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# Measuring community flood resilience and associated factors in rural Malawi

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**Abstract**

With global estimates showing an increasing trend in flooding and its adverse effects on communities and population health, resilience is presented as a concept with potential to help integrate disaster risk management, sustainable development, and climate change adaptation concerns. Resilience research and practice have conceptual and empirical challenges of how to understand, characterize and measure resilience, particularly at community level. Using a multidimensional framework, this paper takes a systems approach to understanding, characterizing, and measuring community flood resilience. Through cluster analysis, bivariate methods and multivariable-adjusted binary logistic regression modeling, we developed a context and hazard specific construct of community flood resilience and investigated its predictor variables. The factors defining the community flood resilience construct captured the community needs to withstand disasters through purpose-built infrastructure, early warning systems for preparedness and utilization of local human capacity for adaptation. These results strengthen the previous arguments for utilizing a comprehensive multidimensional framework for resilience analysis. Access to services for improved health and psychosocial well-being was significantly associated with the three-item measure of being more flood resilient. Additionally, a strong sense of place and resistance to relocation were presented as key elements of resilience, maintaining community system function, and preserving livelihoods. The study further found that these key factors would not be adequate to guarantee community flood resilience outside the transformative capacity of a well-resourced village civil protection committee that can prepare and mobilize stakeholders in response to flood emergencies. Our results suggest that, in the context where policymakers seek to strengthen resilience of communities without relocating them, a focus on public health and on strengthening and utilizing local capacities as adaptation, are key in disaster risk management policymaking and implementation. For the international research community, this study demonstrated the importance of utilizing context and hazard specific measures for defining, characterizing, and measuring resilience to inform policy.

**KEYWORDS**

climate change, disaster policy, flooding, Malawi, resilience, resilience measurement

## 1 | INTRODUCTION

Recent data have shown that, because of climate change, flooding has become a global threat, with flood events already increasing in frequency and magnitude (Centre for Research on the Epidemiology of Disasters, 2019). Flooding results in injuries, morbidity, and mortality, among other impacts, posing a challenge for public health and sustainable development. It is estimated that about 1.47 billion people, or 19% of the world population, are directly exposed to substantial risks of flooding of which 89% live in low- and middle-income countries (Rentschler & Salhab, 2020). Of the 132 million people who are estimated to be living in both extreme poverty (under $1.9 per day) and in high flood risk areas, 55% are in Sub-Saharan Africa (Rentschler & Salhab, 2020). Over 50% of the African population lives in rural areas, with many reliant on floodplains and rivers for food production and other livelihood activities (Lumbroso, 2020). This suggests heightened vulnerability for the Sub-Saharan Africa region in the event of flooding. Hence, the international scientific community's interest in improving current understanding of community flood resilience and relevance for sustainable development, particularly in low- and middle-income countries. Despite this growing interest, literature points to definitional and measurement challenges for the concept of resilience particularly at community level where adaptation to disasters occur.

The definition of resilience as a concept and resilience thinking as an analytical approach has been highly contested (Patel et al., 2017; Rodina et al., 2017) making its operationalization difficult (Ntontis et al., 2018). On one hand, resilience is viewed as a quality or outcome of socio-economic processes that inform it (Manyena, 2006) and on another, it is conceptualized as a process or adaptive capacity than a measure of stability or an outcome. Despite the multiple and continuous redefinitions of the term from different disciplines (natural, social, physical, environmental, etc.) and levels (individual, groups, community, organization and national), resilience has emerged as a dominant discourse in the sustainable development agenda with a focus on partly strengthening community disaster risk adaptation capacity. Based on a systematic review of African-based resilience scholarship, the Resilient Africa Network (RAN) provided a more general definition of resilience as the capacity of people and systems to mitigate, adapt to, and recover and learn from shocks and stresses in a manner that reduces vulnerability and increases well-being (RAN, 2015). This definition aligns with the conceptualization of resilience as adaptive capacity as opposed to an outcome.

The relationship between flood risk management and the livelihood of people who make a living on natural resources, such as floodplains, is of crucial concern to enhancing community resilience, improving public health and the achievement of sustainable development goals. This is mainly because the development and implementation of resilience strengthening policies should not only be consultative from a social justice and inclusive perspectives but should also be seen to be protecting livelihoods and promoting the well-being of the affected people. In line with this, global policy discourses are now in agreement that, to address the adverse effects of climate change, the water governance sector needs to take a resilience and transformative approach (Salinas Rodriguez et al., 2014). As a result, Dewulf (2019) note that there is growing reference to community flood resilience and its cognate terms such as water resilience (Erickson, 2015; Falkenmark & Rockstrom, 2010; Rockström et al., 2014) and catchment resilience (Adger et al., 2021) to capture the growing need for transformation in the water governance sector as it relates to drought and flood management and climate change adaptation, among other areas of focus (Shin et al., 2018; Xu & Kajikawa, 2017). Despite this observed need to transform, the water sector has been critiqued for delaying the adoption of innovative and transformative practices to strengthen resilience including accepting some level of flooding as normal (White et al., 2016). This observed gap is likely informed by the multiple definitions and conceptualizations of resilience that have inexorably challenged the water sector and its operationalization of resilience (Johannessen & Wamsler, 2017).

In the context of flood risk management, there are multiple approaches to resilience varying from a narrower focus on preserving the existent stability of physical infrastructure to more inclusive conceptualizations that emphasize socio-ecological factors in the context of complex adaptive systems (White & O'Hare, 2014).

Informed by the latter conceptualization, which seem to accept transformation and change, Bulti et al. (2019) provided a hazard specific definition of community flood resilience as ability of a community—and all of its socio-ecological and socio-technical networks across temporal and spatial scales—to maintain or rapidly return to desired functions in the face of flood events, to adapt to change, and to transform systems that affect the current and future adaptive capacity.

From a resilience measurement perspective, both conceptual and empirical studies have shown that the community level is an important scale on which to build resilience that can enhance both the individual/household and wider population level outcomes (Cote & Nightingale, 2012). The characterization and measurement of resilience at community level goes beyond a purely socio-ecological systems understanding by incorporating social subjective factors, for example, perceptions and beliefs as well as the wider institutional environment and governance settings that shape the capacities of communities to build resilience (Ensor & Harvey, 2015). Yet, the community remains poorly theorized with little guidance on how to measure resilience building processes and outcomes (Kruse et al., 2017). Both terms—resilience and community—incorporate an inherent vagueness (Patel et al., 2017) and raise, as Norris et al. (2008) put it, concerns with variations in meaning. In addition, attempts to review resilience measures focusing on specific hazard are limited (Bulti et al., 2019). Considering the conceptual vagueness and variations of community and resilience, only a few approaches have tried to characterize and measure community resilience comprehensively (Cutter et al., 2014).

Considering these measurement challenges, the definition of community flood resilience by Bulti et al. (2019) above becomes important for three reasons: (1) its focus on a specific hazard (i.e., flood) which is a critical element of specificity in measurement, (2) its conceptualization of a community as encompassing socio-ecological and socio-technical networks, which goes beyond the economic and physical indicators and, (3) its focus on adaptation, which is a long-term concept, inclusive of ex ante (pre-flooding) preparedness and mitigation efforts (Keating et al., 2014) which are important for a comprehensive disaster risk management (DRM) approach.

Given the noted gaps in defining and measuring resilience at community level, this paper, adopts, for the reasons cited above, the definition of community flood resilience by Bulti et al. (2019) to further fill the knowledge gap by using empirical data to construct the variable "community flood resilience" and quantitatively investigate the factors associated with being resilient to flooding as evidenced by support for government to implement policies that reduce vulnerability of people in the existing communities without relocating them to alternative land ("*community agency*"). Thus, the study provides an empirical heuristic framework for conceptualizing and measuring community resilience to flooding.

## 2 | RESILIENCE CONCEPTUAL AND ANALYTICAL FRAMEWORK

This section presents a multidimensional heuristic framework for understanding, characterizing, and measuring community resilience flooding used in this paper. To that end, we briefly discuss the historical evolution and conceptualizations of resilience from different research strands, point out the gaps and how our quantitative approach helps to address some of these identified gaps.

With its roots in the field of ecology (Holling, 1973), the term resilience has found increasing popularity in the fields of engineering (Davoudi, 2012; Holling, 1996), socio-ecological systems (Holling, 1973), psychology (Berkes & Ross, 2013; Norris et al., 2008), economics (Hallegatte, 2014) and disaster risk management (Keating et al., 2016). Despite this growing interest in resilience application across disciplines, there is no consensus in its definition and measurement (Bene, 2013) with some measurement frameworks designed to operate in multiple shocks while others are designed to be hazard and context specific. In its earlier definitions, resilience was considered to imply the ability of a system to return to its equilibrium state after a temporary disturbance, commonly equated to the concept of stability (Holling, 1973). However, the widespread adoption of resilience among disciplines has led to ambiguity surrounding definitive application of the concept with over 70 definitions in literature (Fisher, 2015). With time, elements of system flexibility to absorb change (Walker et al., 2004) and capacity to adapt, learn and self-organize (Doorn et al., 2018) were added to the definition to account for emerging strands of resilience research such as socio-ecological (complex-adaptive systems) and systems (ecological) resilience.

The main arguments for the shift from a purely engineering informed definition to more inclusive definitions and approaches are informed by the need to account for social and the ecological dimensions of resilience (Mao et al., 2017). When resilience is defined from a unidimensional (engineering or systems or socio-ecological) perspective, the importance of one set of factors (physical infrastructure or governance or human livelihoods) is given prominence over others (Davidson, 2010; Duit et al., 2010; Methmann & Oels, 2015). Available evidence suggests that beyond the physical infrastructure (built structures), human capital assets such as health conditions (Weldegebriel & Amphune, 2017), gender (Llorente-Marrón et al., 2020), population pressure (Donner & Havidán, 2008), and household interest in learning and practicing adaptive flood-based farming practices (Nguyen & James, 2013), are key determinants of flood resilience. Unidimensional frameworks, especially those informed by the natural sciences revealed conceptual challenges that call for a comprehensive community resilience framework (Cote & Nightingale, 2012; Kruse et al., 2017).

With the increase in disaster frequency and magnitude, and the importance of bottom-up interventions at community level where adaptation to disasters occur and social capital is displayed through neighbors helping each other, the call for comprehensive resilience framework application has increased. In these calls, resilience is presented as a concept with potential to help integrate disaster risk management, sustainable development, and climate change adaptation concerns (Adger et al., 2021; Bene et al., 2012). Broadly, these theorists argue that a holistic concept of resilience is needed for a better understanding of the relationships among human, financial, natural, social, and physical systems. An answer to these calls seems to have come from Martin-Breen and Anderies (2011) who developed a three interdisciplinary multidimensional conceptual framework (Engineering resilience, Systems resilience, and Resilience in complex-adaptive systems) that accounts for over 50 years of practical application in comprehensive community resilience assessment. Through this interdisciplinary spectrum of resilience, the authors emphasized the need for resilience assessment to investigate the capacity of communities to prepare for any disturbances pre-event and being able to resist the impacts (Engineering resilience), cope with the effects and maintain functionality throughout the disturbance (Systems resilience), and then adapt and learn post-disturbance to increase future resilience (Complex adaptive systems; Martin-Breen & Anderies, 2011). This framework is aligned with the definition of community flood resilience adopted for this study as they both capture the aspects of hazard specificity, the importance of social aspects of risk management and the need for long-term adaptation to characterize how the two communities interacted with their ecological environment.

The authors argue that resilience should be considered as a multidimensional construct that cover all the three frameworks although certain aspects maybe more desirable than others at any one point and scale of measurement. This argument is also supported by the United Nations (UN) World Food Programme's (WFP; Constas et al., 2013) who posit that resilience is a capacity explained by or composed of multiple dimensions. Martin-Breen and Anderies (2011) also argue against over-emphasis on finding a united definition of resilience as such calls fail to acknowledge the fluidity of the concept in different contexts. Along this interdisciplinary spectrum of resilience, this paper focused on addressing one key question regarding community flood resilience, namely, what are the pre-flooding, during flooding and post-flooding factors that help build community flood resilience for different groups of communities that are incessantly affected by floods, but choose to stay in harm's way? To answer this question, we first derived, through measurement, the hypothetical construct of flood resilience before exploring relationships among factors. Through this approach, the study addresses some of the conceptual challenges associated with defining and measuring resilience by capturing the subjective aspects of social change and transformation, the interrelationships between resources, people's actions and learning in shaping individual and collective perceptions that may help with the characterization and development of a typology of community flood resilience.

## 3 | MATERIALS AND METHODS

### 3.1 | Research design

This study is based on secondary analysis of population-based survey data collected to assess the level of support for flood mitigation policy options in the two traditional authorities (TAs) Nyachikadza and Ndamera, in southern Malawi. A Deliberative Polling® (DP) based repeat cross-sectional survey, with pre-deliberative and a post-deliberative event assessment, was conducted (Figure 2). This study analyzed the post-deliberative event survey data as it was considered to be the final and well-informed scores that participants had made in their support for various flood risk management (FRM) policy options to strengthen community flood resilience.

### 3.2 | Explanation and justification of the case selection

In Malawi, about 40% of all documented disasters are a result of flooding (Nillson et al., 2010). In 2019, Malawi experienced heavy rainfall which resulted in flooding that affected 15 out of its 28 districts (Government of Malawi, 2019) with devastating effects on about 1 million people (Centre for Research on the Epidemiology of Disasters, 2019). The floods also affected pregnant and lactating mothers who need high nutritional food diets, and deepened levels of child malnutrition, especially in

Neno and Mangochi districts (Government of Malawi, 2017a, 2017b), where over 45% of children are already stunted (Government of Malawi, 2019). The flood-induced devastation occurred against the backdrop of limited government capacity for preparedness (Dewa et al., 2021; Kita, 2017a), and limited coping capacity at community level (Dewa et al., 2021; Kita, 2017b; Mijoni & Izadkhah, 2009), pointing to the need for strengthened community disaster/flood resilience. The Nsanje district of Malawi in southern Africa, which is particularly prone to flooding, is home to two communities called Traditional Authorities (TA), Nyachikadza and Ndamera (Figure 1). The two TAs are adjacent to each other, with the former being on lowland and the latter situated on high ground. Due to this topography, the lowland is incessantly flooded by water from the Shire River which forms most of the border of the lowland community with all its neighbors. When floods occur, residents of the lowland community find refuge in the upland community (TA Ndamera). Due to the fertility of soils on the lowland, particularly following a flood, people from the higher ground also rely on the lowland for agricultural production. Research indicates that the lowland has capacity to produce enough food to feed the whole district (Lilongwe University of Agriculture and Natural Resources, 2018).

TA Nyachikadza is home to over 1000 households located across nine group villages (GVs). The community is affected by frequent flooding. When flood waters come, residents of TA Nyachikadza seek refuge in the neighboring TA Ndamera (Resilient Africa Network, 2017). TA Ndamera has 28 GVs. Of these, 14 GVs are neighbors with TA Nyachikadza. In these 14 GVs, around 80% of the households grow crops in the wetlands of Nyachikadza. Half of these households own land in the wetlands of Nyachikadza, and the remaining half grow their crops on rented land (Resilient Africa Network, 2017). In general terms, these two communities depend on each other due to the recurrent flooding and the need for food production.

Following the devastating flood of 1997, the Government of Malawi (GOM) was reported to have declared the lowland community a flood prone area, prohibiting anybody from staying in the area and banning the provision of social services, including construction of a health facility, in the area as a way of forcing people to relocate (Resilient Africa Network, 2017). However, people in the lowland community have disregarded the government

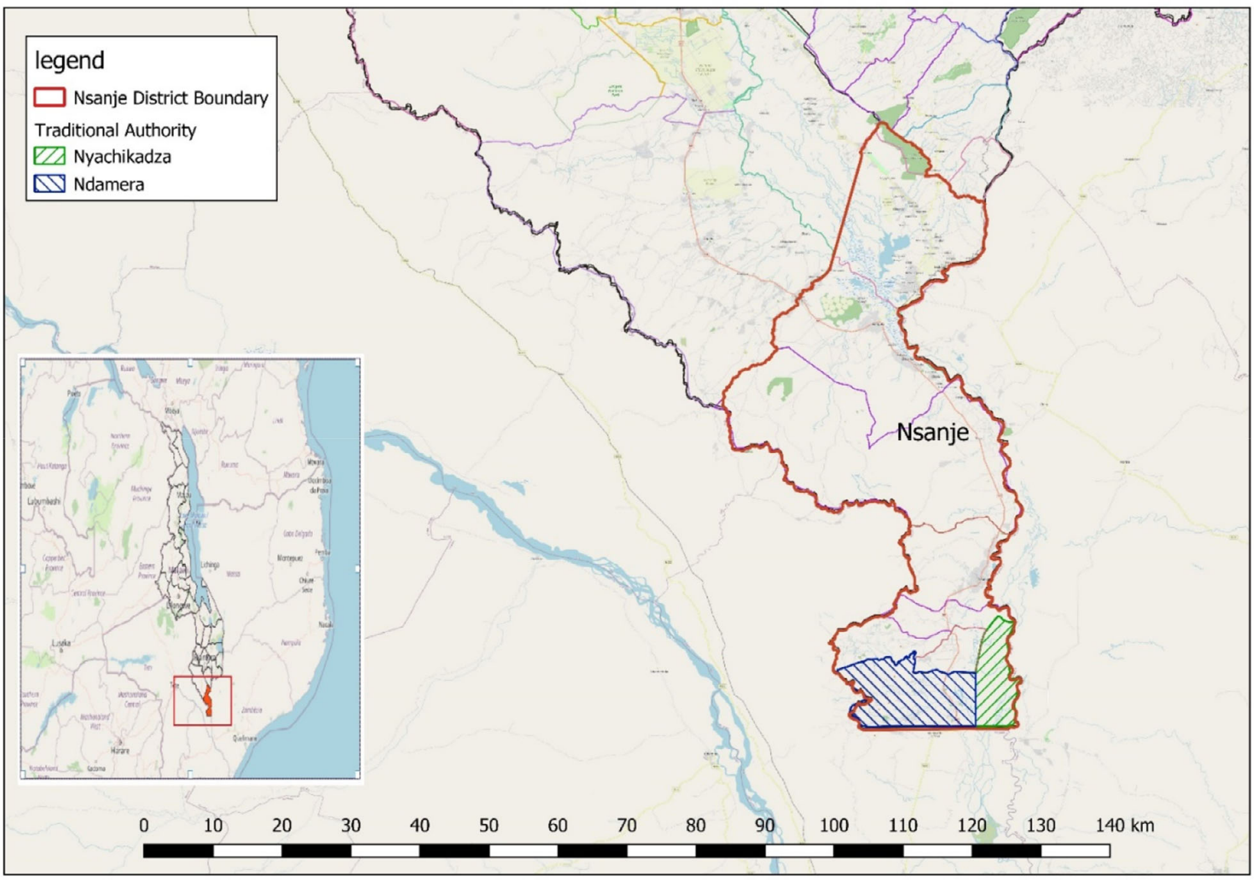


FIGURE 1 Location of traditional authorities Ndamera and Nyachikadza in Nsanje district of Malawi

directive and continued to stay in the area. The question remains what makes them resilient to flood risk, and hence their choice to stay in the flood prone area.

Because the two communities' inherent characteristics of being the most affected by floods (RAN, 2017), coupled by their reciprocal relationship based on socio-ecological model of coping with flooding following government's directive prohibiting provision of essential services and increasing their vulnerability, the two communities were selected for this study.

## 3.3 | Participants and sampling

The DP participants were selected through a four-stage sampling technique previously published in detail elsewhere (Dewa et al., 2022). Briefly, in the first stage, two TAs (Nyachikadza in the lowland and Ndamera in the upland) from Nsanje District were purposively selected (Ames et al., 2019) and considered two strata from which participants would be drawn. TA Nyachikadza was selected as the worst affected by flooding among all TAs in the district (Odukoya et al., 2015) while TA Ndamera was selected due to its experiences with flooding and adjacence to TA Nyachikadza. People from TA Nyachikadza temporarily relocate to TA Ndamera for shelter in times of flooding, while people from Ndamera plant their food crops on TA Nyachikadza's fertile floodplains following a flood (Resilient Africa Network, 2017).

The second stage involved the selection of GVs (a political administrative level immediately below the traditional authority constituting more than one village, grouped to the discretion of the Chief, as described in the Chiefs Act; https://www.lawcom.gov.mw/law-commission-report-review-chiefs-act, accessed on 01 March 2022; GVs). In TA Nyachikadza, 5 out of 9 GVs were selected while in TA Ndamera, 7 out of 14 GVs were selected using simple random sampling technique. The total number of GVs in each TA was used in the distribution of selected GVs. The third selection stage involved a random selection of 40 households from each GV.

Obtaining a representative sample was important for the DP for generalization to the rest of the two communities' population. Sample size calculation took into consideration three factors of confidence level, the degree of variability in the population and the desired level of precision (Israel, 2013; Kish, 1965). Thus, we assumed a 95% confidence level (Yamane, 1967), 0.5 degree of variability which refers to the distribution of attributes in the population representing maximum variability in a population which is used as a standard in sample size determination in academic practice and 7% level of precision (Kish, 1965). The following finite sample size calculation was used:

$$n = \frac{z^2 p(1-p)N}{e^2(N-1) + z^2 p(1-p)},$$

where $n$ = sample size, $p$ = proportion of population containing the major interest, $z$ = Z-statistic corresponding with confidence level, $e$ = confidence interval, and $N$ = population size.

With the projected population sizes (National Statistics Office, 2017) of 8370 for the 7 GVs in TA Ndamera and 4157 for selected GVs in TA Nyachikadza, using the above formula, the calculated sample sizes were 192 and 187, for the selected GVs by TA, respectively. The calculated sample sizes were then rounded up to 200 for each TA before estimating an attrition rate of 20% between pre- and post-DP surveys resulting in 240 targeted participants for each TA and 480 for the study. The fourth stage involved the listing of all households in the two TAs to form a sampling frame. Out of the 480 households identified, adults over the age of 18 years were listed from which one member was randomly identified to participate in the survey with no option for replacement in subsequent data collection stages. Out of 484 participants who completed the pre-DP survey, about 468 (97.5%) completed the post-DPsurvey using a paper-based structured questionnaire, consisting of the same questions as the pre-DP questionnaire.

## 3.4 | Data collection

Data collection was conducted using a seven-step community consultative approach called DP (Fishkin & Luskin, 2005). Applied for the first time in southern Africa, and for the fourth time in Africa (Malawi; OECD, 2020), the approach involved the following seven steps (Figure 1), as previously published elsewhere (Dewa et al., 2022) and outlined below (Figure 2).

While the study questionnaire was completed by individual participants representing a household, the measurement of resilience in this study is to a large extent reflective of community-level flood resilience because of the following factors, namely (1) data were collected from a representative sample drawn from the two communities; (2) participants completed the questionnaire after small groups and plenary discussions of various policy options with fellow community members (Dewa et al., 2022); (3) participants had an opportunity to get clarification from a panel of experts on collective questions they would have had in their small group discussions; and (4) the questionnaire had many factors speaking to community-level factors which required the completing individual to reflect on their household and

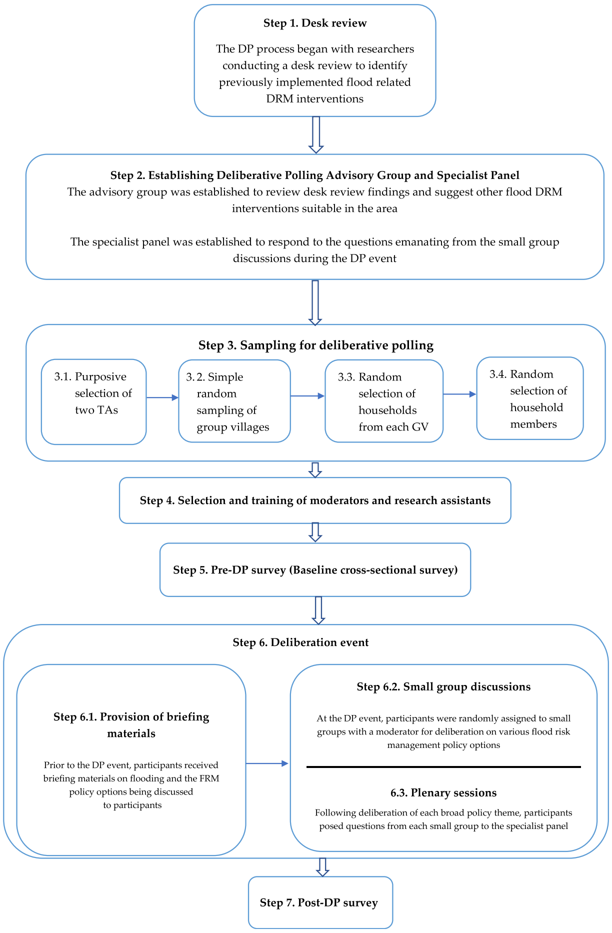


**FIGURE 2** The DP data collection flow process *Source*: Dewa et al., 2022

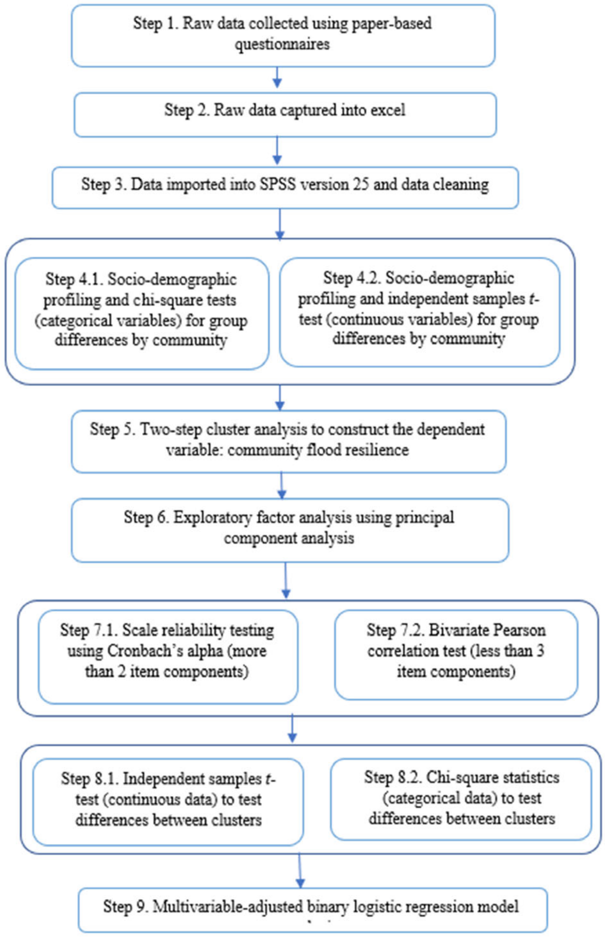


**FIGURE 3** Data analysis process

the community they represent, as opposed to their individual perception.

## 3.5 | Data analysis

Figure 3 presents the data analysis process followed for this study.

The primary data was captured in excel before being imported into and analyzed using IBM SPSS Statistics for Windows, version 25 (IBM Corp., Armonk, NY). Group differences for categorical and continuous data were tested using chi-square statistics (Shi et al., 2018) and independent sample *t*-tests (Tabachnick & Fidell, 2007), respectively. All tests were two-tailed and statistical significance was set at $p < 0.05$. Data analysis involved a nine-step process (Figure 3) including data cleaning, descriptive statistics, cluster analysis, principal component analysis, scale reliability testing, bivariate analysis and multivariable-adjusted binary logistic regression.

### 3.5.1 | Operationalizing the dependent variable (measure of community flood resilience)

Because community flood resilience is a latent variable that is not directly observable, this study used an observable variable as its proxy (d'Errico et al., 2018). The use of a proxy for measuring resilience was also reported by Lee et al. (2009) in a study conducted to understand the resilience of African Americans after hurricane Katrina. The authors reported that for Katrina evacuees, resilience was considered to mean perseverance, the ability to work through emerging difficulties, as well as maintaining optimistic views on recovery. In the current study, the flood mitigation policy domain, with nine actions/policy options, on reducing vulnerability within the existing communities (Table 1) without relocating people (*community agency*) was conceptually conceived to imply community flood resilience (Isa et al., 2018; Keogh et al., 2011).

A community flood resilience composite variable was computed by identifying different homogeneous groups

**TABLE 1** Actions or policy options for reducing vulnerability in existing communities used for constructing the dependent variable (responses on a 0–10 Likert scale 0 considered being least import and 10 being most important)

| |
|---|
| a. Construct a dyke along the Shire River from Nsanje District Centre to TA Nyachikadza (a distance of around 40 km). |
| b. Construct a dyke along the Shire River from Nsanje District Centre to TA Nyachikadza with labor from the communities coordinated by the District Council as part of the Public Works Programme. |
| c. Allow TA Nyachikadza communities to "access" land upland to temporarily relocate during floods and return afterwards. |
| d. Allow communities to remain but develop an effective flood-early warning system. |
| e. Sensitize TA Nyachikadza communities on flood early warning. |
| f. Develop places of safety for children and vulnerable groups (elderly, sick) when flood warnings are administered. |
| g. Put in place effective life-saving measures (such as petrol boats, life jackets, etc.) in all strategic places to be used to rescue people during floods. |
| h. Have the VCPC, ACPC and DCPC consider indigenous knowledge systems (IKS) in flood early warning. |
| i. Have all the Area Civil Protection Committees (ACPCs) and Village Civil Protection Committees (VCPCs) along the Shire River form an alliance to share information about flood early warning. |

**TABLE 2** Actions or policy options for resettlement and relocation used as predictor variables

| |
|---|
| a. Facilitate the relocation of TA Nyachikadza community to suitable land in the high land area within the same district. |
| b. Facilitate the relocation of TA Nyachikadza community to the best suitable land anywhere in Malawi. |
| c. Should only proceed with resettlement after it has developed a plan that is approved by the TA Nyachikadza community. |
| d. Provide legal title to land for TA Nyachikadza community members before relocation. |
| e. Facilitate a complete relocation but allow communities to continue using their land for crop cultivation. |
| f. Prohibit provision of any social service (hospitals, schools, etc.) in TA Nyachikadza as a way of "forcing" people to relocate. |
| g. Provide increased social services (e.g., schools, health centers) in TA Ndamera if people are relocated there. |
| h. Facilitate TA Ndamera's access to the low land for crop cultivation in exchange for hosting TA Nyachikadza's residence in the upland (TA Ndamera). |
| i. Facilitate increased agricultural production in TA Ndamera. |

that existed in the sample through a two-step cluster analysis (Tkaczynski, 2017). The rationale for using cluster analysis is that it can use both continuous and categorical variables to determine an optimal number of clusters in a sample. Two-step cluster analysis is also capable of empirically identifying important combinations as opposed to using a priori structure (Conry et al., 2011).

To conduct a two-step clustering, the flood mitigation policy priority on reducing vulnerability within the existing communities without relocating people (Table 1) was conceptually conceived to imply community flood resilience (Isa et al., 2018; Keogh et al., 2011). To that end, a two-step cluster analysis was conducted to identify community cluster profiles with substantial similarity in source grades (Laurien et al., 2020), as grouped by the nine factors identified (Table 1), thereby developing a multidimensional typology of community flood resilience as guided by Martin-Breen and Anderies' (2011) three interdisciplinary conceptual framework of resilience. All nine factors were loaded for classification analysis and respondents who scored the policy options (factors) high were, for classification purposes, considered more resilient than the others since reducing vulnerability while supporting community agency is considered central to strengthening resilience (Wood, 2007).

### 3.5.2 | Operationalizing the independent variables (predictors of community flood resilience)

In addition to 12 socio-demographic factors of participants, 23 questionnaire items (Tables 2 and 3), also on a Likert scale of 0 to 10, drawn from two flood risk management broad domains of relocation and resettlement and population pressure, gender and social services, were considered potential predictor variables for the dependent variable: community flood resilience.

Exploratory factor analysis (EFA) was conducted by means of principal component analysis (PCA), using a correlation matrix, to explore, from the 23 questionnaire items (Tables 2 and 3), items that could be reliably grouped satisfactorily to constitute the various community flood resilience dimension scales. Items with communality scores of $<0.40$ were excluded from further PCA (Osborne et al., 2008). Items that were not considered satisfactory were used as index measures of a specific community flood resilience dimension. The scale items were factor-analyzed using the eigenvalue cut-off of $>1$ (Cheplyaka, 2017). Variance was based on rotated sums of squared loadings and the Varimax with Kaiser normalization was used as the orthogonal rotation

**TABLE 3** Actions or policy options for population pressure, gender and social services used as predictor variables

| |
|---|
| a. Provide wide access to free family planning services. |
| b. Construct a health center in TA Nyachikadza so long as people live there. |
| c. Have families consider their land resources in deciding how many children to have. |
| d. Increase the use of temporary shelters for evacuation instead of classrooms. |
| e. Use community by-laws to restrict child marriages. |
| f. poor families with children of school-going age should only receive a cash transfer if they enroll their children to school. |
| g. adults with children of school-going age should only participate in the Public Works Program if they enroll their children in school. |
| h. Establish collective storage facilities for food in the uplands (by the people from the lowlands). |
| i. Provide adequate security in evacuation centers to ensure that women and girls are protected from abuse and rape. |
| j. Allow families to be able to stay together during flood evacuations. |
| k. Allow households with persons who are vulnerable and sick be prioritized during flood evacuations. |
| l. Promote the capacity building of the VCPCs to know how to respond to emergencies. |
| m. Promote village savings and loans to provide alternative income sources for women. |
| n. Ensure a woman should not lose the family land if her husband dies. |

method as it maximizes the loading of each variable on one of the extracted factors while minimizing the loading on all other factors (Weide & Beauducel, 2019). The loadings represent correlation between the individual flood mitigation options and the patterns. Flood mitigation options with positive loadings were positively associated with a policy pattern while negative loadings were inversely associated. PCA was conducted on both communities combined.

The scale items obtained from the PCA were subjected to a test for internal consistency as a measure of scale reliability as depicted by the Cronbach alpha value, using a minimum acceptable level of >0.69 (Cortina, 1993; Taber, 2018). All scale items with alpha values below 0.7 were used as stand-alone items in the logistic regression model to explore their associations with the odds of a represented household being resilient. A bivariate Pearson correlation test was conducted as a reliability test for a component with less than three items (Eisinga et al., 2013). Group differences of the clusters were tested using chi-square statistics and t-test for categorical and continuous data, respectively. All factors with $p \leq 0.2$ in a bivariate analysis were included in the multivariable-adjusted binary logistic regression analysis and only those with $p < 0.05$ were retained in the final model.

### 3.5.3 | Investigating factors associated with community flood resilience

To understand the corelates of resilience to flooding, a multivariable-adjusted logistic regression model (Hidalgo & Goodman, 2013) was conducted using an enter method (Ranganathan et al., 2017). Using this approach, all input variables (PCA scales and individual indices), including socio-demographic factors, were entered simultaneously. After obtaining a full (saturated) model, backward stepwise regression (Bursac et al., 2008) was applied to eliminate insignificant variables from the model to generate a parsimonious model as the final model. A binary logistic regression model was built, with being more or less resilient as outcome or dependent variable, and potential predictors adjusted for age, gender, and community. All statistical significance was defined using a two-sided and *p*-value <0.05.

## 3.6 | Study validity

To ensure both internal and external validity (Patino & Ferreira, 2018), the study was designed based on a participatory (bottom-up) process using substantial input from stakeholders from the affected communities including the identification of policy options for flood risk mitigation, selection of the expert panel from district stakeholders to advise on specialized topics such as policy, among others, for context specificity, a key tenet in resilience measurement. The data collection team, guided by a multidisciplinary team of research experts from Stanford University (United States of America), University of Pretoria (South Africa), Makerere University (Uganda) and Lilongwe University of Agriculture and Natural Resources (Malawi), were all recruited locally with a good understanding of both English and the local language, Chichewa. As this study used a DP method, in a situation that required consultation of an entire community about their opinions on a policy aspect, representativeness was essential. To that end, a random selection of participants from the two communities was conducted to ensure that they are representatives of the socio-demographic profile of the two communities for generalizability within the study communities. Although the purpose was not to generalize the results to other similar communities, this study developed a community flood resilience analytical framework that can be replicated in other communities with similar characteristics and produce results with important public health policy implications. In subsequent multivariable binary logistic regression, the analysis controlled for community so that the association between the resilience latent construct and its predictors could be assessed independent of any differences that could be because of the community from which participants came from.

## 4 | RESULTS

As the first step to understanding the characteristics of study participants, a comparison of socio-demographic factors between the two study communities (lowland and upland) was conducted (see Supplementary file 2). This is followed by a presentation of results from cluster analysis, bivariate analysis, the EFA and the multivariable-adjusted binary logistic regression model.

### 4.1 | Comparison of socio-demographic factors between the two study communities (lowland and upland)

The data shows that the samples from the two communities differed significantly in terms of socio-demographic factors (see Supplementary file 2). Compared to those in the upland, a significantly higher proportion of those in the lowland were males, farmers, had more formal education, and fewer proportion were members of village or area civil protection committees. Furthermore, a lower proportion of those from the lowlands as compared to those from uplands owned land in both communities (14.6% vs. 60.8%; $p < 0.000$). However, a higher proportion of those in the lowlands as compared to those from the uplands indicated they had an alternative place to go during floods (65.4% vs. 27.5%; $p < 0.000$).

### 4.2 | Community flood resilience construct

The two-step cluster analysis identified two cluster groups with a fair cluster quality (average silhouette measure of cohesion and separation) of 0.4 (see Supplementary file 2). The clusters were built around strong support for three flood mitigation items, namely; construction of a dyke along the Shire river (natural capital for engineering resilience) from Nsanje district council to lowland, construction of a dyke using labor (human capital for systems/ecological resilience) from the local communities, and allowing lowland community to stay but developing early warning systems (EWSs, physical capital for complex adaptive systems resilience). The two clusters were logically labeled “more flood resilient” ($n = 296$, 63.8%) and “less flood resilient” ($n = 168$, 36.2%) with ratio of sizes of 1.76. Thus, through cluster analysis, this study managed to derive a dichotomous construct “community flood resilience” as measured by the three variables differentiating the two identified clusters.

### 4.3 | Description of identified principal component flood risk management actions/policy options

Six flood risk mitigation patterns, which explained about 60.87% of the total variance (total flood mitigation items variability) were retained by the overall PCA (see Supplementary file 2).

The first PC factor had the largest number of items on resisting relocation, namely, approved resettlement plan; access to social services, access to lowland for cultivation; increasing services and agricultural production upland; relocation to suitable land anywhere; complete relocation with access to land; relocation to suitable land upland; provision of legal title to land; facilitating access to land for food production by upland community in exchange for hosting the lowland community; and construction of a health center in lowland. This PC, which somewhat captures the communities' resistance to relocation and an expression of “sense of place,” was named “*Sense of place*” and accounted for 25.53% variance in flood risk policy option patterns. The second PC was loaded with issues to do with prioritization of vulnerable and sick people in flood emergencies, strengthening response capacity of Village Civil Protection Committees (VCPC), and ensuring adequate security in evacuation camps. This PC, which somewhat captures elements of social capital assets, contributed 8.18% of the total variance with positive factor loadings and was named “*Sense of caring*.”

Two items relating to keeping children in school (families to participate in public works programs if their children are enrolled in school and families to receive disaster cash transfers if their children are enrolled in school) were captured in a PC called “*Child education support*.” This third PC, which captures elements of human capital assets, had a variance contribution of 8.07%. The fourth PC identified also had two items, namely, having families consider their land resources in deciding the number of children to have and ensuring women do not lose family land if their husband dies. This PC had a total variance contribution of 6.92% and was named "*Family wellness*." The fifth PC had three items, namely, use of community by-laws to restrict child marriages, provision of wide access to free family planning services, and promoting village savings and loans to provide alternative income sources for women. This PC had a total variance contribution of 6.92% and was named "*Women empowerment*." The sixth PC identified had one item about allowing families to stay together during flood evacuation. This PC contributed 5.26% variance, and was named "*System function*," as it captures elements of continuity of the family unit.

A scale reliability analysis for the component items produced varying scales' reliability, with a Cronbach alpha ranging between 0.457 and 0.902 for three patterns with more than two component items (Table 2). One (1) pattern, that is, "*Sense of place*" ($\alpha = 0.902$) produced very good (>0.8; Ursachi et al., 2015) internal consistency. The other two patterns had alpha values below the minimum acceptable level of 0.70 (Taber, 2018), hence the component items were used as standalone items in subsequent analysis. Based on 468 complete observations, bivariate Pearson Correlation tests for the two-item components produced a strong (>0.6; Mukaka, 2012) and statistically significant coefficient for *Child education support* ($r = 0.652$, $p = 0.000$). Therefore, the direction of the relationship is positive, meaning that the items in this component tend to increase together and were considered a scale measuring the same underlying construct. The correlation coefficient for the component "Family wellness" ($r = 0.220$, $p = 0.000$) was considered weak and probably not a scale measuring the same underlying construct (Mukaka, 2012), therefore, the individual items were used as standalone items in subsequent analysis.

## 4.4 | Factors that differentiated the more from the less flood resilient households

Table 4 presents results of differences between the "more flood resilient" and "less flood resilient" households from the bivariate analysis for categorical variables.

The data shows that the two clusters differed significantly in terms of gender ($p = 0.000$) with more males (70.3%) in the more resilient cluster. The two clusters also differed significantly in terms of marital status ($p = 0.010$). Participants differed significantly in terms of community of residence ($p = 0.000$). The two clusters were also significantly different both in terms of ownership of land in both communities and having an alternative place to go during a flood ($p = 0.000$). From the participant characterization table (see Supplementary file 2) comparing the two communities, it was noted that there were more participants from the lowland with an alternative place to go during a flood, compared to participants from the upland. Conversely, participants from the upland had proportionally more ownership of land in both communities ($p = 0.000$) compared to participants from the lowland.

Like Table 4, Table 5 presents the differences between the "more flood resilient" and "less flood resilient" clusters, for continuous variables.

Data shows that the two clusters differed significantly in terms of sense of place ($p = 0.000$), strengthening capacity of civil protection committees ($p = 0.000$), allowing households with people who are sick and vulnerable to be prioritized during evacuations ($p = 0.000$), access to free family planning services ($p = 0.010$) and allowing families to stay together during flood evacuations ($p = 0.011$).

## 4.5 | Multivariable analysis of the factors associated with community flood resilience

Table 6 presents results of a multivariable-adjusted binary logistic regression model of the factors significantly ($p < 0.05$) associated with community flood resilience controlled for age, sex, and community.

The results indicate that participants who resisted relocation and expressed a stronger sense of place had 1.251 times higher odds of being more flood resilient (95% CI = 1.123–1.394; $p = 0.000$). It is noteworthy that staying in the lowland (flood prone area) was 4.610 times more likely associated with being more flood resilient (95% CI = 2.274–9.346, $p = 0.000$). Participants who did not own land in both communities had 0.540 times lower odds of being more flood resilient (95% CI = 0.310–0.940, $p = 0.029$) compared to those who owned land in both communities. Participants who were in favor of the provision of free family planning services were 1.198 times more likely to be more flood resilient (95% CI = 1.042–1.377, $p = 0.011$). Similarly, those who were in favor of having families stay together during a flood evacuation were 1.145 times more likely to be more flood resilient (95% CI = 1.065–1.232, $p = 0.000$). Participants in support of allowing households with persons who are vulnerable, and sick to be prioritized during flood evacuations were 1.324 times more likely to be more flood resilient (95% CI = 1.166–1.504, $p = 0.000$). Support for strengthened capacity of VCPCs to know how to respond to emergencies was strongly associated with being more flood resilient (OR = 1.163, 95% CI = 1.026–1.318, $p = 0.018$). Surprisingly, participants without an alternative place to go during a flood were 1.659 times more likely to be more resilient compared to those with an alternative place (95% CI = 1.009–2.730, $p = 0.046$).

**TABLE 4** Comparison of socio-demographic factors between the more resilient and less resilient clusters

| Variables | Less flood resilient ($n = 168$) | More flood resilient ($n = 296$) | $p$-value |
|---|---|---|---|
| Gender | | | |
| Male | 87 (51.8%) | 208 (70.3%) | |
| Female | 81 (48.2%) | 88 (29.7%) | |
| | | | 0.000*** |
| Marital status | | | |
| Married | 137 (81.5%) | 246 (83.1%) | |
| Single | 4 (2.4%) | 15 (5.1%) | |
| Divorced | 1 (0.6%) | 11 (3.7%) | |
| Widowed | 26 (15.5%) | 24 (8.1%) | |
| | | | 0.010* |
| Ownership of land in both communities | | | |
| Yes | 74 (44.0%) | 97 (32.8%) | |
| No | 94 (56.0%) | 199 (67.2%) | |
| | | | 0.016* |
| Having an alternative place to go during times of flooding | | | |
| Yes | 54 (32.1%) | 164 (55.4%) | |
| No | 114 (67.9%) | 132 (44.6%) | |
| | | | 0.000*** |
| Education level | | | |
| None | 43 (25.6%) | 66 (22.3%) | |
| Primary | 81 (48.2%) | 175 (59.1%) | |
| Secondary and above | 44 (26.2%) | 55 (18.6%) | |
| | | | 0.057 |
| Traditional authority (community) | | | |
| TA Ndamera (upland) | 124 (73.8%) | 97 (32.8%) | |
| TA Nyachikadza (lowland) | 44 (26.2%) | 199 (67.2%) | |
| | | | 0.000*** |
| Occupation | | | |
| Farmer | 159 (94.6%) | 275 (92.9%) | |
| Non-farmer | 9 (5.4%) | 21 (7.1%) | |
| | | | 0.558 |
| Household size | | | |
| ≤3 | 17 (10.1%) | 29 (9.8%) | |
| 4–9 | 135 (80.4%) | 246 (83.1%) | |
| ≥10 | 16 (9.5%) | 21 (7.1%) | |
| | | | 0.637 |
| Disaster training | | | |
| Yes | 42 (25.0%) | 85 (28.7%) | |
| No | 126 (75.0%) | 211 (71.3%) | |
| | | | 0.448 |
| Age | | | |
| 18–29 | 39 (23.2%) | 55 (18.6%) | |

**TABLE 4** (Continued)

| Variables | Less flood resilient ($n = 168$) | More flood resilient ($n = 296$) | $p$-value |
|---|---|---|---|
| 30–49 | 72 (42.9%) | 131 (44.3%) | |
| 50–69 | 47 (28.0%) | 87 (29.4%) | |
| 70+ | 10 (6.0%) | 23 (7.8%) | |
| | | | 0.625 |
| Health status (household member living with chronic illness) | | | |
| Yes | 22 (13.1%) | 42 (14.2%) | |
| No | 146 (86.9%) | 254 (85.8%) | |
| | | | 0.781 |
| Village civil protection committee member | | | |
| Yes | 42 (25.0%) | 70 (23.6%) | |
| No | 126 (75.0%) | 226 (76.4%) | |
| | | | 0.737 |

*$p < 0.05$; ***$p < 0.001$.

## 5 | DISCUSSION

The factors associated with community flood resilience, in this study, coalesced at the intersection of the need for improved access to public health services, sense of place (resistance to relocation), existential learning from past flooding experience and the need for human capital development for community flood preparedness.

The need for wide access to free family planning services (possible proxy for access to basic primary health care), having families stay together during a flood evacuation (psychosocial health and possible proxy for community's sense of connection and maintaining system function) and prioritization of the sick and vulnerable members of the community during a flood (possible proxy for community's sense of caring and maintaining system function) collectively expressed the importance of public health services in disaster risk management and climate adaptation. From a disaster risk science perspective, these health elements capture both coping (staying together during evacuation and prioritization of the sick and vulnerable) in the short-term (Ulrichs et al., 2019) and adaptation strategies (having access to free family planning services; Daramola et al., 2016). The centrality of health and well-being in flood resilience science and strengthened DRM capacity is supported by De Souza (2014) and as suggested by Bayntun (2012), resilient health systems are better able to protect themselves and human life from the public health impacts of disasters. This finding is also supported by a study conducted by the RAN (2016), in Uganda, in which they concluded that DRM and climate change mitigation interventions would be incomplete without mainstreaming family planning as it has an impact on population pressure, which in turn, increases disaster risk. Rockström (2003) has called such factors resilience parachutes due to their focus on enabling communities and ecosystems to move significantly (if not rapidly) from situations of vulnerability, for example, if families are separated during flood evacuation, toward a maintained system that can continue functioning ex post flooding.

Most of the study participants were recalcitrant to government's resettlement and relocation policy position with higher odds of being more flood resilient among participants living in harm's way (flood-prone community). While resistance has been perceived by some to be detrimental to the capacity to adapt (Liao, 2014), it has also been conceived by others, as in this study, as an inherent element of strengthening resilience (Hegger et al., 2016; Restemeyer et al., 2015). Results of this study capture resistance and a strong sense of place as essential elements of resilience, perhaps informed by learning from existential experience of previous floods the two communities have, for years, endured with little to no support from government. Learning from past disaster experiences is considered an essential element of adaptive and transformative capacities for resilience (Aslam et al., 2019). Nava (2022) captures learning from disasters and learning through disasters as two essential elements of organizational processes emerging in the aftermath of a disaster. As learning from and through disasters are essential elements of resilience, this study captured this phenomenon through evidence suggesting that participants from the lowland (with higher odds of being more flood resilient) did not own land in both the upland and the lowland but they had an alternative place (in the

**TABLE 5** Bivariate analysis comparing the more resilient and less resilient clusters with regards to scores (continuous variables)

| | Less flood resilient ($n = 168$) | More flood resilient ($n = 296$) | |
|---|---|---|---|
| **Variable** | **Mean (±SD)** | **Mean (±SD)** | ***p*-value**[a] |
| Sense of place | 4.60 (2.97) | 6.86 (2.62) | 0.000*** |
| Child education support | 8.75 (1.96) | 8.85 (1.91) | 0.576 |
| Promote the capacity building of the VCPCs to know how to respond to emergencies | 8.11 (2.16) | 8.94 (1.69) | 0.000*** |
| Allow households with persons who are vulnerable, and sick to be prioritized during flood evacuations | 8.20 (2.32) | 9.10 (1.60) | 0.000*** |
| Provide adequate security in evacuation centers to ensure that women and girls are protected from abuse and rape | 8.93 (1.87) | 9.18 (1.58) | 0.137 |
| Provide wide access to free family planning services | 8.89 (1.97) | 9.32 (1.51) | 0.010* |
| Use community by-laws to restrict child marriages | 9.17 (1.60) | 9.36 (1.55) | 0.223 |
| Promote village savings and loans to provide alternative income sources for women | 9.04 (1.67) | 9.24 (1.60) | 0.188 |
| Ensure a woman should not lose the family land if her husband dies | 8.93 (2.32) | 8.84 (2.31) | 0.666 |
| Have families consider their land resources in deciding how many children to have | 7.30 (3.05) | 7.83 (2.80) | 0.062 |
| Allow families to be able to stay together during flood evacuations | 7.39 (3.43) | 8.19 (3.10) | 0.011* |

[a]Independent sample *t*-tests.
*$p < 0.05$; ***$p < 0.001$.

upland) to run to during a flood. This finding reveals two communities that have learnt to interact with their socio-ecological environment to sustain their livelihoods (Baudoin et al., 2014) and therefore can risk living in harm's way. This observation is consistent with the results of a study conducted in Jakarta that showed that, for poor families, living in flood prone areas was necessary for a livelihood (Hellman, 2015) as they paradoxically depend on the same river that causes flooding. The results discussed here demonstrate that this study has managed to present a community flood resilience framework that accounts for previous conceptual challenges relating to failure of other resilience conceptualizations and measurement approaches to capture soft elements of community (lived values) that are often considered difficult to measure.

At the onset of a flood, the first responders are the trained personnel within the affected communities, in this case, the village civil protection committee members. This is considering that external help is usually delayed due to limited access and communication challenges (Islam & Walkerden, 2014). Therefore, it is essential that these first responders have adequate knowledge and skills to prioritize at-risk populations and facilitate safe and effective community evacuation. Thus, such capacity is required to make use of the other capitals discussed above. Results from the regression model identified the capacitation of the village civil protection committees (proxy for social support asset) to respond to flooding as one of the factors significantly associated with being more flood resilient. This seems to suggest that for the short-term absorptive capacities to be effectively deployed, social support linked to human capital development is an important and needed transformative capacity—a finding supported by other similar resilience studies (Department for International Development, 2011; Guiteras et al., 2015).

The results of this study reveal that sense of place, health and community well-being are linked, and yet, distinct dimensions of resilience. As Masterson et al. (2019) note, loss of place attachment and meaning, in this case, through relocation, may have emotional and mental health effects on the affected people. Therefore, interventions that seek to measure and strengthen the resilience of flood prone communities should not only look at physical infrastructure and economic related indicators, but

**TABLE 6** Multivariable-adjusted binary logistic regression model of the factors associated with community flood resilience in TAs Nyachikadza and Ndamera, Nsanje District, Malawi

| Variables | | Odds ratio | 95% CI for odds ratio | | Significance |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| Sense of place | (per unit increase in support) | 1.251 | 1.123 | 1.394 | 0.000*** |
| Community/TA location | Upland (Ndamera) | Ref. | | | |
| | Lowland (Nyachikadza) | 4.610 | 2.274 | 9.346 | 0.000*** |
| Ownership of land in both communities | Yes | Ref. | | | |
| | No | 0.540 | 0.310 | 0.940 | 0.029* |
| Having an alternative place to go during times of a flood | Yes | Ref. | | | |
| | No | 1.659 | 1.009 | 2.730 | 0.046* |
| Provide wide access to free family planning services | (per unit increase in support) | 1.198 | 1.042 | 1.377 | 0.011* |
| Promote capacity building of the VCPCs to know how to respond to emergencies | (per unit increase in support) | 1.163 | 1.026 | 1.318 | 0.018* |
| Allow households with persons who are vulnerable, and sick be prioritized during flood evacuations | (per unit increase in support) | 1.324 | 1.166 | 1.504 | 0.000*** |
| Allow families to be able to stay together during flood evacuations | (per unit change) | 1.145 | 1.065 | 1.232 | 0.000*** |

*$p < 0.05$; ***$p < 0.001$.

also into the social determinants of health. These social determinants of health, supported by strengthened or skilled community disaster civil protection committees (human capital development) have potential to build and sustain the much-needed capacities for communities to maintain system function, cope and sustain livelihoods in the face of adversity.

## 5.1 | Contribution to the science of resilience

This paper has presented cluster analysis as an effective method for empirically deriving, through measurement, and constructing an abstract typology of community flood resilience and still maintaining capability to understand underlying context specific community level common characteristics of resilience using data collected at household level. While we acknowledge that the two communities studied differed topographically (upland and lowland) and in their interaction with flooding, the identification of a common typology of these community resilience characteristics helps policy makers and stakeholders in identifying intervention pathways that transcend community sub-group differences with potential to improve the well-being of the affected people, from a systems approach. Thus, the study makes contribution to previously observed scarcity of empirical evidence of resilience measurement at community level (Bulti et al., 2019). To account for sub-group differences, which has been the major point of critique for the systems approach (McClymont et al., 2020), this study also identified context specific predictor variables associated with being more resilient to flooding through a disaggregation of data for different sub-groups in the sample population.

From a conceptual perspective, this study found that the latent construct of community flood resilience, as measurement derived, captured all the three elements (engineering resilience, systems resilience, resilience in complex adaptive systems) of the conceptual model of resilience (McClymont et al., 2020). From an engineering and systems (ecological) resilience perspective, this study has shown that the construction of a dyke to ward off flooding and the provision of EWSs to alert communities of an impending flood would enable the communities to continue with their livelihood activities while maintaining system function, with minimum impairment, thereby strengthening community flood resilience. This finding is in line with Chambers et al. (2014) and Curtin and Parker's (2014) postulation that strengthening ecological resilience increases system persistence and adaptation in the face of disruptive change. The resilience element related to the extent of support for use of labor from the local communities in the construction of a dyke captures the ability of the communities to reorganize themselves and collectively respond to a crisis, which is an essential element of complex adaptive systems for adaptation, learning and transformation. Collectively, the three elements, as derived from this study, capture a strong emphasis of community agency and social capital through an accentuation of what the two communities can do for themselves and the need to strengthen their capacities, as opposed to focusing on their vulnerability to flooding and relocating them to mitigate flood risk. Thus, this study confirms resilience as a multidimensional concept and validates the theoretical model of the three frameworks of resilience (McClymont et al., 2020) at measurement level, with empirical support of predictors of community flood resilience.

A study by Lee et al. (2009) found that for hurricane Katrina evacuees, resilience was considered to mean perseverance, the ability to work through emerging difficulties, as well as maintaining optimistic views on recovery. These findings found expression in this study in that being resilient was associated with staying in harm's way ("*perseverance*") and the need to strengthen the ability of households to cope during flooding through staying together and prioritizing the sick and vulnerable ("*ability to work through emerging difficulties*") and strengthening community flood preparedness through capacitation of VCPCs which seem to capture the element of optimism of recovery if the necessary adaptation capacities are strengthened. Similarly, findings from the study by the RAN in Southern African communities (RAN, 2017), suggested that environmental stability (defined as construction of a dyke and establishment of EWSs in the current study) has a direct positive effect on human capital (knowledge and skills) development (operationalized as capacitation of VCPCs in the current study), which in turn, contributes positively to wealth creation and food security. As wealth creation and food security were considered important dimensions of resilience in the RAN study, it is conceivable that being more flood resilient would be strongly associated with factors that would protect the livelihoods of the people most at risk of flooding. Such convergence of empirical findings from different spatial and temporal scales confirms the heuristic conceptual and analytical approach, developed based on participatory (bottom-up) approach using substantial input from potential stakeholders (Norris et al., 2008), used in this study as effective in understanding, characterizing, and measuring resilience in the context of disaster risk management and climate adaptation.

### 5.2 | Study limitations

This was a cross-sectional study, hence the caution in making any causal inferences. Furthermore, this was a quantitative study with no explanatory qualitative information to provide all of the context for the participants' responses that may fully explain some of the observations made on the data. In addition, the study participants were mostly male (63.5%) which could have resulted in biased reporting or choice of supported flood risk mitigation options. However, to address these limitations, this quantitative study followed on a qualitative deliberative event at which all the flood mitigation policy options were discussed among all the participants, and a panel of experts availed to provide explanations on aspects that were not clear to the participants before they completed the survey. It can be argued that participants had balanced information on all the policies to be able to make independent informed decisions about their own choices. In the calculation of the community flood resilience construct, we make a normative assumption that responses to the question regarding reducing vulnerability within the communities (community agency) represent flood resilience. This assumption was based on previous resilience literature showing that commitment to remain in a flood prone area despite the prospect of continued future flooding (Keogh et al., 2011; Isa et al., 2018) can be conceptualized as resilience. In addition, reducing vulnerability while supporting community agency is considered central to strengthening resilience (Wood, 2007). The findings of this study provide a foundation for further mixed method studies to understand why poor people living in flood prone areas in similar settings in low- and middle-income countries choose to continue staying there despite the obvious risks to their health and livelihoods.

## 6 | CONCLUSIONS

This study sought to contribute to knowledge on resilience and resilience measurement as a growing area of research and development by using empirical data to construct the variable "community flood resilience" and quantitatively investigating the factors associated with being more resilient to flooding. The community flood resilience construct, in this study, was defined by three factors, namely, the construction of a dyke to ward off flooding, the provision of EWSs and the construction of a dyke using labor from the local community. Therefore, we conclude that, empirically, the construct captured all the three elements (engineering resilience, systems resilience, resilience in complex adaptive systems) of the earlier conceptual model of resilience. Thus, the approach taken in this paper is considered to be comprehensive as it captured the soft elements of resilience that are often considered difficult to measure. While resilience measurement was at community level, our analytical approach enabled us to also investigate the differential sub-population factors that make other population groups more vulnerable than others. The conceptual and measurement achievements of this study were achieved mainly due to the participatory design of the study that galvanized the two communities to action by providing them with context specific information about flooding, its effects and various actions/policy options available to them.

As the results of this study accentuated and buttressed the central role of public health and the need to understand the interactions between affected people and their ecological environment in addition to the physical environment factors, this confirms resilience as a multidimensional concept. However, the level of importance of the various dimensions may differ depending on the context. In this case, public health service provisioning was presented as an important, yet missing component for the two communities to function effectively. In addition, the socio-ecological factors may have been considered important as they captured the already existing flood adaptation mechanism that undergird the livelihood and well-being of the two communities. The confirmation of importance of human capacity (knowledge and skills) development for disaster preparedness and predictor of community flood resilience in this study, as was captured in other studies in the African region, shows the importance of directly capacitating people living in flood prone communities as the first responders to disaster situations. Finally, resistance to relocation as a flood mitigation strategy was shown to be a strong statement by the affected communities in defiance of a government relocation plan, and an expression of a strong sense of place. It is also a call to stakeholders to support community members' efforts to continue living within the existing community but implement interventions that would reduce communities' risk and promote sustainable development of the community. The study further demonstrates that affected communities in this study, and in similar settings in low- and middle-income countries, are not ideal recipients and implementers of policies, but rather they are knowledge generating labs capable of making decisions on matters of policy that affect their lives and well-being. Therefore, this study makes the following specific recommendations to policymakers:

- Policymakers need to recognize that communities have the capacity to self-organize and develop context-specific flood coping and adaptation practices that with time become recursive and part of their everyday life and inherently a key determinant of their resilience to flooding.
- Over and above the construction of protective physical infrastructure, policy makers need to put socio-ecological interactions and processes at the center of understanding flood resilience which imply the need for highly participatory and inclusive policy development consultations. Such consultations should be geared toward galvanizing communities to identify possible interventions or actions that can be implemented to reduce their vulnerability while at the same time, sustaining their livelihoods.
- Governments should provide, and allow other stakeholders to provide, social services that strengthen the human capital assets of communities to be able to adapt to the flooding situation as long as people live in harm's way. Provision of such services or support will instill a sense of community agency and autonomy to determine their future which may nurture a less contentious attitude among the affected people when they interact with policy makers.

Despite its limitations, for example, being purely quantitative, this study has provided a heuristic resilience measurement framework and a foundation for further mixed method studies to understand why poor people living in flood prone areas in similar settings in low- and middle-income countries choose to continue staying there despite the obvious risks to their health and livelihoods.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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