attended school.

3.1.1. Risk and vulnerability perceptions

Based on the respondents' experiences, the hazards of significant concern included floods (94.1%), food scarcity (11.8%), droughts (64.4%), climate change (59.3%) and wildfires (25.4%), as shown in Fig. 6. Residents recollected several floods, droughts and food scarcity events over the years. Evidence of dissymmetry in awareness and knowledge of hazards was found among villagers. For instance, many respondents stated informally that floods were not a threat and food scarcity was only a concern after significant flood events in 2009, 2010, and 2011. However, Kabbe has been declared a flood, drought and food scarcity disaster area in Namibia [51,52].

Among the main impacts of flood disasters, residents reported: crop loss (94.9%), loss of livestock and cattle (3.4%), water scarcity (94.9%), loss of life (37.2%); property damage (84.7%); loss of livelihood (69.4%); disruption of schools and transportation services (89.8%); public health (20.3%); social (72.8%); culture (16.9%); environment (30.5%); well-being (11.8%); food/water insecurity (77.9%); and recreation (1.7%). While 94.9% of the respondents knew of community safety refuges, evacuation meeting areas and

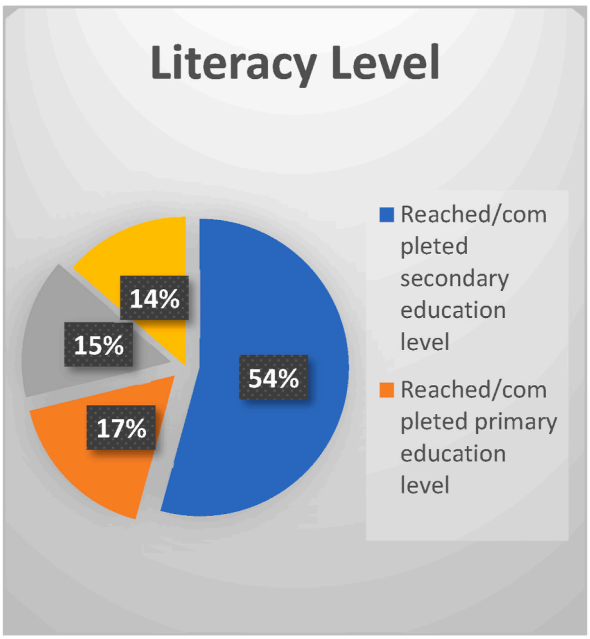

Fig. 5. Literacy level.

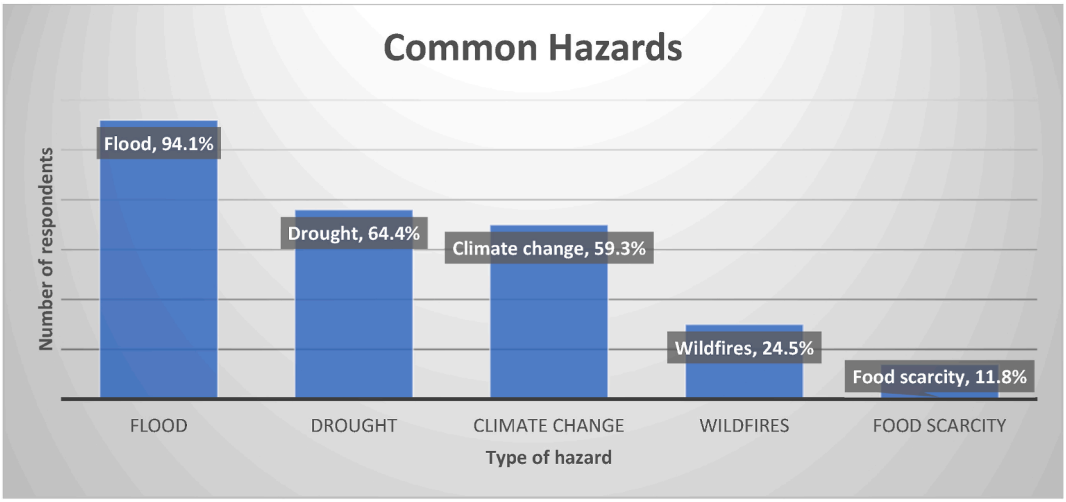

Fig. 6. Common hazards in case study villages.

evacuation shelters, only 84.7% said they would evacuate in the event of a flood. Community desirability was highlighted as the respondents indicated their willingness to participate in planning and training for improved flood DRR. Respondents also indicated the desire for increased access to disaster information, participation in awareness and preparedness campaigns and education to assist them in enhancing flood preparedness, mitigation, coping, response and recovery strategies.

3.1.2. Perceived preparedness

Many study participants (91.5%) feel prepared for low-medium impact flood events, with 100% having personal flood disaster experience and 94.9% demonstrating high levels of disaster preparedness knowledge (91.9%). Most FGD respondents use indigenous knowledge for flood forecasting and traditional preparedness and coping strategies (94.1%) to reduce flood impacts, summarised in Tables 2 and 3. However, only 61% felt that entire communities were prepared, primarily due to the disaster-level floods in 2009 and 2011 and challenges in timeously accessing the most vulnerable residents. According to Ref. [53]; the intensity of flood disasters is often more catastrophic than recurrent low-medium impact floods; poor communities are usually unable to withstand these shocks without external assistance. Many participants (62.7%) expressed willingness and ability to assist neighbours in preparedness and evacuation activities.

3.1.3. Community action, governmental roles and expectations

Respondents revealed the existence of several community organisations and volunteer groups in their respective communities, including CDRMCs, pastoralists and fishermen's associations, women's groups and the tribal court and headmen committees, which play

Table 2
Overview of flood forecasting indicators in the case study communities.

Category	Example Indicators
Ecological	Plant behaviour
	- the early blooming *acacia nigrescens*
	- marula tree blooms early
	- the early blooming of the fiscus tree
	Animal Behaviour
	- fisherman observe increased amounts of fish in the river
	- the abundance of red ants' siuluwi' in villages
	- the increased number in local bird species, including duck and geese
	- increased number of frogs
	- hippos migrate from riverbanks to dryland
	- weaver birds build their nests higher up than usual in trees
Celestial	- rainfall expected after three consecutive full moons
	- concentric rings around the moon
Meteorological	- high-intensity rainfall
	- sweltering weather
	- heavy winds
	- occurrence of dark clouds
Riverine	- frothing of water
	- increased sound and velocity of running river water
	- change in the colour of water (muddy, carries debris)
	- smaller channels still filled with flood waters from the preceding year

Table 3
An overview of the different indigenous coping strategies employed to address floods.

Impact Category	Indigenous Coping Strategies Implemented
Food and water conservation	- Dried spinach, maise flour, sorghum, nuts, millet, potatoes, pumpkins and other high-starch foods are placed in plastic containers (to keep out moisture). These are stored in raised platforms built on stilts to prevent damage. - Seeds, dried and smoked fish are also stored - Water is stored in plastic bottle containers - Many respondents sent these supplies to their second residence in the upper lands when deemed necessary - Some store water purifying tablets they received from relief efforts the preceding year
Protection of human lives	- raising a homestead before a flood - elevated beds with bricks - night watch and ensuring entryways are secure to avoid animals like crocodiles - building raised platforms as shelter while monitoring the flood
Protection of homes and temporary shelters	- Reinforce homes: using more water-resistant materials for roof thatching, patching cracked spots around the homes, - patching holes in corrugated zinc roofs, using plastic on roofs to prevent leakage - building tunnels around the home to divert water - building temporary raised shelters - placing sandbags around homes to divert floodwater
Crop protection	- select varieties that are flood resistant and suitable for the local climate - plant early maturing crops - change planting locations; plant both in the lowland and upland area - harvest early
Livestock and poultry protection	- Poultry is kept in raised platforms - Goats and larger livestock are relocated to the uplands - Poultry is sold if water levels start rising too quickly
Fodder management	- The storage of fodder for cattle and other livestock, - Storage of feed for poultry (based on availability)
Relocation and evacuation	- Relocate to the uplands to stay with relatives, a second home, temporary shelters, or evacuation centres - Women, children, elderly, disabled people and livestock go ahead. The men remain to monitor the flood, fishing and farming - Prepare canoes and relocation sites
Adaptation to food scarcity	- Skipping a meal - High carb and protein diet - Watermelon is consumed as it is filling and hydrating

a central role in warning dissemination among communities in Kabbe. Most of the respondents (69.4%) participate in a range of community or volunteer groups, emphasising that most groups are active throughout the year but meet more frequently before and after the rainy season.

During the seasonal floods, many residents (62.7%) do not require assistance from governmental authorities or relief agencies. In contrast, 30.5% highlighted the need for assistance of essential services (evacuation, food, water, shelter) for the most vulnerable. However, most residents (94.1%) stressed the need for transportation services (boats) as communities in Kabbe are often cut off from the rest of the region during the floods. Respondents informally stated that due to the region's rural nature and high poverty levels, some residents evacuate to government facilities only to alleviate food and water scarcity and manage their food stores. Additionally, 62.7% expect emergency healthcare services, 59.3% require financial support/job protection, and 52.5% require assistance with reconstruction, while others noted the need for increased public safety and property protection. The need for sustainable rebuilding and resources to strengthen community capacity was emphasised by many respondents-indicating a high level of self-sufficiency.

Fig. 7 illustrates the sources of flood warning communication of flood disaster warning by public sources; 76.2% of the respondents reported having access to at least one, including village messengers, radio, cell phones, governmental and non-governmental agencies, and community members. Most residents were unaware of the early warning system (66.1%) and what institutions they could contact during flood emergencies, while others referred to the Red Cross as the main point of contact. Residents noted receiving training on monitoring, preparedness, evacuation and rebuilding from the agency in the past.

3.1.4. Workforce profile

Of the case study respondents, 18.6% were excluded from the workforce. Although skills diversity is extensive in the study communities, respondent wage profiles were relatively low. Most respondents were subsistence farmers (23.7%); other professions included teachers (10.1%), homemakers (10.1%), carpenters (3.39%), small business owners (10.1%), government employees (3.39%), craft vendors (10.1%) and fishermen (20.3%). Respondents accredit the low level of formal employment and poor salary scales to the unavailability of jobs and rural conditions of the area. However, most respondents own assets (Fig. 8), such as land (81.4%), livestock (54.2%), farmland (49.1%), gardens (88.1%) and poultry (72.8%), which they use for both trade and sustenance.

3.1.5. Access to critical infrastructure

Among the main environmental concerns are the inaccessibility to health facilities during flood emergencies (100%), a lack of communication facilities (88.1%) and physical safety structures (94.1%). Only 13.5% of respondents have electrically powered homes, while 76.2% live in mud-built homes. The poor built environment capacity in the area is attributed to the minimal infrastructural development in Kabbe, which is a significant challenge during flood emergencies. Poor infrastructural development also trans-

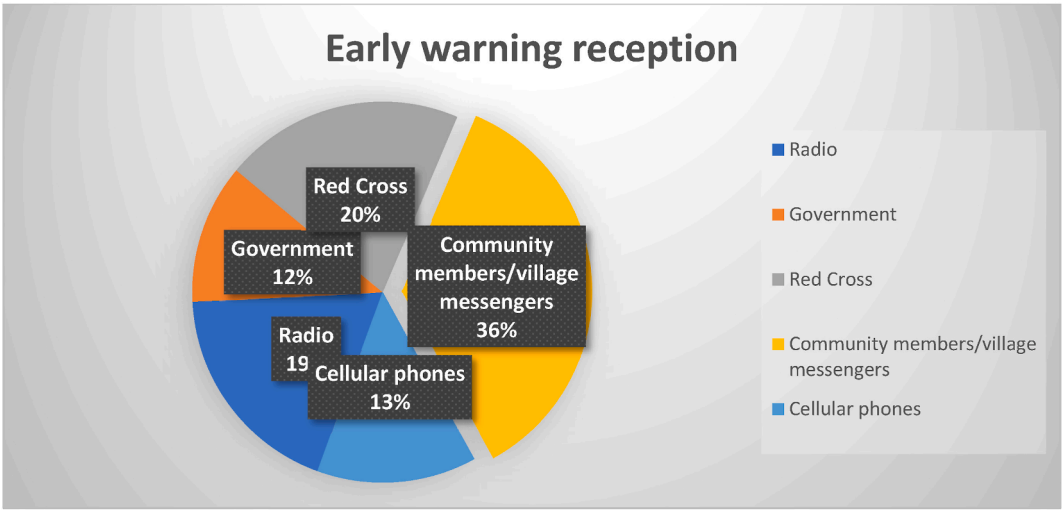

Fig. 7. Modes of early warning reception by participants.

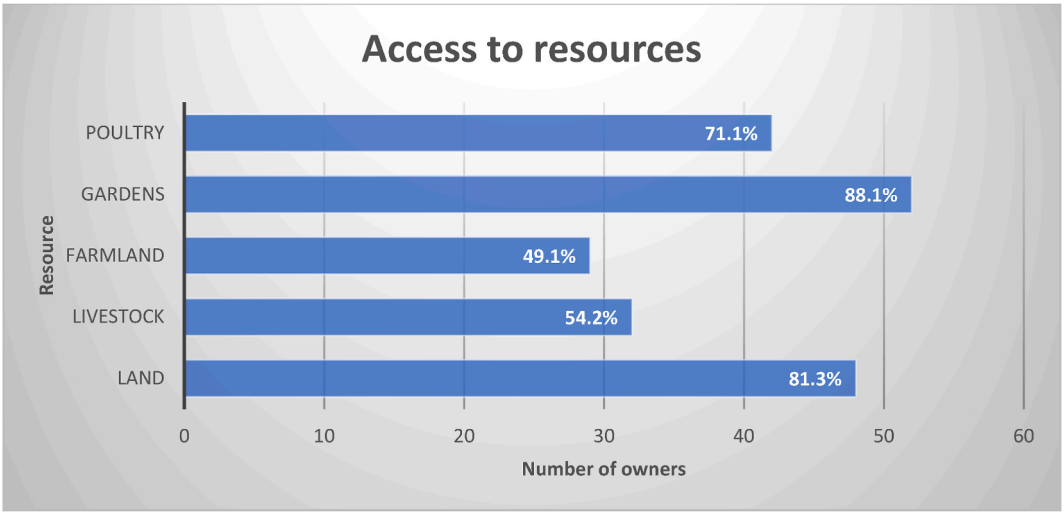

Fig. 8. Number of respondents with access to resources.

lates to non-existent insurance coverage in the area, as most homes do not meet the criteria [45]. Fig. 9 illustrates the flooding situation in 2009; all but one health facility in Kabbe were submerged.

4. Discussion

Although economic and environmental (i.e. infrastructure) conditions require extensive development in Kabbe, the target communities' overall coping, anticipatory and adaptive capacity was found to be relatively high. Communities demonstrated high levels of preparedness, self-sufficiency, desirability, and strong adaptive capacity based on skills diversity, knowledge and expertise in coping with floods. Additionally, the high literacy level is indicative that residents can accurately interpret, transmit and apply risk, hazard and early warning information, should it be more accessible.

By observing predominant low-cost housing and assessing low migration rates [54], attachment [32] and similar cultural backgrounds of the residents in the area, the study found that the social demography of Kabbe has remained relatively the same. The strong socio-ecological linkages within and between respondent communities also offered a conduit for community early warning participation. The unchanged social demography implies that a high proportion of residents with knowledge of community hazards, resources, ecosystems, coping, and adaptation strategies for dealing with flood disturbances are still present. This proves that the social networks and sense of community essential in coping with disaster have remained intact. The study revealed a high level of social cohesion expressed through the willingness to assist each other, sharing resources, farming and fishing practices and significant community involvement in flood mitigation activities.

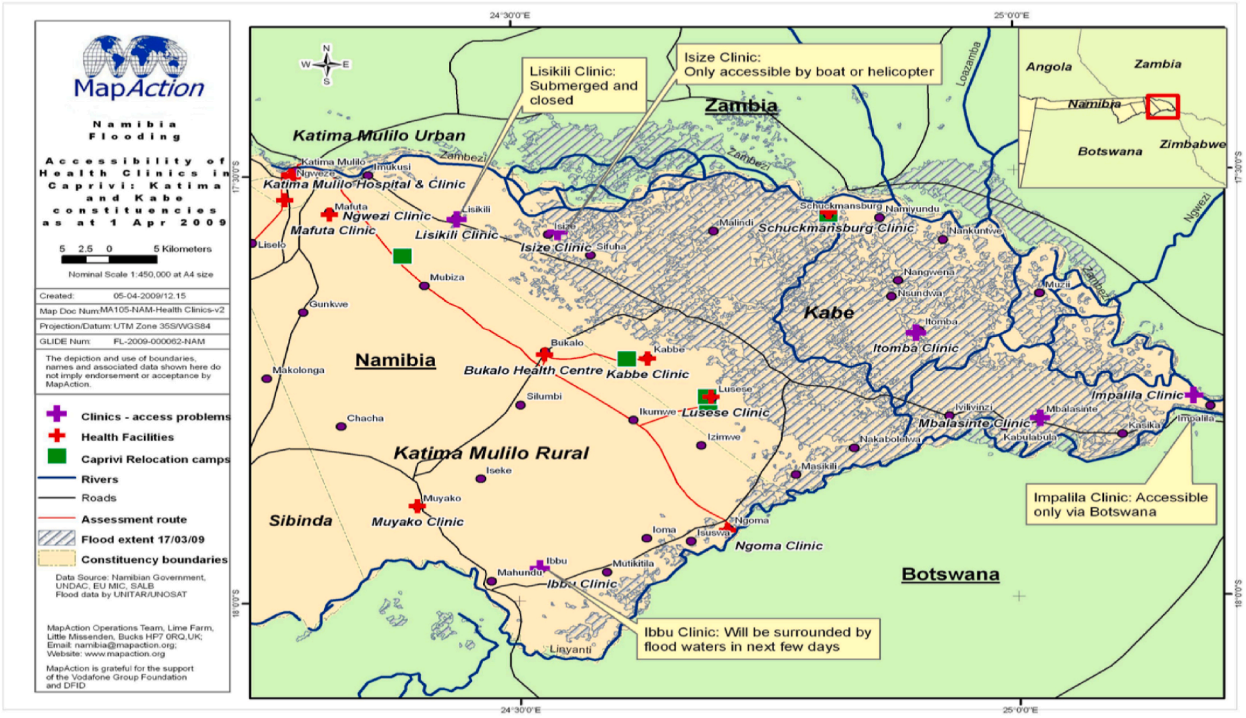

Fig. 9. Overview of the limited access to health facilities in Kabbe during the 2009 floods.

The pre-disaster and short-term post-disaster periods primarily define coping capacity, as resources are often strained and risk depletion during this time [55]. Disaster shocks and resultant impacts are often alleviated if affected individuals have access to resources [56]. Although very few respondents had access to savings that would enable them to sustain themselves during this time, several other liquid assets were identified. Ownership of, or access to, farms, gardens, poultry and livestock, stocked food and water supplies, and the ability to fish and harvest crops during the flood enable survival, with many residents having access to such resources.

Homeownership and insurance alleviate loss and expedite reconstruction; however, most households are constructed from mud, wood and corrugated zinc, not meeting insurance criteria. The inadequate infrastructural development in Kabbe means that most residents (89%) lead a traditional lifestyle with very few brick houses, inadequate electricity, water and sanitation facilities and primary dependence on the environment for most of their essential needs. Though this may seem discouraging, the customary lifestyle of the target communities is well suited for the assets they possess. After all, resilient communities are defined as those with high adaptive and coping capacities [57], which is definitive of the target communities who have experienced minimal socio-ecological change while living with floods for decades. Land ownership and social networks have enabled residents to temporarily relocate to secondary residences in the upper lands and seek support and shelter from other community- and extended family members where necessary. Since all respondents hail from Kabbe with similar cultural backgrounds, these findings support the notion that the existing familial and social networks and resident familiarity with the area increase coping and adaptive capacity.

Variances may exist between networks, differential skill sets, knowledge systems, experiences, and the available resources accessible to the two gender sets, as the study identified a lower coping capacity among female respondents. In this regard, the targeting of women by the Namibia Red Cross and their engagement in flood disaster mitigation planning, training and awareness in the past served as a means to target women for coping capacity enhancement. Ongoing recruitment, training, education and awareness campaigns with women by authorities can strengthen female coping capacity. Long-lasting collaboration is required to minimise the loss of life and injuries, strengthen livelihood resilience and effectively manage health emergencies due to the high undesirability of evacuation and relocation among residents.

Through environmental protection and resource knowledge-sharing strategies, coping and adaptive capacity can be increased as these methods improve natural resource management knowledge [58–60]. Most residents in the case study area have preserved and continue to implement flood hazard forecasting, preparedness, coping and adaptation techniques (Tables 1 and 2). According to Taiban, Lin and Ko [61]; resilience and adaptation can be built by passing down indigenous and other knowledge systems and coupling cultural resources within at-risk communities. Disaster response and recovery initiatives are underscored by livelihood and skills diversity among residents, as these assist in food and water resource management, clean up, reconstruction, and emergency medical care. Whereas area-based resource management and social capacity are increased by the conventional livelihoods of the study area residents, reliance on the environment for sustenance, i.e. fishing, farming, and hunting, simultaneously result in the vul-

nerability of these resources [59]. Enhancing food security creates another conduit for sustainable rebuilding and preparedness collaboration through government-assisted sustainable agricultural and fishing practices and local food production initiatives.

5. Recommendations

This study explored the socioeconomic and environmental conditions of rural communities to identify prospects for rural resilience and community integration for improved flood early warning actions in the case study area. Recommendations are based on differential social, economic and environmental vulnerabilities and capacities that affect a rural setting (Fig. 10). The recommendations are centred on addressing cross-component gaps in flood early warning systems operations through area-based solutions and are targeted for integration and collaboration with aligned community groups and governmental and non-governmental institutions.

The identified community prospects and recommendations for their use in FEWS operations include the following.

- Strong community networks: Community networks can be enlisted for flood early warning message communication and dissemination. By identifying, linking and collaborating with key players in local organisations, FEWS institutions will establish two-way communication between themselves, support organisations and end-users and expand the degree of reach of warning communication. Using their community-embedded methods, e.g. drums, meetings, and blowing of horns and whistles, residents can participate in ensuring that the most vulnerable are alerted on time. To this end, formal FEWS institutions can 1) establish collaborations with community-led disaster communications and coordination groups, 2) establish coordination platforms and training with community DRMCs, group leaders and volunteers, 3) provide training to support CDRMCs and other community leaders on first aid, CPR and emergency communication education 4) provide key community DRR players with go-kits with appropriate emergency communication tools (e.g. radios, transmitters and charging stations and gateway devices).
- Community-wide indigenous flood forecasting, mitigation and coping practices: Understanding, strengthening and integrating indigenous forecasting, mitigation and coping strategies with scientific methods into formal FEWS.
- High literacy levels, desirability and social cohesion: these community qualities can be used to create diversified public outreach & awareness campaigns and strengthen CDRMCs as a unified and coordinating voice of the community before-/during/post-disaster. Additionally, local communities can assist with flood monitoring and evacuation activities as they exhibit high levels of community competence.
- Community risk and resource knowledge: These community capacities can be utilised for 1) mapping, linking and establishing community resource and hazard databases, 2) identifying flood hazard evacuation routes and refuge areas, 3) identifying prearranged assembly points, emergency drills and evacuation training points and 4) identifying vulnerable communities for predetermined planning rumination and conducting public outreach and awareness programmes.

6. Study limitations

The reported situational analysis naturally has limitations as it focuses on a single hazard and not the multi-hazard systems addressed by other researchers. However, the financial and institutional limitations faced by developing countries pose an obstacle to the development of such systems, consequently limiting local research [62,63]. Additionally, while flood risk is a national concern,

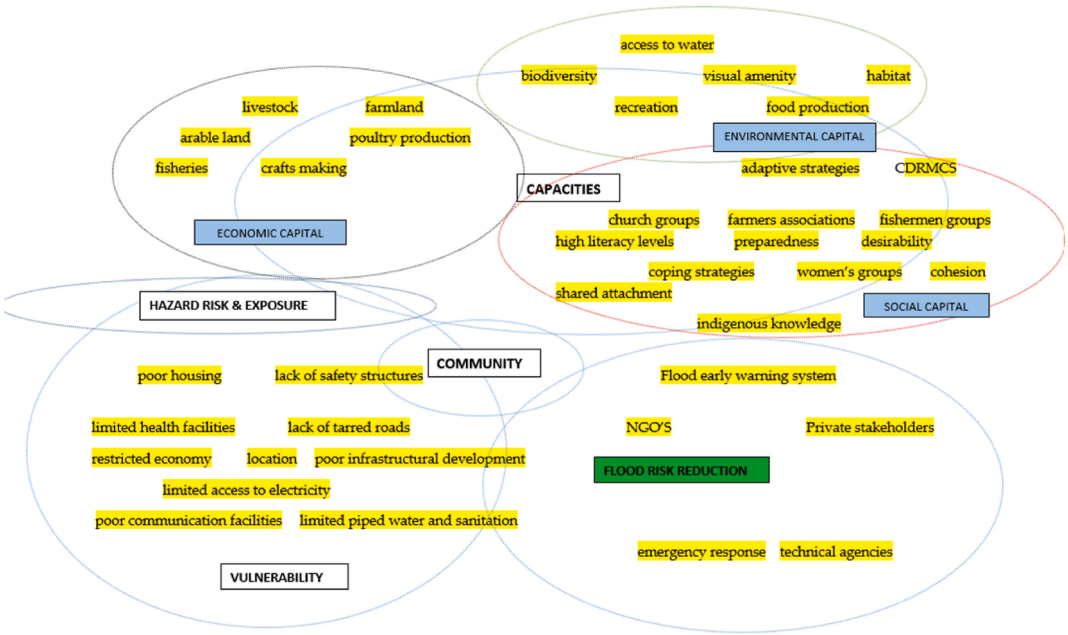

Fig. 10. Situational map of the different component interactions collectively influencing flood risk reduction.

the analysis draws on a single constituency's social, economic and environmental context. Furthermore, the researcher acknowledges the participant sample size. While standard FGD protocols were employed (i.e. adequate provision of the study objectives and participation and time and location for focus groups), several FGDs yielded between eight to ten participants. The reduced willingness to participate displays the difficulties faced in engaging rural communities in research, specifically those reliant on subsistence farming for their livelihood.

7. Conclusion

Increases in the efficacy and success of flood early warning systems are highly probable if they are designed with end-user elucidations of their communities' socio-cultural and ecological demographics, inherent resource systems, environmental capacity and risk and vulnerability perceptions. The diversified engagement of stakeholders from communities, FEWS and partnering institutions, collaborative organisations and groups assist in identifying critical socioeconomic and environmental DRR drivers and contextualising them into a set of place-based scenarios that highlight the major challenges in the systems' future operations while simultaneously providing pathways for solutions [64].

This paper explores rural communities' socioeconomic and environmental conditions for capacities that can be exploited for improved flood risk reduction. Recommendations are provided to better support flood EWS operations based on the realisation that capacity building extends beyond risk reduction and can ultimately address climate change adaptation. Given the growing need for EWS in light of climate change, these systems must be strategically developed and tailored to communities' needs, especially in countries with limited resources and financing. Communities possess various innate capacities that can be used to this end, and EWS planning and implementation should seek to enhance and exploit these benefits where possible. The study emphasises that collaborative assistance should be granted to local organisations and initiatives directed at enhancing local capacities at the community level, as this increases socio-ecological, economic and environmental resilience and enhances DRR systems performance.

Credit author statement

Deolfa Jose Moises: Investigation, Resources, Conceptualization, Methodology, Writing – original draft, Review & Editing **Olivia Kunguma**: Supervision

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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