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ORIGINAL RESEARCH ARTICLE

Localizing vulnerability, hazard, and disaster risk assessments based on the Hazards-of-Place model in Southern Malawi

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Abstract: The localization of vulnerability, hazard, and risk assessments to advance disaster risk reduction is critical. Although several models of vulnerability, hazard, and disaster risk exist, their applicability at a microscale level remains largely untested, limiting their ability to inform stakeholders directly involved in disaster risk management (DRM) in Malawi. Different regions of Malawi face distinct levels of risks and vulnerabilities, prompting stakeholder participation in the DRM discourse, but with limited access to evidence-based decision-making tools. Therefore, this study applies the Hazards-of-Place Model to assess vulnerability, hazard, and disaster risk in the traditional authorities (TAs) of Lundu and Kalembo, located in the disaster-prone districts of Chikwawa and Balaka, respectively, in southern Malawi. The model was employed to evaluate vulnerability and disaster risk; analyze mitigation, resilience, and adaptive capacity (AC); and develop a community engagement and resilience framework. Designed as a qualitative study, it employed 15 focus group discussions and semi-structured interviews with 352 participants to provide in-depth, locally specific insights into community values, perceptions, practices, and social contexts. Findings indicate that households in both TAs are exposed to multiple hazards due to the biophysical characteristics of their areas, while AC measures remain insufficient to mitigate risks. Furthermore, land governance and leadership structures exacerbate vulnerability. This study highlights that the degree of exposure to hazards in Lundu and Kalembo significantly influences vulnerability to disaster risk. This study provides a community engagement resilience framework that can be applied to hazard and risk mitigation and serves as a tool to support the implementation of adaptive and transformative interventions aimed at reducing multiple vulnerabilities and risks in these communities.

Keywords: Vulnerability; Hazard; Disaster risk; Chikwawa; Balaka; Malawi

1. Introduction

Local-level assessments of hazards, vulnerabilities, and risks provide strategies and indicators that can be utilized in the implementation of disaster risk reduction (DRR), including the identification of resilience among specific populations and areas. Many contemporary disaster risk management (DRM) models and frameworks have been developed to measure vulnerability and risk within the context of disaster resilience.[1-3] One such framework is the Hazards-of-Place model (HoPM).[4,5] The HoPM emphasizes that vulnerability is shaped by the geographical and contextual conditions of an area. The model demonstrates that hazards occur in specific places and exert different impacts depending on an individual's vulnerability and resilience.[6] It highlights "place vulnerability" to environmental hazards and risks, where individual vulnerability is contingent on geographical location, the natural resource base and the built environment, and the availability of adaptive resources. This perspective suggests that each place is unique and requires context-specific analysis. The model also recognizes the interplay of biophysical and social vulnerability (SV) in shaping environmental risk. Biophysical processes (e.g., location, proximity, and elevation) create hazardous conditions, and understanding vulnerability is essential for effective risk reduction.[7,8] SV includes societal conditions such as levels of development, social relations, risk perception, political power, and demographic characteristics (e.g., gender, race, age, and income).[6,7]

The preceding discussion underscores that vulnerability in the context of disaster risk is a multi-dimensional concept, and its construction must be grounded in dual perspectives. On one hand, it is a technocentric concept that emphasizes engineering- and science-oriented approaches. In this sense, it relates to the biophysical factors in the HoPM, which attribute disasters to natural forces[6-10] and therefore necessitate physical and technological interventions implemented through simulation and modeling approaches. This perspective, however, neglects the role of human systems in mediating the outcomes of hazard events, as vulnerability is conceptualized primarily in terms of proximity to the source of risk or hazard. It views disaster as a departure from normalcy, to which society returns upon recovery,[11] through tangible (material) structures intended to reduce the impacts of natural or physical forces. However, the solutions proposed from this perspective may be considered limited, as they often lack inclusivity regarding resilience, entitlement, social protection, and socioeconomic factors that are critical for reducing risk and vulnerability. The emphasis on material disaster mitigation results in greater dependence on externally driven, engineering-oriented perspectives and fails to prioritize local participation in planning and prevention. Shitangsu[6] observed that engineering-based approaches emphasize addressing the causes of vulnerability within the political and structural spheres of society. The approach, however, tends to view hazards as standalone entities that harm human society, and it exhibits shortcomings in engaging multilevel stakeholders to address the diverse dimensions of risk and vulnerability across cultures, social groups, and societal needs. While this approach emphasizes infrastructural resilience, the infrastructure provided is often unsustainable and may even increase disaster vulnerability. It also promotes a top-down command-and-control model for disaster management, in which local structures, such as community-based DRM initiatives, are not supported.[12,13] Consequently, efforts to integrate resilience, adaptive capacity (AC), and policy formulation tend to be slow and limited at all levels. Above all, this approach is highly capital-intensive, failing to account for the limited resources available in developing countries, a condition that often renders DRM reactive rather than proactive.[13,14]

On the other hand, the social sciences perspective relates to SV within the HoPM. This perspective uses SV as a starting point for risk reduction, positioning disaster vulnerability as a combination of political economy, entitlement, and empowerment.[15] The perspective is centered on societal responses to disasters,[11] where the experience of disaster is shaped by societal conditions such as class, income, social status, gender, institutions, freedom, and power relations. It explains why people experience the impacts of hazards differently, depending on their societal conditions and other endowments. This approach incorporates multiple factors that influence vulnerability—including physical, social, economic, environmental, and institutional characteristics[2,10,12]—which shape opportunities for strengthening multilevel engagement to reduce vulnerability and risk. It also considers the specific vulnerabilities of groups such as women, children, the elderly, youth, persons with disabilities, and low-income populations,[11,14,15] and how these relate to human activities, behaviors, and political interventions. Therefore, this approach is population-centered, focusing on the identification of underlying factors and root causes embedded in individuals' everyday lives that give rise to dynamic pressures affecting particular groups.[16-18] It further highlights

the significance of fostering empowerment and entitlements, aiming to create conditions that enhance people's capacities through the use of their freedoms. By considering both biophysical and social conditions to model vulnerability to environmental risks, the HoPM remains an important framework for evaluating vulnerability, hazard, and disaster risk. However, this study incorporates a multilevel stakeholder engagement approach that can be applied in DRM, particularly across disciplines such as engineering, DRM, and policy-making, to expand the applicability of the HoPM. This is important because most tools currently available for disaster response are insufficient to minimize societal vulnerabilities. For example, a study by Manda and Thindwa[19] observed that state and non-state organizations in Malawi were often unprepared to plan and implement actions aimed at reducing community vulnerability to disaster, largely due to the narrow and limited tools available for stakeholder engagement in DRM.

The lack of supporting tools implies that community vulnerability to hazards continues to vary across different areas. The variation is determined by several factors, such as geographical location, socioeconomic conditions, and the presence of adaptive measures.[20-22] The impact of natural hazards is typically greater in low-income populations, as they have fewer coping capacities compared to higher-income households.[23-25] Multiple conditions shape the vulnerability of low-income groups, such as limited productive assets, residence in hazardous locations, substandard housing, and dependence on labor to meet livelihood needs.[26-28] The occurrence of natural hazards, such as floods, has increased globally,[29] and their impacts have caused widespread destruction across the physical, social, economic, environmental, and cultural domains.[30,31] For example, in Malawi, climate change has influenced the occurrence of weather-related hazards, increasing the frequency and intensity of rainfall events.[32] Recently, Malawi has experienced cyclones that have caused severe impacts on people and their livelihoods. Between 2015 and 2025, multiple cyclones[24,33,34] have been recorded, generating different types of risks and hazards.[19,20,22] These events have caused severe socioeconomic impacts in rural areas where households largely depend on absorptive capacities, which are constrained by limited agricultural livelihoods, poor infrastructure, and dependency on local practices. Many Malawians have endured the devastating impacts of these extreme events in the form of physical destruction, uncertainty, displacement, fear, and overwhelming burdens associated with rebuilding.[23-25] For example, cyclone Chido resulted in the deaths of 13 people, displaced 46,000 individuals, and caused severe damage to livelihoods and assets.[26,27] Cyclone Jude affected 26,000 vulnerable individuals in the districts of the Southern Region of Malawi. Cyclone Freddy, which occurred from March 11 to March 13, 2023, claimed 679 lives, injured 2,178 people, displaced approximately 563,602 individuals, and left about 511 people missing, while also causing widespread damage and losses in sectors such as agriculture, infrastructure, food security, and health.[20,27]

Following the devastating impacts, a national state of disaster was declared on March 13 in the districts affected by Cyclone Freddy.[20,27] Chikwawa and Balaka are among the districts in Southern Malawi included in the declaration. These districts exhibit varying degrees of risk and vulnerability to hazardous events, primarily driven by geographical position, poor agricultural practices, and a limited resource base that is often unable to cope with climate change impacts.[28] Although the vulnerability of Chikwawa and Balaka has been acknowledged, studies remain limited in localizing vulnerability, hazard, and disaster risk assessments within contemporary DRM models. In this study, the HoPM is employed to assess vulnerability, hazard, and disaster risk in the traditional authorities (TAs) of Lundu and Kalembo in Chikwawa and Balaka districts, respectively. Specifically, the study applied the HoPM to assess the dimensions of vulnerability and disaster risk; analyze disaster mitigation, resilience, and AC; and develop a community engagement and resilience framework.

1.1. Literature review

Vulnerability involves a combination of numerous factors that determine the level of risk to individuals' lives and livelihoods. In the context of disaster risk,[29-33,35] the progression of vulnerability is conceptualized at three levels: root causes, dynamic pressures, and unsafe conditions. According to Wisner,[30] vulnerability can be traced from unsafe conditions through economic and social (dynamic) pressures to the underlying root causes. The HoPM positions vulnerability at the center of hazard and risk. Risk is defined as a combination of social and physical factors. When a hazard is imminent to a community, physical risk results from the frequency or probability of the hazard occurring, as well as its magnitude.[36,37] The extent of social risk faced in a community is determined by the interaction between the hazard and the community's

vulnerability. Vulnerability represents the susceptibility of a community to experience losses, including human, physical, and economic, as a result of a hazard. Location underscores the linkage among vulnerability, risk, and hazard. Previous studies suggest that locations with low vulnerability exhibit low risk, and vice versa.[38,39] Therefore, while physical, social, and economic factors determine risk, risk can be reduced through AC. The conditions shaping these vulnerability factors and AC are discussed below.

1.1.1. Physical vulnerability (PV)

PV incorporates indicators of structural and environmental sensitivity.[39] Physical conditions relate to infrastructure, which aims to enhance the resilience of physical assets to losses and damages from hazardous events.[20,39] Key components of PV include topography, proximity to environmental features such as rivers and water bodies, building depth, structural condition, and construction materials.[40] Birkmann *et al*.[11] highlight that PV relates to the geography, infrastructure, and population of an area or region. The physical components that shape the conditions of PV include geomorphological and climatic characteristics, as well as infrastructures such as buildings, dams, and levees.[41-43]

This study considered elements of infrastructure—such as construction materials and the nature of buildings—to define the physical causes of vulnerability. The use of such physical indicators is supported in the literature. Birkmann *et al*.[43] indicate that the physical dimension of vulnerability depends on the exposure and fragility of ecosystem services on which people depend, such as water systems and infrastructure. Mwalwimba *et al*.[44] conducted a study to develop a flood vulnerability framework for rural and urban informal settlements in Malawi and classified PV as a combination of physio-exposure factors. PV and exposure components were combined using a binomial multiple logit regression model to predict physio-exposure factors contributing to household flood vulnerability. They found that housing typology, lack of construction standards, and building materials contribute to vulnerability. In this regard, physical causes of vulnerability should be particularly selected based on material aspects of the physical environment that may be affected by location. Physical infrastructure represents indicators of vulnerability that can be assessed at the community level.[34,45]

1.1.2. SV

Birkmann *et al*.[11] state that vulnerability patterns are not universal but often depend on specific contextual conditions and development processes in the respective country or region. Therefore, SV refers to the impact of disasters on societal structures.[41,46] Key determinants of SV include limited access to health services, education, and social networks.[42,43] Other studies in the literature emphasize poverty, social marginalization, weak social networks, and powerlessness as key social causes of vulnerability.[44,45] Birkmann *et al*.[11] further indicate that the social causes of vulnerability include, among other aspects, justice, social differentiation, societal organization, and individual capacity.

Most people residing in disaster-prone areas have limited access to social services such as healthcare, education, and decent housing. They also lack access to knowledge and information that can improve their quality of life, including limited access to safe shelter.[41,47,48] Moreover, vulnerability among these populations increases because they live in hard-to-reach areas.[20,42] Often, such areas are difficult for emergency services to access, and the remoteness of these locations creates challenges for the delivery of relief and recovery assistance during disasters.[34] Mwalwimba *et al*.[44] found that social factors contributing to vulnerability include limited access to communication, lack of training and advocacy, and human rights issues. Birkmann *et al*.[11] highlight several characteristics of SV, including livelihoods and resilience, self-protection, social protection, and social networks. Iloka[34] emphasizes that social conditions such as health and nutrition, education, and illiteracy contribute to community vulnerability to hazards and disasters. Other studies describe SV as losses incurred due to population characteristics, including age, health, gender, poverty, and employment.[39] In this study, SV was analyzed based on societal conditions, such as coping capacity, access to social services, community risk perception, and interpretation of warning information.

1.1.3. Economic vulnerability (EV)

EV is related to the availability of economic resources in a country.[39] It refers to the ability of a country to support itself during a disaster and the susceptibility of its economy to disasters. A country's economic stability and the financial resources allocated to DRM determine EV. Individuals are considered more vulnerable to economic challenges due to their levels of economic well-being.[12,41] In most cases, local people are marginalized from the economic mainstream and live in poverty.

Poverty is widely recognized as one of the most important causes of EV[20,39,41] because the poor tend to

have lower coping capacities and bear a disproportionate share of disaster impacts. Iloka[34] further stipulates that dependency on limited resources and agricultural production contributes to vulnerability in the absence of household and community-level precautions. Previous studies also indicate that limited access to resources and wealth, a weak national resource base, and low levels of technological advancement determine variations in vulnerability and exposure.[38,41] Munthali *et al*.[39] note that EV includes indicators associated with monetary hazard losses. It is also related to income levels and structural weaknesses in economies predisposed to flooding. This study considered EV parameters such as poverty, lack of alternative livelihoods, and limited income-generating activities to contextualize vulnerability, hazard, and disaster risk assessments based on the HoPM.

1.1.4. AC

Vulnerability and hazard reduction require measures that can increase household resilience to disaster risks. These measures can be generated within the community through households' AC or outside the community through institutional support.[46] AC refers to the ability of a system (e.g., local government), population (e.g., low-income community in a district), or individual/household to take actions that help avoid losses and accelerate recovery from a hazard.[47] The availability or absence of AC to cope with risks influences the vulnerabilities of households. For example, low-income households are often disproportionately affected by extreme weather due to their greater exposure. Cutter *et al*.[4,5] suggest that AC can mitigate disaster risk by reducing vulnerability. It is further emphasized that AC is determined by the characteristics of communities, countries, and regions.[41]

Studies indicate that AC is related to coping capacity, adaptability, conflict management, and resilience.[20] However, a closer examination of these terms reveals a distinct difference. The Intergovernmental Panel on Climate Change[49] defines AC as the ability of a system to adjust to extreme events to minimize potential damages, take advantage of opportunities, or cope with consequences. While this definition broadens the conception of AC, it incorporates key aspects of adaptation and resilience. Liu *et al*.[50] note that the concept of AC is complex, as it has been defined differently across disciplines. The concept relates to a range of resources and assets, comprising four interconnected categories: economic/financial, social, informational, and community.[34,51] In disaster resilience literature, AC refers to counteracting mechanisms that reduce the effects of hazard exposure and susceptibility.[34] Given its complexity, this study defines AC as a set of actions and resources employed by households to withstand a hazard that interacts with vulnerability and results in a disaster, across the pre-, trans-, and post-disaster phases. In simpler terms, AC refers to actions that people take to reduce vulnerability and to adapt, absorb, and cope with a hazard event in both short- and long-term processes.

Cutter *et al*.[5] state that the components of AC include access to information, access to resources, and the role of institutions. It is also emphasized that barriers that hinder communities from adapting to natural hazards should be considered part of AC.[48] Pauw *et al*.[41] argues that AC is influenced by factors such as awareness of natural hazards, mobility, socioeconomic status, duration of residence, and the extent of community support. Despite these variations, it is important to note that people in the community have their own adaptive measures to respond to natural hazards, and these must be utilized. Mtembenuzeni and Kushe[33] observed that communities in flood-prone areas of Malawi are adapting to floods, but their AC remains insufficiently understood.

This study highlights that assessing the AC of households to hazards is crucial for understanding their level of preparedness, response, and recovery. Once these levels are understood, the role of institutions in DRM may include activities that strengthen absorptive, adaptive, and transformative capacities across the pre-, trans-, and post-disaster phases. However, evidence on these capacities remains limited, as indicators for assessing AC are not well established in Malawi. This situation has led many studies to adopt indicators based on the purpose of the research and the disciplinary background of the researcher. It has also resulted in state and non-state organizations becoming constrained within absorptive responses,[52] focusing primarily on short-term relief rather than implementing long-term solutions to support communities. Maldonado-Méndez *et al*.,[53] however, identified several determinants for AC, as presented in Table 1.

Pathways to AC include absorptive capacity, defined as the extent to which institutions responsible for DRR are able to provide communities with protection during disasters.[54] It is a component of disaster response, and most activities rely on the availability of resources, infrastructure, and emergency management. This understanding makes AC different from community-level and household-level capacities.[41] Second, factors that trigger AC may range from resource availability to resource allocation and utilization. In this case, AC refers to the ability of organizations to adjust operations

Table 1. Indicators for measuring adaptive capacity

Code	Indicator/determinants
1	Technological adaptation options
2	Distribution of resources within the population
3	Availability of institutions, resource allocation, and decision-making
4	Human capital and education for personal security
5	The stock of social capital includes the definition of property rights
6	The system's access to risk-spreading processes (e.g., insurance)
7	Information management, leadership ability to set disputes, credibility of information

Note: Data adapted from Maldonado-Méndez *et al*.[53]

and reconfigure processes to maintain service delivery.[54] Iloka[34] outlines seven key factors influencing AC, namely the availability of funds, the roles of politics and polity, human relations, the level of managerial skills, access to relevant technologies and information, the type of infrastructure, and the adaptation environment. The third pathway is transformative capacity, which involves the ability of institutions responsible for DRR to change structures, functions, and governance systems to ensure long-term sustainability. Thanvisitthpon *et al*.[55] argue that there is a lack of consensus on how to incorporate transformative AC. Barriers to the adoption of transformative AC include the perceived attractiveness of response activities, the reluctance of external institutions to pursue sustainable measures, and the lack of clear regulations to guide organizations in disaster aid assistance. There are six components of AC: economic resources, social capital, awareness and training, technology, infrastructure, and institutions.[56]

A study conducted by Thanvisitthpon *et al*.[55] on the AC of Phetchaburi Municipality in Thailand, using the six components of AC, revealed that the municipality's AC in response to flooding was high in the economic resources and infrastructure components but low in social capital, technology, institutions, and awareness and training. Bixler *et al*.,[25] in their study of AC in urban environments in Austin, Texas, United States, demonstrated that social capital measures (e.g., neighbor cohesion, flood protection behaviors, trust, and network) are associated with SV and help explain the AC of residents. Their findings indicated a significant effect of social capital on flood mitigation as an adaptive measure.[57]

In a dynamic assessment of AC to climate change, a study of water management in Makondo, Uganda, found that AC is shaped by power relations, gender-based village-level water governance, context-specific strategies, the application of local knowledge, and the diversification of livelihoods. Mwalwimba *et al*.[58] conducted a study to assess the role of indigenous knowledge in DRR and climate change adaptation in Chikwawa District, Malawi. They found that the lack of integration of indigenous knowledge systems (IKS) in DRR contributes to gaps in awareness and community resilience-building. This, in turn, exacerbates community vulnerability to climate extremes.[59]

2. Materials and methods

2.1. Study area

Chikwawa and Balaka are located in the southern region of Malawi (Figure 1). The districts exhibit notable differences in geographical position and climate. Chikwawa is situated at approximately 16.03°S latitude and 34.80°E longitude, with a low elevation of approximately 95 m above sea level.[59] Its proximity to the Shire River and location within the lower Shire Valley contribute to a hot tropical climate characterized by high temperatures and seasonal rainfall. The district experiences average annual temperatures of around 25.8°C, with the hottest months being October and November, during which temperatures can reach up to 34.9°C.[59] Rainfall is highly seasonal, concentrated between November and April, with January receiving the highest precipitation (approximately 192 mm).[59] This climatic pattern makes the region suitable for crops such as sugarcane but also increases exposure to frequent flooding and prolonged dry spells.[59]

In contrast, Balaka is located farther north at approximately 14.98°S latitude and 34.96°E longitude, and lies at a higher elevation of about 640 m above sea level.[59] This increased altitude contributes to slightly cooler and more temperate conditions than those of Chikwawa. The district has a tropical savanna climate (Aw), with annual temperatures ranging from 22°C to 32°C, and peak values in November and December often exceeding 35°C.[59] Balaka receives more consistent rainfall than Chikwawa, averaging approximately 1,200 mm annually, primarily during the wet season between November and April.[59] The moderate temperatures and more favorable rainfall distribution support a wide range of agricultural activities, including the cultivation of maize, groundnuts, and cotton. However, similar to Chikwawa, Balaka remains

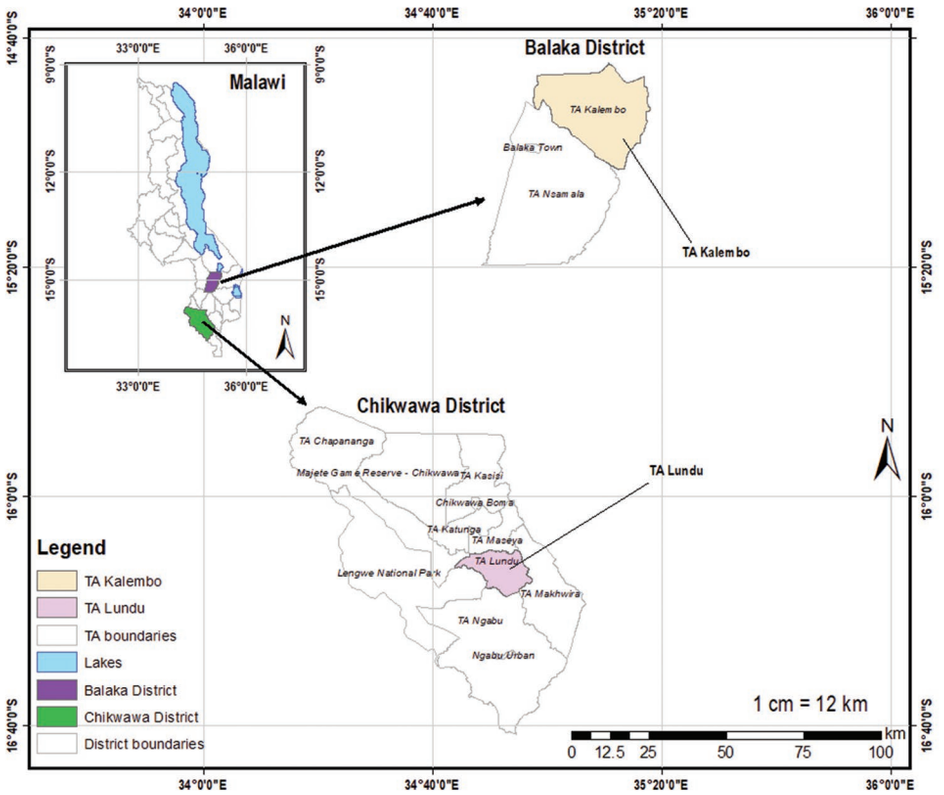

Figure 1. Location of Chikwawa and Balaka districts in Malawi
Abbreviation: TA: Traditional authority.

vulnerable to climate variability, which can negatively affect agricultural productivity.

The study was conducted in the TAs of Kalembo and Lundu in Balaka and Chikwawa districts, respectively (Table 2). In each TA, four Group Village Headmens (GVHs) were targeted. In the TA of Lundu, the selected GVHs were Kanseche, Mafale 2, Sekeni, and Chipakauza, while in the TA of Kalembo, the selected GVHs were Kalembo, Nkweta, Nandumbo, and Nkanda. The two areas were selected because they are prone to natural hazards, which make residents vulnerable to disasters on an annual basis. The choice of these areas was also influenced by the high occurrence of water- and weather-related events, such as floods and droughts.[59]

2.2. Study approach

To conduct an in-depth analysis of vulnerability, hazard, and disaster risk at the household level, this study employed a qualitative cross-sectional survey. The qualitative method relied on community-generated, in-depth data based on local perceptions of vulnerability, hazards, risks, resilience, adaptation, and social accountability.

Table 2. Target traditional authorities and Group Village Headmen in Chikwawa and Balaka districts

Traditional authority	Group Village Headmen
Lundu	Kanseche
	Mafale 2
	Sekeni
	Chipakauza
Kalembo	Kalembo
	Nkweta
	Nandumbo
	Nkanda

Note: The data (villages) were collected directly from the community by the authors during data collection.

The community-generated survey involved community members, local leaders (chiefs and elders), the village DRM committee (VDRMC), the village development committee (VDC), and officials from government departments, non-governmental organizations (NGOs), the private sector, and civil society organizations.

Purposive sampling was employed to select the target population, which included community members

in the eight GVHs, DRM committees for each village (VDRMC and VDC), and local leaders such as chiefs and elders. This sampling technique is commonly used in qualitative research, particularly in small-scale studies. Purposive sampling is a non-probability method—respondents are not randomly selected but are deliberately chosen.[20] The sample size of 352 participants was established in the field based on the number of community members interviewed. The number of villages from each GVH was determined using 30% of the total villages in the selected GHV within each TA.

2.3. Data variables and selection

Data variables were selected from the HoPM, primarily focusing on biophysical vulnerability and SV. The model was developed by Susan Cutter in 1996 and revised in 2003 (Figure 2). The HoPM is used to analyze and explain the vulnerability of different locations to natural hazards by considering a combination of physical and socioeconomic factors, as well as AC measures. While the original research was conducted in the United States, particularly in Charleston, South Carolina, the model has also been applied in Canadian contexts to assess the vulnerability of specific regions to natural hazards such as floods, wildfires, and earthquakes.

In the HoPM, risk refers to the likelihood of a hazard event, while mitigation encompasses activities designed to minimize the risk or potential impact. The intersection of risk and mitigation therefore produces hazard potential, which—depending on the extent of occurrence—interacts with the geographic context (e.g., location, elevation, proximity) and social fabric (e.g., socioeconomic factors, experience, risk perception). The attributes of the geographic context and social fabric constitute the components of biophysical vulnerability and SV, respectively. This framework implies that place vulnerability arises from the combination of biophysical and social vulnerabilities, providing tools to address disaster risk in society. However, research remains limited in developing countries such as Malawi, where the model has not been sufficiently applied to inform decision-making tools, including community engagement and resilience frameworks at the local level.

Based on the HoPM (Figure 2), three main themes were developed: (i) dimensions of hazards, vulnerabilities, and disaster risks; (ii) Disaster preparedness, resilience building, and AC; and (iii) Community engagement and resilience toolkits. During interactive sessions, participants shared information on the three themes in detail, which facilitated a deeper understanding of vulnerability, hazard, and disaster risks.

2.4. Local adaptability of the model

In applying the HoPM, this study evaluated its local adaptability, particularly by examining the differences between the model and the Malawian context, such as social structures (i.e., TA systems) and geographical features (i.e., river valley terrain). The adaptability was further assessed using other frameworks that exist in Malawi, such as the flood vulnerability assessment (FVA) framework developed by Mwalwimba *et al*.[20] (Figure 3).

The FVA conceptualizes vulnerability as the interaction between underlying vulnerability factors (i.e., physical, social, economic, and environmental) and vulnerability components (i.e., exposure, resilience, and susceptibility). Based on these factors and components, a combination of issues—such as

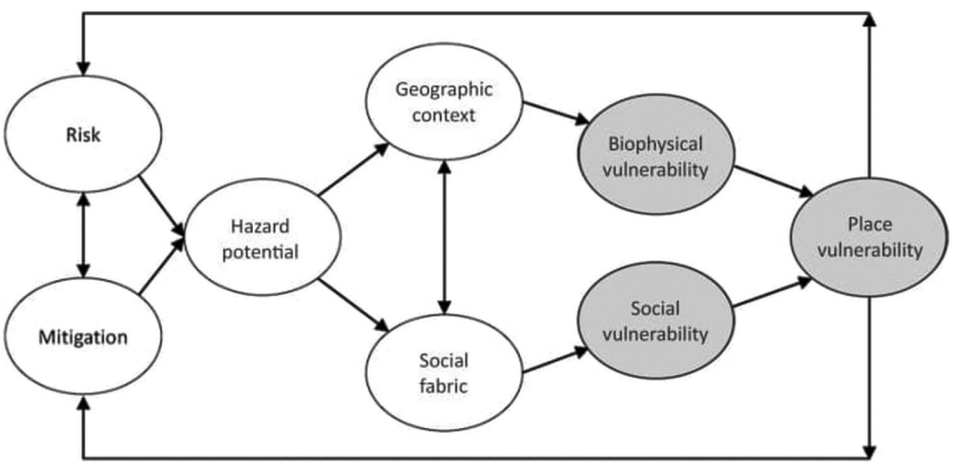

Figure 2. The hazards-of-place model

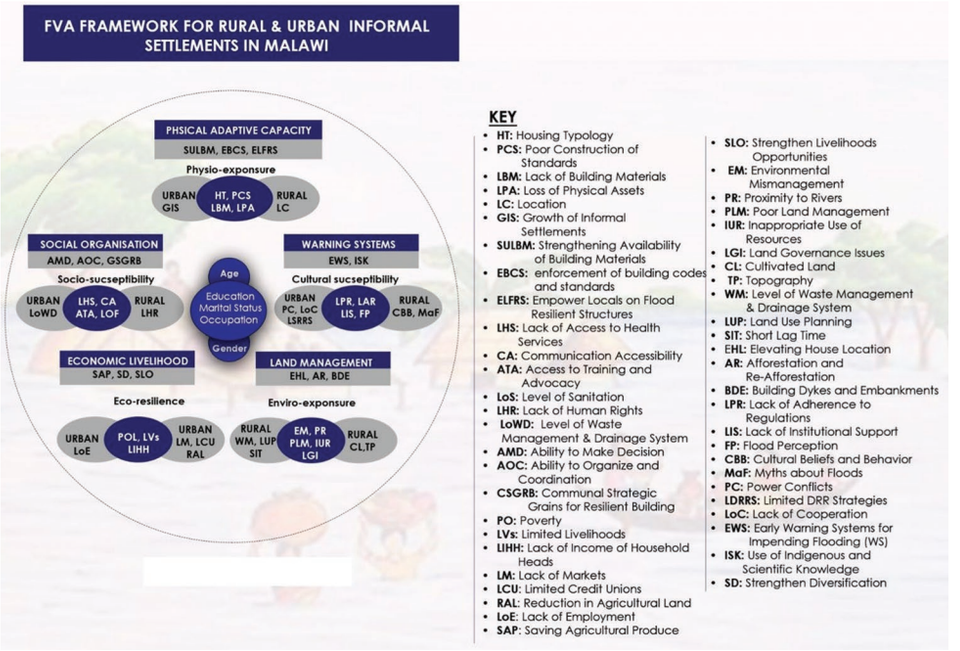

Figure 3. Flood vulnerability assessment framework. Adapted from Mwalwimba *et al*.[20]

settlement location, construction standards, community knowledge of hazards, reliance on social relations, cultural myths and norms, and limited technologies—contributes to an individual's vulnerability to natural hazards in Malawi. Therefore, most of the attributes highlighted in the HoPM, particularly biophysical and social vulnerabilities, are applicable in Malawi, as demonstrated by the FVA framework. However, since the model was developed in the United States, a developed country, its adaptability differences are likely related to mitigation measures. This is because, while individuals in both developing and developed countries may experience similar risks that generate hazard potential from comparable vulnerability drivers, the level of adaptation may differ depending on resource availability for mitigation, which in turn affects the recovery process.

2.5. Population sampling method

The population for this study comprised different groups, including women, men, youths, the elderly, chiefs, members of the VDRMC, area DRM committee (ADRMC), district DRM committee (DDRMC), organizations, religious institutions, and companies. This study employed a purposive sampling method. Participants were selected purposively, and the sample size was determined based on data saturation, which was identified during analysis, to provide the final sample distribution in the study results.

2.6. Data collection

Data were collected using unstructured questionnaires, semi-structured interviews, and focus group discussions (FGDs). To ensure validity and reliability, all tools were pretested in the study areas. The pretesting focused on determining whether: (i) the questions captured the intended data for each theme; (ii) the time allocated for each tool per participant or FGD was appropriate; and (iii) the wording of specific terms was clear and suitable. Following pretesting, the tools were revised; for example, some questions were moved from the disaster risk theme to the vulnerability theme. In addition, validation of the results was performed with the VDRMC, ADRMC, and DDRMC. Inputs from the validation exercise were used to enhance the robustness of the study findings.

2.6.1. Unstructured questionnaire

Unstructured questionnaires were used to collect in-depth data on the dimensions of hazards, vulnerabilities, and disaster risk, including characteristics of hazard exposure and the socioeconomic conditions of the community. A total of 32 participants were involved, including chiefs, community leaders, and members of the VDRMC and ADRMC. The unstructured questionnaires were administered through face-to-face interviews, which lasted approximately 90 minutes. The questionnaire was employed to assess the extent of vulnerability based on people's understanding of

hazards, risks, and vulnerabilities. In-depth personal interviews were also conducted to capture perceptions and coping strategies related to hazards. This approach provided a deeper understanding of the community's lived experiences with varying degrees of risk and vulnerability.

2.6.2. Semi-structured interviews

Semi-structured interviews were conducted with key informants to gain a deeper understanding of vulnerabilities, hazards, disaster risks, and capacities by engaging with individuals who influence local communities. These interviews also ensured the inclusion of local DRM committees, which play a central role in activities that contribute to the success of DRR initiatives in the area. Moreover, communication with key informants enhanced the likelihood of obtaining accurate information on local activities (capacities) aimed at reducing vulnerability. Such activities tend to be more effective when supported, rather than challenged, by those in authority or positions of power. The key informant interview guide contained structured questions, which were asked during face-to-face discussions with 20 key informants. Each discussion lasted approximately 1 h.

2.6.3. Focus group discussions

Focus group discussions were conducted to solicit participants' views on the vulnerability of local communities and their capacity to prepare for, respond to, and recover from disaster events. Two FDGs were conducted in each GVH with members from each village. These discussions were designed to engage individuals who had different perspectives, levels of knowledge, and understandings compared with the majority, to establish variations in vulnerabilities, capacities, and DRR measures in the area. In addition, the FGDs provided opportunities for community members to share their experiences and perceptions of features within their communities that support disaster response. In total, 15 FGDs were conducted, each involving 20 participants. These FGDs were organized at the VDRMC level within each GVH.

2.7. Data analysis

The qualitative data from unstructured questionnaires, key informant interviews, and FGDs were analyzed descriptively. Data were read and examined carefully to provide a detailed understanding of the nature of the problem that contributes to vulnerability. The specific issues analyzed for both key informants and FGDs included hazard profiles, community vulnerability, disaster mitigation, disaster response, DRR, community resilience building, and post-disaster recovery arrangements. From these themes, meaningful patterns were established to support the development of a community engagement and resilience framework. We further analyzed the cross-dimensional mechanisms of the vulnerability factors and their associated causes and risks. We used the terms "high," "medium," and "low" to illustrate the extent of vulnerability. In addition, we conducted a cost-benefit analysis of disaster response and mitigation measures using expert judgment. The expert judgment was based on the criteria of very large positive (++++), large positive (+++), medium positive (++), small positive (+), and insignificant (0) outcomes for the expected costs and benefits of four identified mitigation measures: dykes, behavioral change (adjustment of normal programs), local knowledge, and scientific systems.

3. Results and discussion

3.1. Sample distribution

The sample distribution results showed that a total of 352 participants were interviewed in the study, with details outlined by district and TA (Figure 4). Although the study was conducted using a qualitative approach, the relatively large sample size underscores the importance of capturing perspectives on DRM from a broad group of participants. This approach ensures that strategies for building community AC remain inclusive and supportive of long-term livelihood security.

3.2. Socioeconomic status

The socioeconomic status distribution across participants (Figure 5), including variables such as gender and age, revealed that more females than males participated in the study. The majority of participants were married, had completed primary education, and engaged in farming as their main occupation. These socioeconomic conditions shape the way people respond to hazards and disasters. Therefore, community disaster response activities should focus on sustaining adaptation strategies that promote long-term resilience.[20,31,39,60]

3.3. Dimensions of hazards, vulnerabilities, and disaster risks

3.3.1. Dimensions of hazards

The most common hazards reported by participants during the assessment were floods, droughts, strong

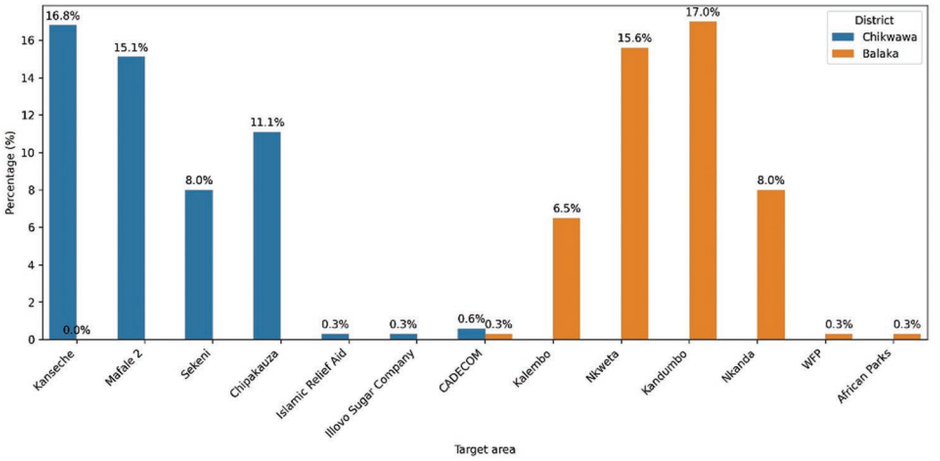

Figure 4. Distribution of target areas by district
Abbreviations: CADECOM: Catholic Development Commission; WFP: The World Food Programme.

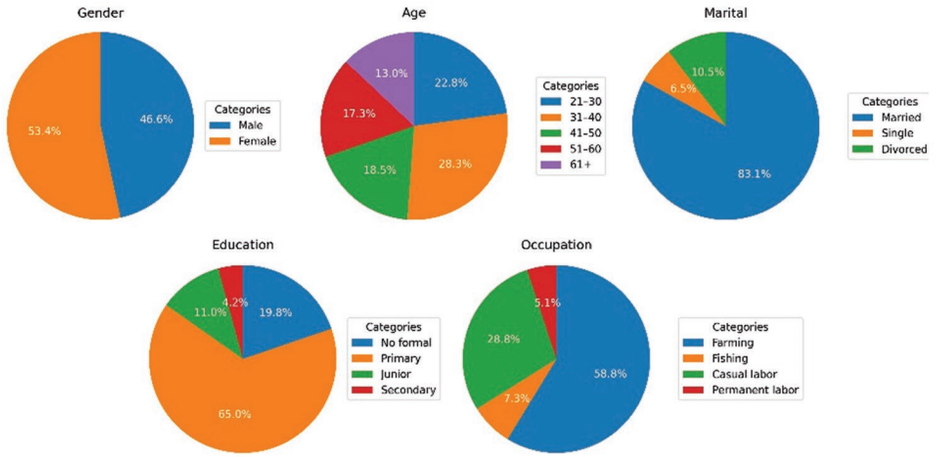

Figure 5. Socioeconomic distribution of participants

winds, armyworms, pests, and storms. For example, community members in the TA of Kalembo, Balaka district, indicated that floods are the most frequent hazards, occurring mainly during the rainy season. They also stated that droughts occur in the area, but not as frequently as floods. The communities reported that floods occur every year, often twice annually. Communities emphasized this frequency because most DRR measures, such as dams, dykes, and river training, do not fully exist to help mitigate rising water levels in the targeted villages. In general, the communities indicated that the frequency of hazards is high and that the severity of the hazards differs each year. They also emphasized that the impacts of these hazards vary from 1 year to another.

Similarly, community members in the TA of Lundu, Chikwawa district, reported that the most common hazards include floods, droughts, strong winds, and lightning. The occurrence of hazards in the TAs of Lundu and Kalembo demonstrates that the severity and behavior of hazards are influenced by the spatial and temporal characteristics of those areas (e.g., frequency, duration, and manageability). This understanding is supported by the HoPM, which posits that hazards occur in specific locations and have different impacts depending on an individual's vulnerability and resilience.[4,5] Therefore, strategies for disaster prevention, preparedness, response, and recovery should aim to strengthen the economic capacity of communities, particularly through transformative ACs.

In terms of attributes of identity, character, and meaning derived from social, economic, political, and biophysical processes occurring in the area, village members, through sketch maps of their villages,

indicated different objects to represent key features. Most villages in the TA of Kalembo identified churches, boreholes, mosques, rivers, and settlements on the maps they drew. Communities reported that these features play a pivotal role during emergencies, as some are used as evacuation centers (e.g., schools and churches). Similarly, communities in the TA of Lundu included features such as "big trees," anthills, agricultural land, rivers, and roads in their community maps. One community member reported that anthills help them find places of evacuation during floods: "we use anthills to construct temporary shelters during flood disasters." They also emphasized that the "big tree" serves as a community symbol and provides protection against strong winds.

These findings highlight the concept that community AC and disaster resilience can be facilitated through the inclusion of IKS. This aligns with the findings of Tembo,[57] which emphasize the importance of IKS in disaster risk mitigation. Therefore, the application of IKS in community disaster response needs to be communicated clearly and systematically to effectively reduce vulnerability and risk.

3.3.2. Dimensions of vulnerability and risks

The assessment revealed that people in the TAs of Lundu and Kalembo have specific vulnerabilities that place them at greater risk during hazards and disasters. It indicated that the vulnerability of men, women, children, people with disabilities, and the elderly varies across time and space due to factors such as a lack of awareness of impending hazards and disasters. The assessment further established that intertwined factors contribute to people's heightened vulnerability in the face of natural hazards and disasters.

First, the high poverty levels among people, often exacerbated by a lack of social protection mechanisms and livelihood opportunities, lead them to adopt behaviors that increase their exposure to frequent hazards and disasters. Such behaviors include poor farming practices, living in high-risk areas, land degradation, and deforestation.

Second, high illiteracy levels, evident in the majority of participants attaining only primary education, are exacerbated by children's failure to attend school because floods and heavy rainfall damage school blocks. This results in teachers and learners lacking adequate facilities for teaching and learning. Moreover, school blocks that remain intact are often used as shelters for communities, thereby disrupting lessons for children in the primary section. For example, in the GVHs of Kanseche and Mafale 2 in the TA of Lundu, it was found that children walk up to 8 km to attend a primary school.

Third, land governance and leadership power also contribute to increasing vulnerability. It was noted that the Illovo Sugar Company acquired the land belonging to the GVH of Kanseche several years ago, while people in the GVH of Nandumbo in Balaka are told that they occupy land belonging to African Parks. It was also noted that these companies, at times, deliberately undertake actions intended to force people to evacuate those areas. For example, Illovo constructs dykes to block water from the Mwanza River, which eventually causes flooding in the Kanseche area. This was identified as a major issue that also affects community engagement by the authorities. A key informant at the Illovo Sugar Company stated:

> In terms of community engagement, it depends on the issue. In some communities, like GVH Kanseche, which has settled on Illovo land, direct public meetings with such communities are difficult because of the perception of the people toward Illovo. The people always accuse Illovo of trying to disperse them so that sugar plantations can be extended. However, the issue is not that Illovo just wants to grab the land illegally, but it is the land which was given to the company by the government some 50 years ago, only that the company could not develop all the land at the same time. Hence, our community engagement meetings only target leaders of the communities.

Fourth, the lack of alternative livelihoods leaves many people dependent on rain-fed agriculture, so that in the event of crop failure, they do not have alternative sources of income. Fifth, the lack of access to adequate shelter and safety. Most people do not have resilient housing to withstand the disasters that they face. Most houses are traditional and substandard, predominantly made of mud floors and thatch. Sixth, the geographical location of some areas. For example, in the GVH of Kanseche in the TA of Lundu, Chikwawa District, the area is very flat, with open fields associated with clay soil, which has high water retention. The area is also located close to the Mwanza River, making it prone to floods.

Seventh, the lack of effective communication about impending disasters. Participants in the Kanseche area, Chikwawa District, stated:

> We have no communication about the magnitude and occurrence of floods; we rely on our human mechanisms, like observing clouds and animal behavior, like when we see chickens flying as high as the tops of trees. The moment we notice that, we

know that it is an indication of high rainfall with the likelihood of heavy flooding.

Eighth, resistance to evacuation from flood-prone areas. Village members reported that people often refuse to be evacuated because they want to take advantage of floodwater to plant their crops. Ninth, age-based discrimination, which serves to exclude and isolate older people and often violates their rights, since they may be unable to respond to disasters quickly. Finally, the physical decline (e.g., mobility and hearing problems) that accompanies aging reduces the ability of older people to respond promptly to impending disasters, thereby increasing their vulnerability.

3.3.3. Interaction mechanisms of vulnerability factors

The analysis of the cross-dimensional mechanisms of the vulnerability factors and their associated causes and risks was conducted. Table 3 presents the results of the dimensional analysis linking vulnerability factors, causes, and risks.

The analysis revealed that poverty, land governance, shelter and safety, and resistance to evacuation from flood-prone areas have been categorized with a higher cumulative causes of disaster vulnerability.

Poverty is associated with factors such as limited social protection and livelihood options, including insurance, credit unions, low-quality education, and lack of diversified livelihoods, among others. The lack of these social protections and livelihood opportunities exposes people to risks such as living in hazard-prone areas, loss of productivity due to land degradation, increased flooding due to catchment management degradation, and poor housing structures, including the inability to access proper construction materials. These risks increase people's vulnerability to hazards to the extent that when a particular hazard occurs in the community, the area is likely to face a disaster.

In Chikwawa, for example, poverty has been associated with land governance issues between the Illovo company and local communities. Many people have either consolidated their land with Illovo in the form of shares or sold it completely to the company, and some have been displaced for occupying company land. As a result, they have remained with limited land, which does not support sufficient food production for their families, while also leaving them exposed to hazards and risks.

Both communities in Balaka and Chikwawa are exposed to higher poverty because the locations are prone to drought hazards. These drought conditions hinder food crop cultivation for subsistence in the absence of irrigation technologies. Therefore, while biophysical conditions (e.g., geographical location) contribute to vulnerability, the dominant causes of vulnerability to hazards and risks in the study areas are linked to socioeconomic conditions (e.g., SV). These dimensions imply that multilevel stakeholder engagement to address these combined causes is crucial for implementing disaster risk interventions aimed at protecting communities within both biophysical and socioeconomic contexts.

The government is responsible for ensuring that these stakeholders implement long-term and sustainable interventions aimed at reducing disaster vulnerability, without necessarily focusing only on absorptive capacities. Other studies[11,43,52,60] assert that the political, legal, social, and economic responsibilities of the state should include enforcing laws, formulating laws with an understanding of vulnerability and the economic needs of the people, and avoiding the creation of laws that appear attractive only when disaster strikes.

3.3.4. Vulnerability differences between gender-based groups

The findings revealed that the variability of gender-based groups falls within physical, social, environmental, and economic categories of causes. Females and males lack physical assets, construction materials, social health services, credit unions, and access to income. In some factors, such as PV (e.g., construction standards and materials), no significant difference was observed between male and female exposure to hazards and risks. However, female-headed households, widows, and divorced women without male children are more vulnerable to hazards and risks than male-headed households. These groups often find it difficult to rebuild their homes once they are damaged by hazards such as floods.

In addition, we observed that when resources are allocated, leaders give priority to influential families who have the power to voice their concerns, rather than to widowed and divorced women. Similar to these results, Mwalwimba *et al*.[20] found that females experienced greater vulnerability than their adult male counterparts in TA Kilupula in Karonga District of Malawi due to limited power and control over resources shaped by societal differentiation.

Our findings suggest that reliance on farming as the main economic livelihood contributes to the vulnerability of both men and women. However, we noted that women, especially the widowed and divorced, are unable to plant their crops at the right time due to limited resources and support, a situation that

Table 3. Interaction mechanisms of vulnerability factors

Vulnerability factors	Causes of disaster vulnerability	Associated risks	Extent of vulnerability
Poverty	(i) Limited access to social protection, quality education, and weak land governance (ii) Poor economic opportunities and livelihoods	(i) Living in hazard-prone areas (ii) Land degradation leading to food insecurity (iii) Degradation of catchments, increasing flood risk (iv) Increased incidence of theft (v) Limited access to resources	High
Low education	(i) Poverty (ii) Age discrimination (iii) Geographical location (iv) Shelter conditions (v) Land governance issues	(i) Increased incidences of early marriages and pregnancies, drug and substance use/abuse, and delinquency behavior (ii) Low awareness of extreme events (iii) Disruption of the learning environment	Medium
Land governance	Selling of land due to poverty	Food insecurity issues	High
	Land control approaches (matrilineal system)	Temporary labor	High
	Weak laws governing land	Increased theft	Low
Alternative livelihoods	Dependency on rainfed	(i) Increased food insecurity (ii) Increased debts (iii) Children failing to attend school	Medium
	(i) Reliance on farming as the main livelihood (ii) Geographic location constraints		Medium
Shelter and safety	(i) Lack of construction standards (ii) Limited access to proper construction materials	Living in weak houses	High
Geographical location	(i) Flat topography (ii) Proximity to river systems (iii) Poverty (iv) Cultural values, attitudes, and practices	Higher likelihood of house destruction	Medium
Communication	(i) Limited scientific systems (ii) Reliance on local knowledge (iii) Education level (illiteracy) (iv) Risk perception and communication	(i) Increased loss of livelihoods and infrastructure (ii) Increased government expenditures	Medium
Resistance to evacuation from flood-prone areas	(i) Resistant to relocation (ii) Weak law enforcement (iii) Poverty (iv) Illiteracy levels	(i) Increased loss of livelihoods and infrastructure (ii) Increased government expenditures	High
Age-based discrimination	(i) Exclusion of older people (ii) Delayed response (iii) Poverty (iv) Education	(i) Lack of basic needs (ii) Increased food insecurity	Medium

restricts their access to economic livelihoods. Ciurean and Glade[10] indicate that societal differentiations and injustices make females suffer disproportionately during disasters.

These findings suggest that most rural households are vulnerable to floods because they depend on limited livelihood options, with agriculture being the primary source of subsistence. As reported by previous studies,[12,38,41,42] these existing economic dynamics between men and women should be well understood and prioritized for integration into disaster mitigation and preparedness activities, including social protection.

Future DRM programming should focus on building transformative capacities, such as the establishment of disaster risk financing mechanisms (e.g., DRR funds) that can be used in mitigation efforts to improve the quality of life for women, men, and children.

3.4. Disaster preparedness, resilience building, and AC

3.4.1. Disaster preparedness

Disaster preparedness involves strengthening the capacity of communities to withstand, respond to, and recover from hazards and disasters.[60] The assessment established several activities undertaken by communities to strengthen their preparedness to cope with and recover from disasters. In addition, institutional activities from government and non-governmental organizations were reported to assist in preparedness. Key activities reported by the communities as part of disaster preparedness include installation of rain and river gauges to predict the occurrence of floods; engaging in afforestation and re-afforestation programs along riverbanks; construction of dykes; planting bananas along rivers; promoting conservation agriculture; provision of life jackets, whistles, and gumboots for emergency rescue; enhancing the capacity of communities and individuals to adapt their livelihoods to climate variability by encouraging the planting of multiple crop varieties; and disseminating weather forecast information. While acknowledging these preparedness activities, respondents also indicated that some of these activities are supported by organizations such as the United States Agency for International Development, Emmanuel International, World Vision, United Purpose, the World Food Programme, and Plan Malawi International.

It was also established that the Illovo Sugar Company helps the community prepare for emergencies such as floods by clearing drainage channels to facilitate water flow. One key informant from the company highlighted that before clearing the drainage channels, the company conducts community meetings to involve villagers in the process. The key informant stated, "Illovo helps to maintain the dykes as part of supporting the communities in Kanseche and Mafale 2 to prepare for the impending disasters." Although this assistance is crucial, it is important to understand the interests of companies such as Illovo and African Parks, and how their actions or inactions affect the surrounding communities in disaster preparedness. In addition, some technologies, such as river gauges and rain gauges, may build capacity to face disasters but can be difficult to use effectively in remote areas, thereby hindering disaster preparedness. This complexity could be due to the socioeconomic challenges faced by poor and marginalized groups in society.

3.4.2. Resilience building

Based on the assessment, the findings revealed that communities engage in various activities to build resilient livelihoods and establish preventive measures. For example, communities in the TA of Lundu, Chikwawa District, reported that they work together in various areas to build their resilience to floods and other hazards before, during, and after disasters. They reported that they coordinate community-level DRR-related initiatives with village heads, such as building flood defense systems, fixing roofs, and strengthening houses. They also encourage one another to engage in activities such as planting grass on riverbanks to reduce flooding.

Communities in the TA of Kalembo reported that they encourage chiefs to enforce bylaws prohibiting community members from cutting down trees on riverbanks. They also acknowledged that the VDRMC, in liaison with the VDC, undertakes tree planting as part of reducing the impact of climate change-related shocks. One member of the VDRMC stated that "one of our achievements as members of VDRMC is that we have managed to have a woodlot where different stakeholders bring their committees to appreciate what we are doing here." However, there is a need to further empower communities, especially the VDRMC, through training on how they can undertake and sustain these resilient livelihoods.

3.4.3. Community understanding of resilience

Building resilient livelihoods means enabling people to create buffers such as savings and other assets and helping them invest in strategies such as food preservation and storage, safer housing, and children's education, thereby reducing household vulnerability. This study established how community members understand resilience and their subsequent training needs.

Based on the assessment, the findings revealed that community members have a broad understanding of a resilient society, highlighting various indicators such as strong houses, uninterrupted school attendance for children, sufficient food supplies, ownership of livestock, financial resources, adequate clothing, and access to health facilities. However, during FGDs and key informant interviews, most community members reported that they are unable to achieve a resilient

society because many disaster-affected people are often forced to resort to harmful coping strategies, which further increase their vulnerability. This reality keeps many people trapped in a vicious cycle of poverty and heightened destitution as a result of shocks, stresses, and disasters. The participants suggested that it is important to ensure mechanisms are put in place to provide access to credit and other financial schemes.

In addition, the findings revealed that communities need assistance in various aspects to enhance resilience and thereby reduce vulnerability. During FGDs and key informant interviews in both TAs of Balaka and Chikwawa, community members highlighted a combination of the following aspects:

(i) Supporting communities to establish small-scale irrigation farming to enable crop cultivation during the dry season
(ii) Strengthening the efforts of different stakeholders, such as the Village Child Protection Committee, to help members access services and pool resources, skills, and knowledge
(iii) Providing basic training for emergency responders on strategies such as planting vegetative grasses on riverbanks and implementing other disaster mitigation measures
(iv) Promoting land management coping strategies. For example, creating outlets to manage water overflow and planting trees and grass along riverbanks
(v) Assisting communities in constructing dykes and other embankments to control water flow. While these dykes are crucial, they need to be properly designed to prevent future flood-related vulnerabilities. For instance, some community members in the TA of Kanseche reported that dykes constructed by Illovo Sugar Company obstruct water flow, causing it to return to their villages and create damage
(vi) Assisting households with income-generating activities, such as the provision of early-maturing rice varieties, cassava, and maize seeds for crop diversification, as well as training community members in village savings and loan schemes.

3.4.4. AC

The findings revealed that communities possess a range of capacities that they use to respond to and prepare for the occurrence of natural hazards or disasters. Therefore, there is a need to recognize and support these capacities so that they make a significant contribution to all stages of disaster management activities, from risk assessment to operational response and recovery. According to information obtained from community members during both FGDs and key informant interviews, the study identified the following capacities within communities:

First, villagers have extensive traditional and indigenous knowledge that they use to predict impending flooding. This knowledge can serve as a valuable source of information on local hazard and risk profiles as well as sustainable community-based mitigation strategies. For example, people in the GVH of Kanseche reported the use of traditional indicators, such as the appearance of millipedes and chickens roosting in trees, to signal heavy rainfall. One member of the GVH stated that "when we see a large quantity of mangoes produced in that year, we know that rainfall will be less, which will likely cause drought." However, officials from government departments indicated that scientific knowledge is also provided to communities through the support of NGOs and messages from the Department of Climate Change and Meteorological Services. They reported that rain gauge systems have been installed to generate rainfall data, which can be used to predict flooding.

Second, it was acknowledged that river-gauge systems had been installed in some rivers to provide data on water levels for predicting flooding. Moreover, it was found that communities had been provided with loudspeakers as part of early warning systems. It was also noted that other local initiatives, such as drumming and whistles, served the same purpose as loudhailers. Key informants also reported that they received messages from the Department of Disaster Management Affairs by phone. The messages were disseminated to the community through gatherings convened by chiefs.

Third, villagers have developed ways of protecting their belongings. They construct local structures inside or outside the house, which they use to store items (e.g., food, clothing, household utensils) during floods. However, it was observed that cultural beliefs led many people to accept floods as an inevitable part of life. Even when warnings are issued—or not issued—it was noted that, due to a lack of resources and limited education, their capacity to evacuate from flood-prone areas remains limited.

Finally, villagers engage in day-to-day DRR activities, such as using their traditional means of communication to warn about impending disasters. At times, they use drums to alert fellow villagers about the onset of disasters, such as floods.

The importance of traditional knowledge systems (TKS) and scientific systems (SS) is critical for

mitigating disaster risk. Therefore, the integration of TKS and SS is essential, supporting each other in the areas of (i) dissemination of early warning information, (ii) preparedness and response mechanisms, and (iii) planning disaster recovery, reconstruction, and resilience building. These pathways (Figure 6) are crucial for multilevel stakeholder engagement to ensure that both TKS and SS are part of broader strategies to minimize community vulnerability to disaster risk.

Based on this integration pathway, disaster information systems and dissemination should be strengthened to ensure that local people have access to communication channels, which would contribute to reducing human vulnerability to hazards and risks. This integration can further shape local people's risk perception, while ensuring that institutional responses to disasters and climate risks include mechanisms to verify the effectiveness of early warning messages. These pathways also provide an alternative for institutions and communities to jointly develop and formulate disaster risk messages that are people-centered. The significance of TKS is also acknowledged by other scholars,[41,57] particularly in enhancing DRM by expanding disaster communication channels and strengthening stakeholder collaboration for early warning and early action.

3.4.5. Disaster response through institutional support

Community members reported that various organizations, including the World Food Program, World Vision-Malawi, Goal Malawi, CARE-Malawi, Red Cross Malawi, and the Department for International Development, provide support before, during, and after a disaster. In both TAs, community members reported that they received assorted items such as agricultural seeds, flour, beans, pails, plastic plates, plastic sheets, and water guards. Regarding whether these items met their needs during emergencies, most community members acknowledged that the items were useful, as during such periods, people often lack food and other essentials necessary for survival.

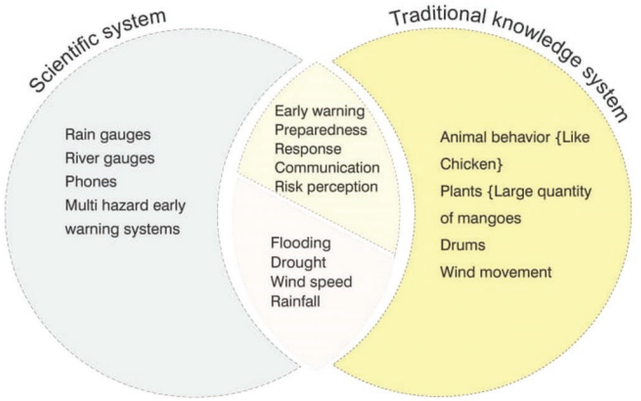

Figure 6. Integration pathway of traditional knowledge systems and scientific systems

However, some members reported that, at times, they received items that did not adequately address their problems. A key informant in the GVH of Kanseche stated that "we need dykes here to control water flowing into our villages rather than giving us temporary materials." Similarly, some community members reported receiving plastic bags, while their primary concern was food.

Other community members reported that the support was insufficient, as some victims of disasters did not receive assistance regardless of their vulnerability. The findings highlight that most of the support provided to the affected communities is short-term, offering only temporary relief without necessarily helping them to prevent similar situations in the long term. In some cases, these relief items may inadvertently create additional vulnerabilities, as people refuse to relocate from disaster-prone areas to continue receiving aid. For example, one key informant stated that "some people are used to handouts, so they deliberately do not own some of the initiatives that they are supported with, like tree planting. They would rather remain vulnerable to attract relief items."

3.5. Aid addressing mechanisms

Based on the analysis, the findings revealed that aid from NGOs and external enterprises increases people's dependency on relief supplies, thereby discouraging residents from relocating. The emphasis on aid leads most organizations (state and non-state) to focus primarily on absorptive disaster activities, such as relief and short-term emergency management (e.g., food, tents, water, and sanitation). The provision of these short-term absorptive functions reinforces community reliance on their inherently weak resources and traditional systems, which expose them to further risks. Whether due to the appeal of relief for both organizations and communities or the absence of robust policy frameworks to regulate aid distribution, most organizations in DRM are confined to absorptive functions. Unless aid support is properly regulated, DRM interventions aimed at reducing disaster vulnerability will remain unsustainable for building long-term community resilience.

Although aid support is important in short-term humanitarian activities, including protecting the lives of disaster-affected populations, the findings suggest that aid interventions should be regulated and balanced with

strong adaptive and transformative functions. Therefore, we propose three main aid addressing mechanisms:

First, the government should develop a clear policy for aid packages. This policy should provide guidelines on eligibility criteria, justification for aid provision, and the duration for implementing absorptive, adaptive, and transformative functions. Specifying the duration is essential to align these functions with disaster responses as part of the recovery process. For example, absorptive capacity can be aligned with short-term recovery aimed at assisting victims immediately after a disaster strikes, whereas adaptive and transformative functions should form an integral part of both pre-disaster preparedness and post-disaster recovery interventions.

Second, political influence in food aid distribution should be avoided. Although it is the duty of the state to protect its people during a disaster, the behavior of politicians often promotes a dependency syndrome among populations living in disaster-prone areas, discouraging them from relocating. In addition, food—specifically "Nsima," a local staple in Malawi—is frequently used as a campaign tool by politicians. However, food is a basic human right and should never be instrumentalized to secure votes, as the state has a duty to ensure its provision under any circumstances. Consequently, many statements made during campaign events offer only short-term promises or support that reflect the absorptive orientation of political institutions.

Third, it is necessary to address the gap between policy and practice in disaster management, particularly by ensuring urgency in policy formulation and implementation. Existing policies identify measures such as fostering national housing construction standards, strengthening institutional coordination, resettling populations in high-risk areas, mitigating environmental degradation that may trigger disasters, and integrating development programs with DRM. Although these measures have not yet been fully realized, their implementation could provide long-term interventions that strengthen adaptive and transformative capacities.

3.6. Cost-benefit assessment of disaster mitigation measures

The analysis examined the cost-benefit assessment of four disaster mitigation measures, namely the construction of dykes, behavioral change, local knowledge systems, and scientific knowledge systems. Table 4 presents the results of these four key mitigation measures, highlighting their approaches, associated activities, resources required, and feasibility rankings.

Based on Table 4, dykes and scientific knowledge systems fall within the category of protective measures, whereas the adjustment of normal programs and local knowledge systems fall within the problem-focused category. Dykes and scientific knowledge systems involve activities that are capital-intensive and associated with substantial maintenance costs. Although they provide higher benefits, their implementation requires supporting structures such as technical assessments, design codes, and monitoring and warning systems, as well as resources like power supply, which may not be feasible in communities in developing countries, where interventions are most needed. Nevertheless, the activities and resources required for mitigation measures that focus on adjusting normal development programs and utilizing local knowledge are less capital-intensive. These can often be generated within the community, with additional support from local institutions and government sector budgets.

3.7. Community engagement and resilience framework

The community resilience toolkits are formulated based on the dimensions of vulnerability, hazards, and risks. It is important to note that institutions are responsible for building community resilience to specific hazards and should integrate considerations of vulnerabilities, hazards, and risks. The indicators are grounded in the community's practical realities rather than solely in the theoretical knowledge embedded in policies and protocols. Figure 7 presents a framework for community engagement and resilience to natural hazards at the local level in Malawi.

The framework connects the place of community engagement (area of project or study interest) with hazards, risks, and vulnerabilities. It places the hazard at the center, reflecting the idea that understanding hazards provides the foundation for vulnerability and risk assessments. This implies that vulnerability and risk assessments cannot be conducted in the absence of a hazard, and disaster risk remains theoretically low when a hazard exists but vulnerability is absent. Therefore, community engagement interventions (CEIs) aimed at strengthening community resilience to hazards need to account for the interconnections among disaster risks, hazards, and vulnerabilities. Wisner *et al.*[17] conceptualize disaster risk as the product of hazard and vulnerability (disaster risk = hazard × vulnerability).

In this framework, the indicators of hazards for resilience-building processes should underscore the

Table 4. Cost-benefit analysis of disaster mitigation measures at the community level

Disaster mitigation	Approach	Mitigation activities	Resources required and applicability to combine social and biophysical needs	Feasibility ranking	
				Expected costs	Expected benefits
Dykes	Protective behavior	(i) Construction according to the required dimensions (ii) Engagement of experts, including engineers, environmental specialists, and ecologists, for design and assessment (iii) Preparation of environmental and social impact assessments or management plans (iv) Technical assessments (e.g., soil, topography, hydrology)	Resources required		
			Financial	++++	++++
			Experts (internal or external)	++++	++++
			Constraints/benefits		
			Cannot be implemented with local skills and resources	++++	++++
			Requires external funding or support	++++	++++
			Capital-intensive	++++	++++
			May exacerbate vulnerability if poorly designed	+++	+++
			Sometimes unattractive to communities due to non-inclusive planning	++	++
			Potential to displace people	+++	+++
			Considers hazards as stand-alone entities	+	+
Changing behaviors—adjustment of normal programs (no business as usual)	Problem-focused coping	(i) Sensitization of communities on risks (ii) Understanding individual/community risks (iii) Planting crops suited to changing conditions (e.g., drought-resistant crops) (iv) Implementing shelter safety measures	Resources required		
			Financial	++	++
			Local experts (government officials and non-governmental organizations)	+	+
			Constraints/benefits		
			Not capital-intensive and can be implemented with local skills	+	+
			Use locally available resources	+	+
Local knowledge systems	Problem-focused coping	(i) Documentation (ii) Validation (iii) Integration with science	Resources required		
			(i) Financial support for documentation (ii) Local experts	++	++
			Constraints/benefits		
			(i) Not capital-intensive (ii) Utilizes local expertise	++	++

(*Cont'd*...)

Table 4. (*Continued*)

Disaster mitigation	Approach	Mitigation activities	Resources required and applicability to combine social and biophysical needs	Feasibility ranking	
				Expected costs	Expected benefits
Scientific knowledge systems	Protective behavior	(i) Development of warning systems (ii) Dissemination of information (iii) Monitoring weather and climate patterns	Resources required		
			Significant financial investments	++++	++++
			External and technical expertise	++++	++++
			Constraints/benefits		
			Capital-intensive	++++	++++
			Requires technical skills	++++	++++
			Dependent on the electricity infrastructure	++++	++++

Notes: The expert judgment was based on the criteria of very large positive (++++), large positive (+++), medium positive (++), and small positive (+) outcomes for the expected costs and benefits of four identified mitigation measures.

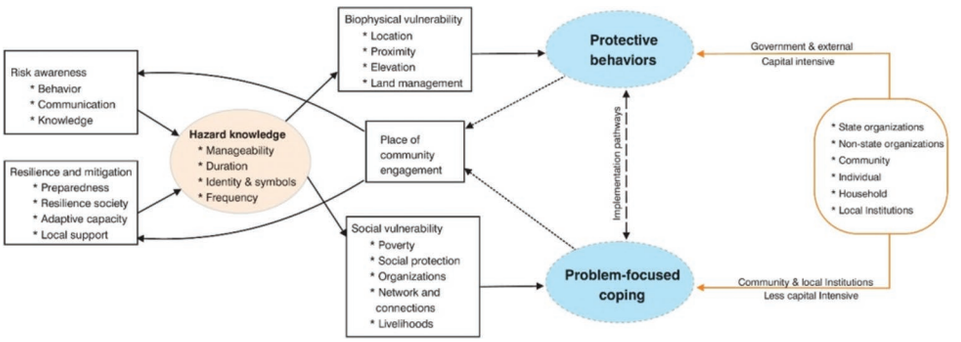

Figure 7. Community engagement resilience framework

spatial and temporal aspects of a particular hazard in a specific area of interest (place of community engagement), including manageability, duration, frequency, identity, and symbolic significance. Those involved in CEI should understand the interrelationships among risk, resilience, and hazard mitigation. Understanding disaster risk in a specific place should be based on risk awareness, local behaviors that influence risk, and risk communication. In terms of resilience building, specific issues such as community preparedness activities and local support should be targeted. Within the place of community engagement, biophysical and socioeconomic vulnerabilities should be assessed to determine the extent to which a particular hazard could heavily affect the community or increase the area's susceptibility to multiple hazards.

Based on the findings of the present study, particularly the indicators demonstrated in the community engagement and resilience framework, we infer that the HoPM is an applicable model for DRM implementation at the local level in Malawi. However, it does not explicitly specify indicators of hazards, risks, and resilience, which the current framework identifies through a community-based monograph assessment survey. Furthermore, regarding biophysical vulnerability, the HoPM remains silent on issues of land management, whereas this study has revealed land-related issues to be significant contributing factors to vulnerability in the study areas.

Similarly, regarding SV, the HoPM is unclear about what exactly constitutes the social fabric, making it difficult for stakeholders and users to determine which dimensions of the social fabric should be considered during community engagement. Therefore, given these shortcomings, the current framework can be applied to understand vulnerabilities, hazards, and risks at different community levels and serves as a tool to support DRM interventions because it provides clear toolkits for use during community engagement.

3.7.1. Framework implementation pathways

In the framework, two implementation pathways are suggested as strategic technical directions to influence the disaster responses of different stakeholders. The first pathway is a problem-focused coping intervention. This implementation pathway emphasizes that institutions such as communities, faith-based organizations, local NGOs, district councils, and households need to take action to prevent or reduce risks associated with the negative consequences of place-based vulnerability. Specifically, these institutions need to adopt protective measures in response to risks such as floods, droughts, and strong winds. These protective measures could be implemented at the individual, household, community, district, and national levels. The measures could include changing farming systems, promoting diversification, relocating to safer areas, and adjusting behaviors to current conditions.

The problem-focused coping intervention is not capital-intensive; it involves measures that are feasible in addressing specific risks. As such, allocation of resources to these measures could be at the microscale level, such as the village level, small groups of individuals, or the broader community level. These measures require collective action, as no person is entirely risk-free, to ensure some form of risk mitigation in areas of community vulnerability. More importantly, organizations and institutions can prioritize training communities within vulnerable areas, particularly on practical disaster response measures—activities that people can realistically undertake. For example, if a particular community has a water source yet faces food insecurity, the focus should be on training people to utilize the water source for food production. Similarly, if people are living too close to a water source, institutions should focus on building capacity and empowering individuals with skills and resources to ensure that the available water can be used to enhance their productivity. This means that capacity-building efforts should shift from being theoretical to becoming practical, thereby imparting the required skills.

Second, protective behavior is an implementation pathway that encompasses both structural methods of protection—such as barriers, zoning, land-use planning, human occupancy, relocation or resettlement, and AC—and non-structural methods—such as raising risk awareness, developing early warning systems, and providing disaster preparedness training and education. The protective behavior pathway is largely capital-intensive and therefore requires more planning, investment, and the commitment of various integrated government sectors, partners, and institutions. The implementation of this pathway also requires external funding from multilateral and bilateral institutions. International organizations such as the World Bank, the African Development Bank, and the European Union need to fully support this pathway. More importantly, this pathway should support the allocation of funds within the National Budget to ensure that the Malawi Government and institutions responsible for disaster and climate risk management (e.g., the Department of Disaster Management Affairs and the Department of Climate Change and Meteorological Services) are adequately funded for different activities and are not caught unprepared.

3.7.2. Framework and policy compatibility

The proposed community engagement framework is compatible with Malawi's national DRM policies (NDRMPs) in several aspects, including vulnerabilities, exposures, risks, hazards, DRM systems, and early warning systems. Similar to the proposed framework, the NDRMP identifies inadequate design standards, poor construction practices, and limited maintenance as causes of vulnerability in communities.[26] In both the proposed framework and NDRMPs, poor network coverage and inadequate access to certain media are recognized as limiting factors for effective early warning systems.

Although the national policies acknowledge the crucial role of IKS, they provide only a limited understanding of integration pathways. In contrast, the proposed framework advances this by outlining integration pathways, including categories of hazards that can be prioritized during the process. The NDRMP also emphasizes community participation, inclusivity, and a rights-based approach as a means of achieving DRR.

In the community engagement framework, community participation through problem-focused coping interventions is advanced as critical to strengthening community resilience to natural hazards. Similarly, the proposed framework and the NDRMP connect the effectiveness of DRR to the understanding of disaster risk through the assessment of vulnerability, capacity, exposure, and hazards in the community.

Although the implementation of structural and non-structural measures to reduce risk and vulnerability has been emphasized in the national policies and the proposed framework, the latter extends this by providing an economic feasibility analysis of implementing such measures at the community level. This extension could

provide a better mechanism for resource allocation, addressing the challenge of funding shortages, which have been identified as contributing to an institutional gap in disaster risk identification and assessments.

4. Conclusion

This study was conducted in the TAs of Kalembo and Lundu in Balaka and Chikwawa districts, respectively. The study applied the HoPM to assess vulnerability, hazards, and disaster risks and to develop a community engagement and resilience framework. The findings revealed several factors contributing to disaster risk and vulnerability:

(i) Physical factors, including the lack of permanent buildings, exposure to environmental features, and poor construction standards
(ii) Social factors, such as limited access to knowledge and information on DRR and DRM, and high illiteracy levels, which exacerbate vulnerability and risk
(iii) Economic factors, including the lack of alternative livelihoods and low community income, which further increase vulnerability
(iv) Demographic factors, which limit access to economic resources for certain groups, such as women and the elderly. These groups become even more vulnerable to future hazards when they enter the rainy season without sufficient food. Moreover, many children face difficulties attending school during disasters because of their age
(v) Environmental and land-use factors, such as residing in hazard-prone areas, deforestation, unsustainable farming practices, and land pressure due to poverty, also heighten people's vulnerability to hazards.

Given these factors, people are inclined to continue living in the same areas and are therefore impacted by natural hazards and disasters whenever they occur. Thus, the extent to which individuals in the TAs of Lundu and Kalembo in Chikwawa and Balaka districts are exposed to hazards directly influences their vulnerability to disaster risk.

5. Research limitations and future work

The findings of this study were obtained from data collected using unstructured questionnaires, semi-structured interviews, and FGDs with participants from Chikwawa and Balaka districts to develop a framework, which is proposed to be applied to other regions in Malawi. Therefore, this might have implications for the results, as it could overlook the differentiation of vulnerability causes across all regions in Malawi.

However, this study used variables from previous studies[58] conducted in Malawi to discuss the adaptability of the HoPM and the local structures. Thus, the proposed community engagement and resilience framework, including its outcomes, could be generalized across Malawi. Although we conducted validation of the results to ensure validity and reliability, certain potential subjective biases could still exist because of the nature of qualitative analysis. Vulnerability in itself is a time-bound concept; hence, it is dynamic rather than static. Its time-bound nature is rooted in spatial and temporal scales; therefore, certain conditions to which the outcomes of this study pertain might vary based on these scales. Consequently, future studies should be guided in this direction, including the need to frequently conduct vulnerability analyses to serve as benchmarks for DRR initiatives.

Above all, this study was conducted based on cross-sectional surveys, but it does not provide explicit evidence of the long-term impacts of disasters on communities, which could result from changes in household assets after repeated hazards such as floods. Therefore, future efforts should focus on conducting retrospective analyses of historical disaster data or implementing long-term tracking plans to verify the dynamic changes in vulnerability.

6. Recommendations

This study provides a community engagement and resilience framework that could serve as a basis for stakeholder engagement in DRM and act as a supporting tool for the implementation of interventions aimed at reducing multiple vulnerabilities and risks in communities. Therefore, stakeholders should commit to designing and implementing effective DRR projects to address the combined factors contributing to communities' vulnerabilities using the indicators established in this framework.

Policy makers should strengthen DRR and DRM strategies to reduce vulnerability and enhance community resilience. Government, institutions, and NGOs should strengthen DRM by:

(i) Enhancing early warning systems. This should be achieved by increasing community awareness through the use of local languages to tailor early warning messages, while integrating both indigenous knowledge and scientific or modern systems into DRR measures

(ii) Increasing resource mobilization for local institutions, which is not capital-intensive
(iii) Strengthening institutional capacity. This should include establishing proper evacuation centers through the development of memoranda of understanding between district councils and communities in disaster-prone areas. In addition, there is a need to build the technical expertise of community-level committees and institutions
(iv) Conducting disaster mitigation activities, such as repairing, clearing, or constructing roads for emergency evacuation, building flood defense systems, repairing roofs, and strengthening houses
(v) Providing continuous training to emergency responders, such as the VDRMC and ADRMC
(vi) Strengthening the integration of development and disaster resilience. The government should lead the development of specific guidelines for managing disaster risks associated with development programs (e.g., formulating construction standards that incorporate problem-focused coping interventions)
(vii) Enhancing monitoring and evaluation through periodic reviews of DRM activities based on current studies and plans
(viii) Leveraging academic collaboration for technical support. There is a need to build community capacity to prevent, prepare for, and respond to disasters, thereby increasing resilience and reducing vulnerability.

Stakeholders should equip people with sustainable interventions to build their capacity and resilience, thereby reducing vulnerability. Furthermore, strengthening community resilience to future shocks and crises requires improving people's ability to protect themselves from disasters through diversified livelihoods. The enforcement of policies on human settlement planning and relocation should be strengthened, including the implementation of bylaws to prevent indiscriminate tree cutting by village leaders

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Conflict of interest

The authors declare that they have no financial or personal relationships that may have inappropriately influenced their writing of this article.

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Ethics approval and consent to participate

Consent was obtained from the Chikwawa and Balaka District Councils to undertake the study in the traditional authorities of Lundu and Kalembo, respectively. Participants from both traditional authorities were consulted and provided their consent before the commencement of data collection. Participants were requested to sign the consent form before the interviews. They were also assured of confidentiality.

Consent for publication

Verbal consent was obtained from both participants and stakeholders for the publication of the data provided during the interviews.

Availability of data

Data for this article are available upon request to the corresponding author.

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