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Exploring Household Preparedness towards Earthquakes along the East African Rift Systems in Tanzania: A Case of the Bukoba Municipality

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Abstract

Tanzanian households in the East African Rift System (EARS) are susceptible to regular earthquake shocks, but it is uncertain how they are prepared to handle the consequences. Residents of Bukoba Municipality are particularly at risk because of its location along the EARS, rapid population growth, and encroachment of earthquake fault zones. This study was conducted in the Kashai and Hamugembe wards of the municipality to examine household readiness for potential earthquakes. A mixed-methods approach was used, gathering data from 391 respondents, 8 key informants, and 12 focus group participants through a questionnaire survey, interviews, focus group discussions (FGD), and physical visits. Qualitative and quantitative data were analysed using content and descriptive statistics, respectively.

The findings revealed that most respondents were unaware of the cause of earthquakes and safety measures. The dominant earthquake skill in the study area was evacuation (58.3%). Furthermore, 86.2% of respondents lived in unreinforced buildings, water was the most reserved emergency item (39.4%), and mobile phones were prevalent (96.2%) means of communication and information. We also found that neighbour contacts were the most (91.8%) emergency number respondents had. The limited knowledge and skills, lack of emergency items, and unreinforced buildings indicate that residents are at significant earthquake risk. However, the widespread use of mobile phones presents an opportunity for effective knowledge dissemination. We recommend investing in public earthquake awareness programmes and using multimedia to disseminate earthquake information. Additionally, the government should implement earthquake-resistant construction regulations and improve communication among local communities and first responders.

Keywords: earthquake disaster, earthquake preparedness, east African rift systems, household, Tanzania

1. Introduction

Earthquake vulnerability and its associated impacts, including deaths, injuries, and property disruption have significantly increased (Alaneme & Okotete, 2018; Mara & Vlad, 2012; Shaluf, 2007; United Nations Office for Disaster Risk Reduction-UNDRR, 2019) For instance, between 2000 and 2019, over 58% of deaths from natural disasters were from earthquakes and tsunamis (Freddi et al., 2021). Between 1900 and 2016, 2.3 million people lost their lives as a result of earthquake shaking and the tsunamis, fires, landslides, liquefaction, floods, and surface rapture that followed. The direct economic costs of these catastrophes were US$ 2.42 trillion, while the total financial costs were US$ 3.41 trillion. (Daniell et al., 2017). These impacts stem from social, economic, cultural, political, and environmental changes, particularly rapid population growth, poverty, poor construction methods, and negligence of building codes and preparedness measures by governments and communities living in earthquake-prone areas (Becker et al., 2012; United Nations Department of Economic and Social Affairs_Population Division, 2021). Tanzania, situated along the EARS, frequently experiences earthquakes that cause significant impacts. One of them is the 2016 Kagera earthquake that killed about 17 people, injured 560, and destroyed almost 18,764 residential buildings (United Nations-UN & United Republic of Tanzania-URT, 2016). Poor residential building structures, ignorance, and a slow response were blamed for the effects.

The Bukoba Municipality provides a good case study as it was the worst-affected area by the 2016 Kagera earthquake. All 17 deaths occurred in the Bukoba Municipality. The remaining seven councils of the Kagera region did not experience any deaths (International Federation of the Red Cross and Red Crescent Societies-IFRCS, 2016). Additionally, the National Bureau of Statistics (NBS 2021) indicates that the population in Bukoba Municipality increased remarkably from 8,141 people in 1967 to 186,089 in 2020. The population density increased from 974 to 1,552 people per square kilometre in 2002 and 2012, respectively (Tanzania National Bureau of Statistics-NBS & Bukoba Municipal Council-BMC, 2018). This rapid population growth has increased household vulnerability to earthquakes as housing demands surge.

2. Earthquake Disaster Preparedness

Earthquake preparedness measures for individuals or households involve adopting mitigation and survival strategies (Adhikari et al., 2018; O'Meara, 2010). The former include creating a plan for what individuals will do if an earthquake occurs; retrofitting buildings and securing objects within a residence; and educating and undertaking social actions related to earthquake preparedness (Ejeta et al., 2015; Pradhan, 2016). As for survival measures, these are actions to help individuals or households sustain themselves for 3 days after an emergency. They include having supplies, material resources, information resources, financial reserves, food resources, water resources, a torch, a radio, medication, evacuation capacities, and developing survival skills in individuals (Sutton & Tierney, 2006). Effective earthquake or disaster preparedness considers three interconnected and interrelated preparation phases: pre-, during, and post-earthquake or disaster. According to The Theory of Planned Behavior (TPB) and the Social Construction Theory, preparedness results from certain factors. The TPB views preparedness as behaviour driven by intention, influenced by three motivational factors: attitude, subjective norms or social factors, and perceived behavioural control. Conversely, the Social Construction Theory emphasises the role of social elements, such as interactions, inequalities, and perception in shaping preparedness and eventually the occurrence of a disaster. These theories shed light on what concepts, variables, and indicators to address when studying preparedness as a process and an outcome. Engaging in earthquake preparedness helps to reduce vulnerability, facilitates a timely, efficient, and effective response, and shortens the recovery period (Pradhan, 2016; Simpson, 2008; United Nations Development Programme-UNDP, 2016) from which, lives and vital economic assets are saved, and the cost of relief assistance is reduced (Bendimerad, 2004; Malla et al., 2015; Ronan & Johnston, 2005; United Nations International Strategy for Disaster Reduction-UNISDR, 2013). Disaster preparedness is underscored in the Hyogo and the Sendai Frameworks for disaster management, specifically in priority five and three, respectively.

Despite several initiatives to spread knowledge and awareness about the importance of preparedness, global household readiness for earthquakes remains low to moderate (Becker et al., 2012; Greer, 2012). Comparatively, preparedness is better established in developed than developing countries (Mara & Vlad, 2013). In the former, coordination, investment, communication, awareness of disasters, and enforcement of building codes are capital-intensive and high-level compared to developing countries (Idham, 2020; Parashar et al., 2011; Spittal et al., 2006). In countries such as Japan, about 7% of the national budget is allocated for structural mitigation, whereas in Tanzania only 1% is reserved for disaster management (UNDRR, 2020). The successes rely on a strong community linkage, social capital, effective local community leadership, and a powerful governance support system. As a result, although most developing countries experience moderate seismicity, they are more vulnerable to earthquakes than their counterparts (Moon, 2020). Meanwhile, most studies examining earthquake preparedness have been conducted in developed countries and in regions that experience high-magnitude seismicity (Ardalan & Sohrabizadeh, 2016; Patrisina et al., 2018; Simpson, 2006).

Available earthquake studies in Tanzania have examined fault kinematics, tectonic stress, fault segmentation, paleo stress, paleoseismic, earthquake disaster risk management, and possible seismic mitigation strategies and technologies (Haulle, 2012; Haulle & Rugumamu, 2015; Macheyeki, 2008; Manyele, 2016). Research in Bukoba has primarily focused on examining earthquake survivors' experiences and struggles among disaster survivors (Kamanyi, 2020, 2023). Literature on household earthquake readiness in low- to moderate-quake zones is scarce, especially along the EARS that passes through Bukoba. This study investigates various aspects of earthquake preparedness in Bukoba Municipality in the Kagera Region of Tanzania, in a low to moderate-magnitude earthquake zone along the EARS. Particularly, it examines household awareness regarding the cause of earthquakes, earthquake knowledge of safety measures, earthquake response skills, reinforcement status of residential buildings, possession of essential emergency items, information and communication equipment, and emergency contacts.

3. Methodology

3.1 Selection and Description of the Study Area

This study was conducted in Bukoba Municipality in the Kagera Region of Tanzania (Figure 1).

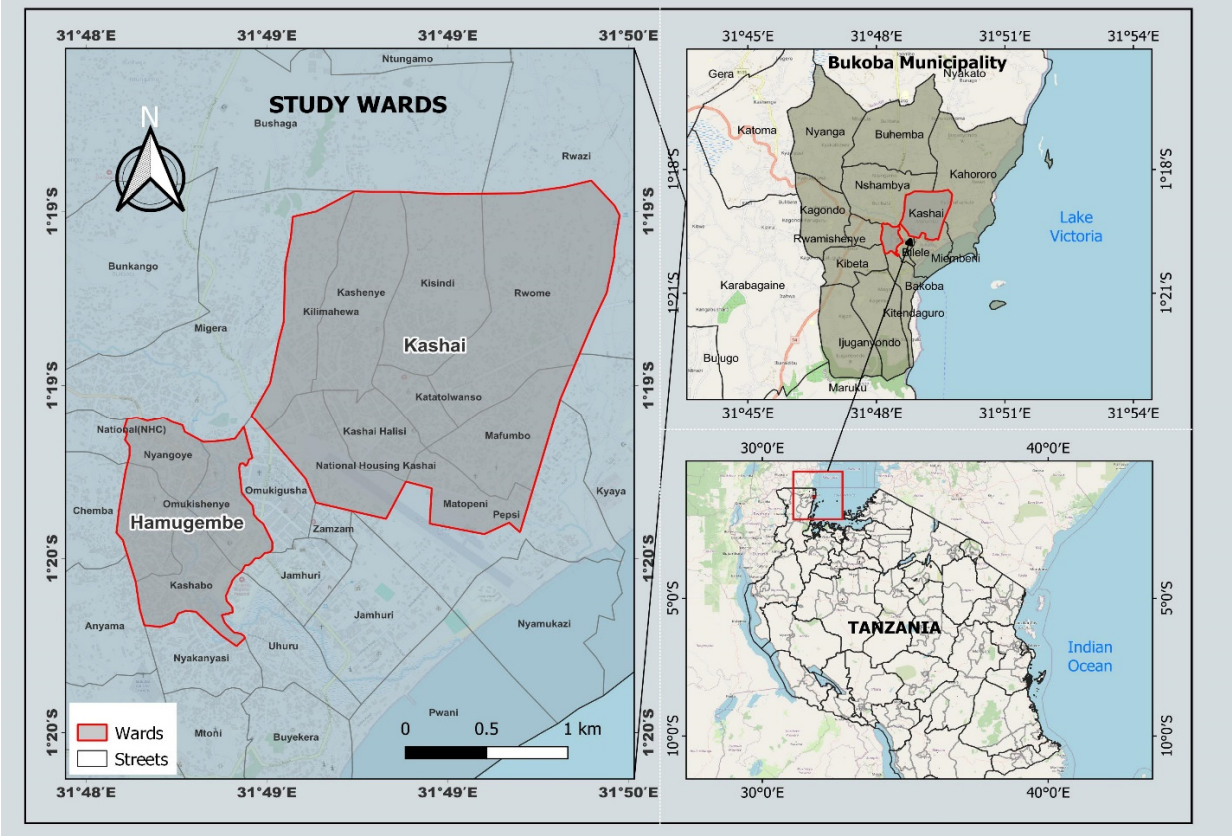

Figure 1. A map of Bukoba municipality including the sampled wards

The Municipality was selected based on the high impacts caused by an earthquake in recent years (NBS & BMC, 2018; URT, 2020). Geographically, the Municipality lies in the western branch of the EARS, which runs over a distance of 2100 km from Lake Albert (Mobutu) in the North to Lake Malawi (Nyasa) in the South (Chorowicz, 2015). It is located between latitudes 1°6'0" to 1°8'42" South of the Equator and longitudes 31°16'12" to 31°18'54" East of Greenwich. Bukoba Municipality is found at an altitude ranging from 1,140 to 1,600 meters above the mean sea level. It borders Lake Victoria to the east and the Bukoba District Council to the south, west, and north. Most town structures are in the lake basin, with escarpments separated by several streams and rivers, such as Nyanshenye, Kanoni, and Kagemu, and their tributaries (NBS & BMC, 2018). The 2022 population census revealed that Bukoba Municipality had a population of 144,938 (68,786 males and 76,152 females) with an average annual growth rate of 1.2%. The trend between the 2012 and 2022 censuses indicated an increase of 12.5%. Regarding population density and distribution, the number of people per square kilometre increased from 974 in 2002 to 1,552 in 2012 and 1,720 in 2022 (URT, 2022). The municipality's location and population density elevate its proneness, vulnerability, and earthquake risk, particularly from liquefaction, falling rocks, and lake flooding.

3.2 Sampling

The study adopted purposive sampling to select the two wards using a set of prepared criteria. The criteria were; a record of earthquake events, earthquake impacts, proneness, urbanity, and shortage of studies. Purposive sampling was also used to select 8 key informants for in-depth interviews, and 12 focus group participants (FGDP) (6 from Kashai Ward and 6 from the Hamugembe). To obtain in-depth information from the two wards, all sub-wards in the two wards (9 from Kashai and 4 from Hamugemebe) were included in the study.

A sample size of 391 households out of 16,587 was determined using Yamane's (1967) formula. Consequently, proportional sampling was employed to determine the number of households from each sampled ward and sub-

ward, as indicated in Table 1.

Table 1. Summary of the types and numbers of stakeholders involved in the study

Location/Office	Sub-ward	Number of HH	Sample of HH	KIs	FGDP	Total
Kashai Ward	Kilimahewa	893	21			
	Kashenye	1,380	33			
	Rwome	1,139	27			
	Katatolwanso	1,349	32			
	Mafumbo	1,206	28			
	Kisindi	756	18			
	Matopeni	1,498	35			
	Kashai Halisi	2,240	52			
	NHC Kashai	873	21			
Total		11,334	267	1	6	274
Hamugembe Ward	Nyangoye	1,452	34			
	Omukishenye	1,377	33			
	Kabangamilembe	1,062	25			
	Kashabo	1,362	32			
Total		5,253	124	1	6	131
Bukoba Municipal Disaster Management				1	-	1
GST				1	-	1
Municipal Engineering				1	-	1
Municipal Town Planning				1	-	1
Bukoba Police				1	-	1
Fire and Rescue Force				1	-	1
Red Cross Society				1	-	1
Total		16,587	391	8	12	412

HH = Household, KI = Key Informant, GST = Geological Survey of Tanzania

The wards' registration books provided the names of the households from which representative households were selected. Households' names were written on papers, folded, and picked randomly to meet the desired number of participants for each sub-ward. The simple random sampling method was chosen because any household in the selected wards was equally likely to be affected by potential earthquakes.

3.3 Data Collection Methods

Data were collected through a questionnaire survey, interviews with key informants, FGD, and physical visits to the study area. The questionnaire items were prepared with guidance from the research objectives and studies by Spittal et al. (2008), Russell, et al. 1995), and Ardalan & Sohrabizadeh (2016), which outline components for household earthquake preparedness. The initial draft of the questionnaire was pre-tested on 30 residents in the study area to check for clarity, reliability, and validity leading to modification by adding, omitting, or rearranging questions. The final draft had 3 sections: the study's aim, the socio-demographic characteristics of respondents, and earthquake preparedness. The questionnaire had 12 items on earthquake awareness, knowledge, skills, reinforcement of residential buildings, emergency items, and information and communication equipment. Semi-structured questions facilitated the acquisition of data related to household awareness of the cause of earthquakes, earthquake knowledge of dos and don'ts, earthquake skills, reinforcement status of residential buildings, and

owning; essential emergency items; information and communication equipment; and emergency contacts. The researchers, two research assistants, and a local guide administered the questionnaire face-to-face to 391 sampled households (household heads or representatives) in the Kashai and Hamugembe wards.

On the other hand, one-on-one semi-structured, in-depth interviews were held with the Bukoba municipal disaster focal person, municipal engineer, municipal planning officer, municipal police officer, Red Cross coordinator, fire and rescue officer, chief geologist of the Geological Survey of Tanzania, and the Ward Executive Officers (WEOs) of Kashai and Hamugembe to get an insight into household preparedness and to facilitate triangulation and complementing the data obtained through questionnaires. Since key informants deal with disasters in their day-to-day activities, interviews offered detailed data on household disasters and earthquake preparedness in the municipality. Interviews were conducted with the help of an interview guide, which had 5 open-ended questions to allow flexibility and leave room for the researchers to ask follow-up questions to capture in-depth information. The interview questions focused on awareness creation, availability of resources, and challenges in earthquake risk management.

Six representatives from each of the two wards participated in focus group discussions to gather information on earthquake readiness. The researchers in collaboration with the Ward Executive Officers of Kashai and Hamugembe arranged the meetings between the researchers and the participants. In each ward, discussions were carried out at the WEO's office. Apart from triangulating and complementing respondents' and key informants' information, the discussions also helped to get information on household earthquake preparedness measures in their wards. The researchers moderated the discussions concurrent with note-taking using a prepared discussion guide, which had five open-ended items based on the causes of earthquakes, earthquake awareness programmes, availability status of risk reduction materials, and communication mechanisms between community members and disaster management stakeholders, especially first responders.

Physical visits allowed verification of information particularly, those related to the reinforcement of residential buildings, physical features, materials, and items for communication and survival that were collected through the questionnaire survey method. This method was accompanied by note-taking and photographs to facilitate linking and substantiating information from other sources and methods for enhancing the reliability of the collected data. An observation checklist with 7 items based on physical features, residential structures, and preparedness items was prepared to identify earthquake preparedness activities like reinforcement of houses.

3.4 Data Analysis

Classical content analysis was used to analyse qualitative data obtained from focus groups and interviews with key informants. Audio data were transcribed and the transcriptions were concurrently studied with interview notes and were coded to get the main themes. Quantitative data from the questionnaire was verified, coded, and analysed using IBM Statistical Package for Social Sciences (SPSS) version 20 and MS Excel spreadsheets to generate frequencies and percentages.

4. Results

4.1 Socio-Demographic Characteristics of the Respondents

Findings in Table 2 show that the majority (57.8%, n = 391) of the respondents in the study area were female, while 42.2% (n = 391) were male. This aligns with the Tanzanian population composition, where females compose the majority (URT, 2022). Furthermore, women were more likely to be present during the study as they are typically responsible for household upkeep. Age-wise, a significant portion of the respondents (51.7%) were between 38 and 57 years old. This age group falls within life expectancy and typically consists of independent individuals from their parents who have their households. Regarding education, most respondents (73.7%) had completed primary school, with only 1.5% having completed post-secondary education. This trend may be attributed to the 1979 Tanzania Educational Policy, which mandated free and compulsory primary education for all children. Marital-wise status, the majority (70.3%) were married, while a small percentage (0.5%) were divorced. The high prevalence of marriage can be explained by its cultural significance and respect as a life stage in most African societies.

Most respondents (55.8%) were petty vendors of food and vegetables, reflecting the semi-urban nature of the study area, where traditional farming has been transformed by urbanization. This occupation influenced the income levels, with the majority (76.2%) earning below 250,000 TZS (106.34 US dollars) per month, based on household daily expenditures. Moreover, the fact that most respondents were indigenous to the area is reflected in their duration of residence, with the majority (71.6%) having lived in Bukoba Municipality for over ten years.

Table 2. Socio-demographic characteristics of respondents (n = 391)

Variable	Parameter	Sex		Average (%) n=391
		Male (%) n=165	Female (%) n=226	
Age (Years)	18-37	23.6	32.7	28.9
	38-57	54.5	49.6	51.7
	Above 57	21.8	17.7	19.4
Education Level	Informal	4.8	5.8	5.4
	Primary	72.1	74.8	73.7
	Secondary	20.6	18.6	19.4
	Tertiary	2.4	0.9	1.5
Marital Status	Single	6.7	7.1	6.9
	Married	86.7	58.4	70.3
	Separated	4.2	15.9	11
	Divorced	0	0.9	0.5
	Widow(er)	2.4	17.7	11.3
Occupation	Peasant	25.5	19	21.7
	Petty vendors	52.7	58	55.8
	Formal Employment	4.8	5.3	5.1
	Others	17	17.7	17.4
Monthly Income	Below 150,000	73.3	78.3	76.2
	150,000-300,000	15.8	17.3	16.6
	300,001-450,000	7.9	2.2	4.6
	Above 450,000	3	2.2	2.6
Duration Stayed	Below 10 years	21.8	33.2	28.4
	More than 10 years	78.2	66.8	71.6

4.2 Awareness of the Cause of Earthquakes

Table 3 indicates that a small majority of the responders (50.9%, n = 199) were unaware of the scientific cause of earthquakes, but 49.1% (n = 192) were aware of it. Among respondents who knew the scientific cause of earthquakes, 66.7% (n = 4) of respondents with tertiary education knew that internal earth movements cause earthquakes. The percentage of the respondents who knew the cause declined with the level of education to 57.9% (n = 44) for secondary, 48.6% (n = 140) for primary and 19% (n = 4) for those with informal education.

Table 3. Awareness of the cause of earthquakes

Education	Knowledge	
	Know (%)	Don't know (%)
Informal	19	81
Primary	48.6	51.4
Secondary	57.9	42.1
Tertiary	66.7	33.3
Total	49.1	50.1

Respondents who were aware of the cause of earthquakes mentioned the internal movements of the earth as the reason. Respondents unaware of the scientific cause mentioned climate variability, God's punishment, and

supernatural forces as the causes of earthquakes.

> *Yes, earthquakes result from high temperatures. I have lived here for most of my 50 years and can confirm that 2016, one of the hottest years I have experienced, coincided with the deadliest earthquake to strike our region. Generally, today's temperatures are higher and there are more earthquakes and droughts. You can see (pointing to banana through the window) how our main food crop is scorching and wilting. This situation was unheard of when we were in our 20s." (Focus group participant)*

4.3 Knowledge of Earthquake Safety Measures

As seen in Figure 2, 83.4% (n = 326) of the respondents were unsure of what to do, 16.6% (n = 65) knew what to do, but 50.9% (n = 199) were unaware of what to avoid, and 49.1% (n = 192) knew what to avoid during and after an earthquake.

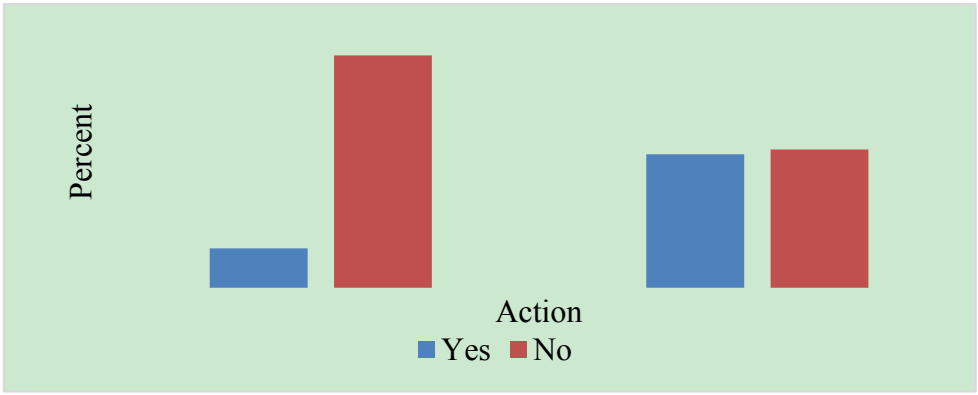

Figure 2. Knowledge of earthquake safety measures

The unsure and unawareness might have been attributed to a lack of training and awareness programmes. We found that only 3.6% (n = 14) of the respondents received earthquake training since the 2016 earthquake. The training and meetings were conducted at different times by the Geological Survey of Tanzania (GST), the Red Cross Society, the Fire and Rescue Force, and the Tanzania Electric Supply Company (TANESCO). Among the locations and things that respondents knew to avoid before, during, and after an earthquake, 95.7% (n = 374) mentioned that they would stay away from walls and tall buildings, 89.5% (n = 350) mentioned tall trees, 71.9% (n = 281) power lines, 47.6% (n = 186) doors and windows, 47.1% (n = 184) running, 42.5% (n = 166) elevators, 36.8% (n = 144) bridges, 6.9% (n = 27) rocks, and 3.6% (n = 14) shouting. Among those who knew what to do, 44.5% (n = 174) were aware of drop-cover-hold, 9.7% (n = 38) knew where to put heavy objects or fasten and brace heavy objects to walls, 6.1% (n = 24) said they would hide at the inside corner of a house, and 5.6% (n = 22) said they would hide at the interior wall, as indicated in Table 4.

Table 4. Understanding of earthquake safety measures (n=391) (multiple responses)

Reaction	Aspects /action	Know		Don't know	
		Number	Percent	Number	Percent
Avoid/don'ts	Door and windows	186	47.6	205	52.4
	Use elevator	166	42.5	225	57.5
	Running	184	47.1	207	52.9
	Shouting	14	3.6	377	96.4
	Tall buildings or walls	374	95.7	17	4.3
	Electric Poles	281	71.9	110	28.1
	Tall Trees	350	89.5	41	10.5
	Rocks	27	6.9	364	93.1
	Bridges	144	36.8	247	63.2
Average		192	49.1	199	50.9
Perform/safety action/dos	Placement of heavy objects	38	9.7	353	90.3
	Drop-Cover-Hold	174	44.5	217	55.5
	Hide at the corner	24	6.1	367	93.9
	Hide at the Interior Wall	22	5.6	369	94.4
Average		65	16.6	326	83.4

Most respondents still remembered that collapsing walls were the primary cause of death during the 2016 earthquake. Also, a good number of respondents were aware of avoiding power lines, walls, and tall trees. These features are so prevalent in the two wards that when the research team asked respondents what to avoid, some would simply look around, see, and mention them.

4.4 Earthquake Skills

The results in Table 5 indicate that 58.3% (n =228) of the respondents had self-evacuation skills, 36.8% (n = 144) could practice drop-cover-hold skills, 29.7% (n = 116) had first aid skills, 26.1% (n = 102) had fire suppression skills, 19.2% (n = 75) had rescue skills, 16.6% (n = 64) had fire prevention skills, and 8.4% (n = 33) lacked any of the explored coping abilities. Of the two administrative wards, 19.4% (n = 24) of the respondents in Hamugemebe lacked any earthquake coping skills, while Kashai had 3.4% (n = 9) without any skills.

Table 5. Earthquake skills

	Respondents' ward (%)		
Skill	Kashai (n = 267)	Hamugembe (n = 124)	Average % (n = 391)
Rescue	20.2	16.9	19.2
First aid	34.5	19.4	29.7
Fire suppression	32.2	12.9	26.1
Self-evacuation	57.3	60.5	58.3
Fire prevention	20.6	8.1	16.6
Drop-cover-hold	34.8	41.1	36.8
I don't know	3.4	19.4	8.4

Apart from evacuation skills, the respondents in the study area had low levels of other earthquake coping skills. Respondents who lacked earthquake coping skills blamed the government and their local leaders for being irresponsible, particularly in failing to arrange training programmes that would expose them to the skills. Our

findings revealed that only 3.6% (n = 14) of the respondents had attended at least one earthquake training after the 2016 earthquake. The victims further accused their leaders of selfishness and favouritism in deciding who should attend seminars, especially those organized by the GST in 2016 and 2017. However, the GST chief geologist reported that the after-2016 earthquake training sessions were public meetings, open to all community members. The geologist associated the poor attendance with people being preoccupied with recovery and follow-ups of relief materials. Poor communication between local leaders and community members might be the cause of various reasons for failing to attend the training. When asked if the GST had conducted follow-up training recently, the official stated:

> *Due to inadequate funding for GST, urgent needs like training are given attention during emergencies and disasters, while administrative activities and other needs take precedence during non-emergencies. (GST chief geologist)*

The above excerpt reflects stakeholders' reactive approach toward disaster management in Bukoba and Tanzania.

4.5 Reinforcement Status of Residential Buildings

It is recommended to tie conventional masonry walls with continuous ring beams on top and near the foundation, and to column the corners in the earthquake-prone areas (Uganda National Bureau of Standards-UNBS, 2003), or else it is better to construct wooden structures as they have a high inherent resistance to earthquake shaking (Robazza et al., 2013). The results presented in Table 6 show that 86.2% (n = 337) of the respondents' residential buildings were not reinforced (they lacked at least two beams and four columns), and 13.8% (n = 54) were reinforced. Furthermore, this study aimed to determine if the 2016 earthquake influenced building reinforcement, so respondents were asked whether their residential buildings were constructed before or after the 2016 event. Results showed that 77.5% (n = 303) of the respondents' buildings were built before 2016, while 22.5% (n = 88) were built after 2016. Among the two periods, the result revealed a scaling up of reinforced buildings from 9.2% before 2016 to 29.5% of those built after 2016 and a decrease of unreinforced residential buildings from 90.8% before 2016 to 70.5% after 2016, as illustrated in Table 6.

Table 6. House reinforcement

Status	Before 2016 (n = 303)		After 2016 (n = 88)		Total (n = 391)	
	number	%	number	%	number	%
Reinforced	28	9.2	26	29.5	54	13.8
Unreinforced	275	90.8	62	70.5	337	86.2
Total	303	100	88	100	391	100

A physical visit to the study area noted that most residential buildings lacked beams and columns. In most cases, houses with a single beam had beams tied after the installation of windows, as depicted in Figure 3.

Figure 3. Reinforcement status of residential buildings

An interview with a GST official who conducted a damage assessment after the 2016 Kagera earthquake disclosed that even the house beams constructed by the residents are ineffective as they are commonly a mixture of substandard ratios of cement, sand, and gravel with one or two 12 mm iron bars. Regarding the same, the municipal civil engineer said;

> *Although Tanzania lacks earthquake building codes, the municipality recommends continuous beams and columns when constructing houses. According to the existing building regulations, a structure should have at least two beams of four iron bars, each with 16mm. One beam is fixed after the foundation, the other after the tops of windows and doors. A plinth is an option, according to the regulations.*

4.7 Emergency Items

A household's ability to effectively lessen the effects of an earthquake depends on what supplies or emergency goods it has. The results of this study show that 39.4% (n = 154) of the respondents owned water that would sustain them for three days, 26% (n = 102) had a torch, and 19.2% (n = 75) had a reserve of food that would sustain them for three days. Furthermore, the result indicates that 5% (n = 20) of the respondents had a whistle, 3.3% (n = 13) had a first aid kit, 2% (n = 8) owned helmets, and 1.8% (n = 7) had fire extinguishers, as revealed in Figure 4.

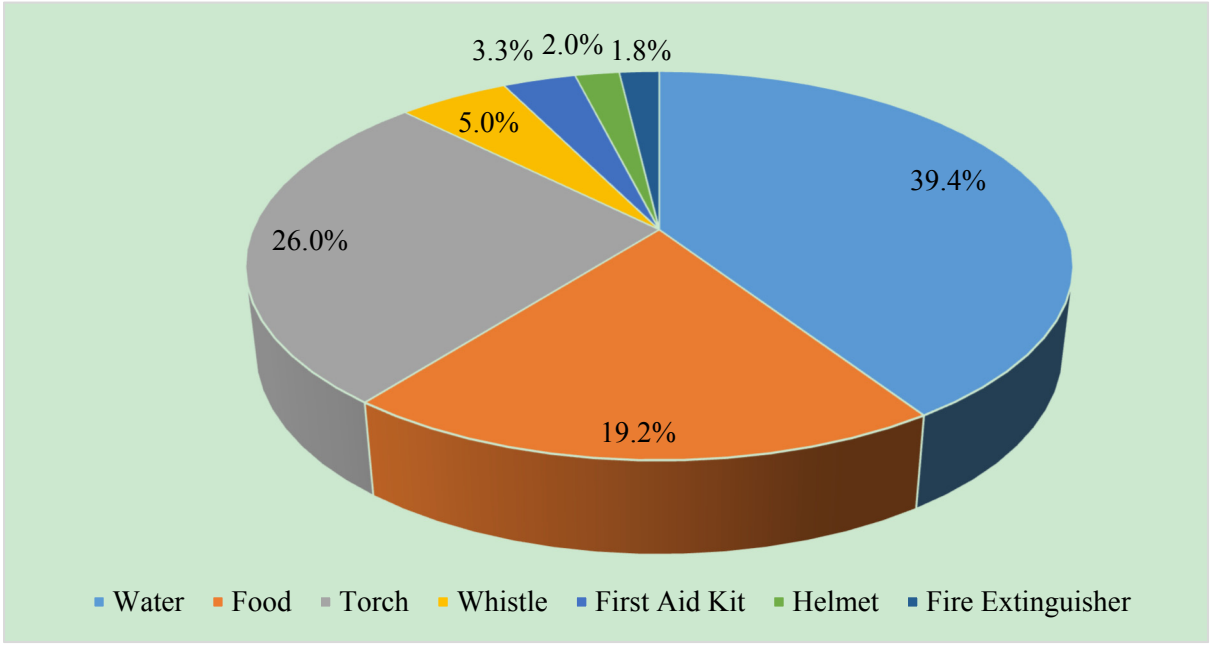

Figure 4. Emergency items (multiple responses)

When respondents were further probed about their lack of materials, they claimed either unawareness of the essential materials needed during an emergency or an inability to buy them because of other pressing needs. The respondents were grateful to the researchers via a questionnaire session, which turned into an eye-opening classroom, and they promised the researchers to start reserving the needful.

4.8 Information and Communication Equipment

The results showed that most (96.2%, n = 376) respondents had mobile phones for communication and acquisition of information, 74.4% (n = 291) had a radio, 74.2% (n = 290) had television sets, and 1.8% (n = 7) did not own any means of information and communication.

Among the two wards, 98.4% (n = 122) of the respondents in Hamugembe had mobile phones, compared to 95.1% (n = 254) in Kashai. Besides, 78.4% (n = 97) of respondents in Hamugembe owned radios, compared to 72.7% (n = 194) in Kashai. Hamugembe was also better off than Kashai because all respondents owned at least one of the three means of information and communication, namely, a mobile phone, radio, or television, while Kashai had 2.6% (n = 7) of the respondents lacking any of the means, as illustrated in Figure 5.

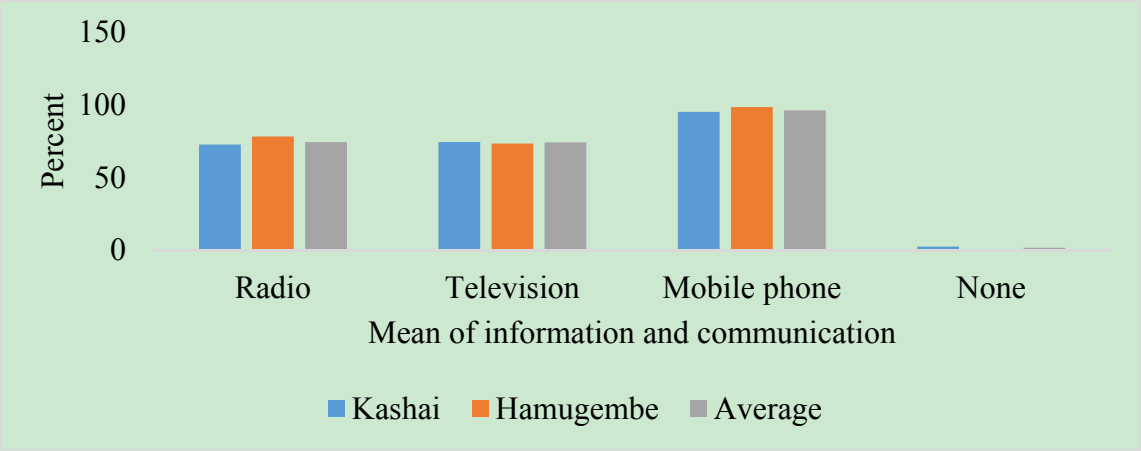

Figure 5. Types of information and communication equipment owned (multiple responses)

In responding to the information and communication equipment used in Bukoba, one participant said;

> *"In the early 2000s, here in Bukoba, there were hardly five mobile phone shops, therefore the phones were expensive and difficult to own. People who owned mobile phones were numbered. We ordered or asked a friend or family member from Dar es Salaam or Mwanza City to buy us one because the mobile phones were cheaper there. However, nowadays mobile phones are more affordable and widely available than in the past, almost every individual has a mobile phone." (Focus group participant at Hamugembe)*

The above excerpt pinpoints the reason behind the increase and wide use of mobile phones compared to radio, as revealed during the focus group discussion. Additionally, participants reported that some phones serve multiple functions of radios and televisions thus why people prefer them. We observed that the cheapest multi-purpose mobile phone in Bukoba was sold at around 30,000 TZS (12.76 US dollars), compared to the phone price of 40,000 - 50,000 TZS (17.01-21.27 US dollars) in the past eight years, respectively.

4.9 Emergency Contacts

Information flow among disaster management stakeholders is crucial before and during an emergency. Households and community members should have the telephone numbers of disaster management stakeholders, particularly first responders, to facilitate pertinent information flow like giving and receiving directives during an emergency. Figure 6 shows that the majority (91.8%, n = 359) of the respondents had contact numbers for their neighbours, 71.6% (n = 280) of their sub-ward leaders, 30.7% (n = 120) of TANESCO, 23.3% (n = 91) of the Bukoba Police Office, 16.1% (n = 63) of the Fire and Rescue Office, and 4.9% (n = 19) had none.

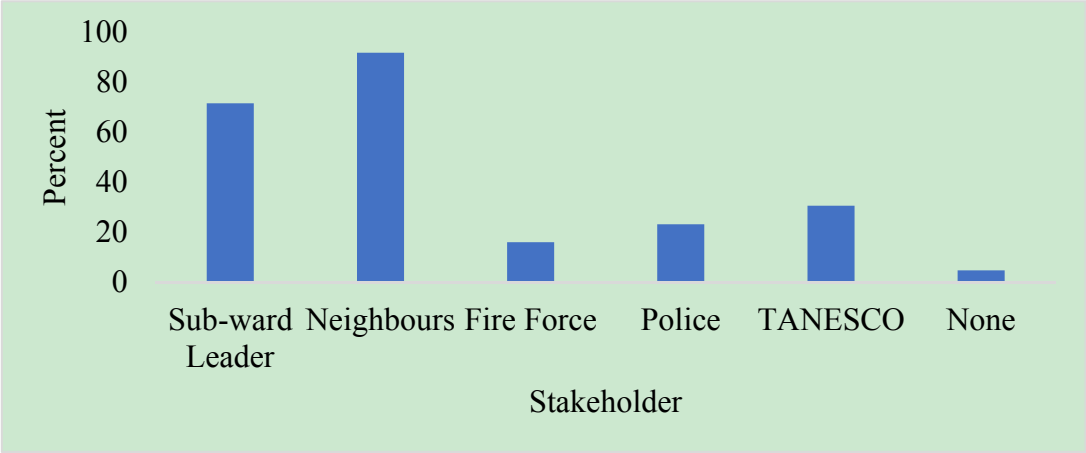

Figure 6. Emergency contact numbers (multiple responses)

Despite the claims by the police, Officer Commanding District (OCD) for Bukoba, and the Fire Official that they had publicized their emergency numbers through posters, stickers, radios, and TVs, a small number (23.3%, n = 91) of the respondents acknowledged possessing the contacts of the police and 16.1% (n = 63) for the Fire and Rescue

5. Discussion

Most respondents were unaware of the scientific cause of earthquakes, and there was a positive correlation between education level and awareness. This contrasts with findings by Songlar et al. (2019) in Thailand, where the majority (66.9%) of the respondents in Chiang Rai understood the scientific basis for earthquakes. The variations in economic levels and experience might have caused disparity in awareness. Thailand is a more developed country that influences investment in disaster management as opposed to our study area which is found in a developing nation. Moreover, the study by Songlar focused on elders aged 60 years and above contrary to ours which had respondents aged 18 years and above. In most cases, age influences experience, subsequently shaping awareness (Tekeli-Yesil et al., 2010; Oral et al., 2015). Since most respondents did not understand the root cause of earthquakes, they were likely to take the wrong measures to counteract earthquakes. Our findings on the relationship between awareness and education run counter to Sözen (2019) in Turkey who found a lack of significant differences between grade levels and earthquake awareness levels among undergraduate students. The variations in findings between the two studies might be attributed to the nature of respondents. Our study covered respondents of all education levels while Sozen's respondents were undergraduate students. Furthermore, the variations mean that earthquake awareness depends not only on formal education but also on other factors such as background, experiences, and peer education.

The study found that most respondents did not understand what to do and avoid during and after an earthquake. Skill-wise, while more than half of the respondents possessed evacuation skills, less than half possessed other earthquake skills. This finding is contrary to Kolanchu (2011) which found that a majority (73%) of the participants in Zamdela township – Sasolburg lacked evacuation skills. The disparity might be due to the time elapsed since the last earthquake, as people who recently experienced a disaster tend to be better prepared (Tekeli-Yesil et al. 2010; Musacchio et al., 2015). Our study was carried out a few years after the last earthquake contrary to Kolanchu's. The findings imply that most respondents are highly vulnerable to earthquakes because they might engage in unrecommended actions or fail to take the right actions during or after an earthquake. Any earthquake occurrence is likely to cause relative injuries and deaths. Lacking any of these skills elevates risks because the skills are independent and differently used. Kashai was better in skills than Hamugemebe, likely because most education programmes were conducted there and attendance was good.

Most residential buildings in the study area were unreinforced. Our finding aligns with Azimi and Asgary (2014) who found that only 12.26% of the residential buildings in the central districts of Guilan Province in Iran were reinforced. Financial inability as per the Theory of Planned Behavior and Social Construction Theory could be the main reason for failure given that residents in Bukoba municipality and those in rural Iran have almost similar incomes to afford reinforcement. Most (55.8%) respondents in Bukoba were petty vendors who earned below 106.34 US dollars (250,000 Tanzanian Shillings) per month. The existence of many unreinforced buildings implies that most residential buildings in Bukoba are vulnerable to earthquakes. However, after the 2016 earthquake, the

construction of reinforced residential buildings increased. This finding agrees with Nienhuys (2015), who reported that reinforced buildings increased in China after the big earthquake experienced in 1976 because the quake stimulated the establishment of seismic design codes. Increased construction of reinforced buildings after the earthquakes indicates a change in people's perceptions and attitudes toward earthquakes. The finding implies a decline in structural vulnerability since the 2016 earthquake, reducing risks to lives, injuries, and properties.

Most respondents lacked essential emergency items, however, water was the most commonly available. This concurs with Kolathayar et al. (2019), who also found that few respondents had crucial emergency survival materials in India: only 34.1% had stored water, 26.5% had a reserve of food, 24.2% had a fire extinguisher, and 34.1% had a first aid kit. Both studies show water as the most reserved item, likely due to its essential nature and cheap availability in the study areas. This suggests that most people in the study area will likely face a shortage of humanitarian needs and assistance during an earthquake.

Mobile phones were the most dominant means of information and communication followed by radio and television, with more than half of the respondents owning these devices. The finding aligns with Aitken et al. (2012) in Australia, who reported that almost all respondents had alternative communication tools such as phones, radios, and trans-receivers backed by emergency information systems. Global advancement in science and technology has made such equipment more available and affordable. The availability of communication equipment could be a valuable means for people to access earthquake information. Among the two administrative wards, Hamugembe was better off having this equipment probably due to its higher level of urbanization, better network, and higher affluence rate. Most respondents had their neighbours' telephone numbers, reflecting high cooperation and closeness among neighbours, which validates the communal feature of African lives (Mabovula, 2011). The close relationship is the potential for earthquake response.

6. Conclusions and Recommendations

This study investigated earthquake preparedness among households in the Kashai and Hamugembe wards of Bukoba Municipality in Tanzania's Kagera Region. Preparedness towards earthquakes significantly minimizes the socio-economic impacts of the events. The study investigated households' awareness of the cause of earthquakes, knowledge of earthquake safety measures, earthquake skills, reinforcement of residential buildings, possession of essential emergency items, information and communication equipment, and emergency contacts. The findings indicate that households in the study area are highly vulnerable to earthquakes. Many respondents are unaware of the cause of earthquakes, which negatively affects their preparedness actions. In addition, the knowledge level of safety measures, and earthquake preparedness skills were low, preventing appropriate earthquake counteractions before, during, and after an earthquake. Most respondents' residential buildings were poorly reinforced, lacking beams and columns to boost their seismic strength. Moreover, most respondents lacked essential emergency items, and emergency contacts, which are useful immediately after an earthquake when awaiting assistance and seeking support from other stakeholders. However, most respondents had information and communication equipment namely cellphones, radio, and TVs which could facilitate information access.

The findings of this study call for the government and other disaster management stakeholders, particularly first responders to establish frequent and regular earthquake education programmes and drills for households and community members to enhance earthquake awareness, knowledge, skills, and emergency materials preparation. Community members should also be advised to share earthquake knowledge among themselves. Furthermore, the government and stakeholders should use the potential of many respondents having cell phones, TVs, and radio to share earthquake and disaster-related information through these media. Lastly, the government should establish and enforce earthquake-resistant building codes and support households in making necessary investments to improve earthquake preparedness. This study recommends further studies to examine the structural seismic behaviour of residential buildings to facilitate the improvement of the buildings that are the major cause of deaths, injuries, and property damage during earthquakes in Bukoba Municipality and areas with similar environmental, economic, and social settings.

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Authors contributions

Mr. Abeli Firimin Abeli was responsible for data collection and drafted the manuscript. Prof. Robert Benjamin Kiunsi and Dr. Fredrick Mathew Salukele revised the manuscript. All authors were responsible for the study design, reading, and approving the final manuscript.

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No additional data are available.