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Weathering the Storm: Community Socio-Economic and Physical Vulnerability Assessment of Informal Settlements to Disasters in Arusha City, Tanzania

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Abstract

Urban population growth has demonstrated a synergetic relationship with the growth of informal settlements and vulnerability to disasters in urban areas. This study employed Community Participatory Vulnerability Assessment (CPVA) to analyse vulnerability in informal settlements in Arusha City, Tanzania. The results show that a plethora of factors, including socio-economic and physical realities interact in complex non-linear ways to shape vulnerability to disasters in informal settlements in the city. The study shows that coping strategies of some individuals in informal settlements reinforce their risks to disasters. This is particularly demonstrated by the stones that are positioned on weak roof structures for protection, and which may potentially serve as projectiles in the event of storm. This quick-fix coping strategy, which results from short-sighted narrow conception of human relationship to the natural environment, may appear sustainable in the short-term. However, given the rising uncertainties of the future, it is unlikely to be sustainable. The study concludes that indigenous knowledge holds great potential in community responses to long term considerations regarding environmental hazards. The study also recommends that measures and strategies aimed at reducing disasters should address the whole set of issues leading to poverty and exposure disparities within the community.

Keywords: Assessment, vulnerability, disaster, informal settlements, Tanzania.

Introduction

The population of Tanzania is growing very rapidly, especially in urban areas, where it grows at more than 5% per annum, the rate twice that of rural areas which is at 2.5% per annum. The UN projects that the urban population in Tanzania will grow from 9.4 million in 2005 to 29 million by 2030 (UN 2011). Rapid urbanization has increased the stress on institutions already struggling to cope with the delivery of basic services such as roads, drainage, sewerage, solid waste management, clean water supply and basic health care while investment in urban infrastructure in the country has not kept pace with the population growth (Jewitt 2011). This has resulted into poor access to urban infrastructure and services in several sectors. The rapid spatial expansion of cities due to increased population growth has resulted in the mushrooming of settlements in unplanned areas (Mnyali and Materu 2021). Incidentally, the fragile urban ecosystems attract the majority of urban dwellers due to their social and economic conditions. As noted by the UN Habitat Agenda in 2004, rapid urbanization, the concentration of the urban population in large cities, the sprawl of cities into wider geographical areas and the rapid growth of mega-cities are among the most significant transformations of human settlements in the 21st century. These need to

be addressed in developing sustainable cities (UN-Habitat 2004).

The Human Settlement Policy (URT 2000) observes that fragile ecosystems in urban areas in Tanzania are occupied illegally. It is stated that building in unplanned and un-serviced areas accounts for most of the new constructions in many urban centres in Tanzania (Hambati and Yengoh 2018). Moreover, these areas accommodate flouring and many informal sector activities and provide employment opportunities on which the majority of urban residents depend for their livelihood (Pelling 2003). According to the Tanzania's National Census Report, 28% of the total population is living in urban areas (URT 2012). The projection also indicated that by the year 2025 the urban population in Tanzania will grow to 46% of the total population. The environmental and social consequences, risks and demands of this shift are challenges to urban authorities in developing sustainable city ecosystems in the country.

In general, cities are vulnerable to the impacts of natural hazards due to their population density and concentrations of infrastructure and economic assets (AU 2016). Many Tanzanian urban areas are located near the coast or along rivers, drainage lines and extreme climatic events such as windstorms and heavy rainfall that can cause tidal surges, floods and soil erosion (Myeya 2021). Within cities, the impacts of disasters are distributed unevenly among the urban population (Hambati and Gaston 2015). Generally speaking, lower-income communities tend to live in marginalized lands that are vulnerable to disasters. Their capacity to respond is also low. Poorer residents tend to have less access to information, scant resources to withstand adverse impacts, and fewer safety-nets. With little assurance that their homes and belongings will be safe in the case of evacuation, they may be reluctant leaving and thus take risks with their property, health and safety.

The general objective of this study was to assess the community socio-economic and physical vulnerability to disasters in Arusha City. Community perceptions on the main disaster variables (hazards and vulnerability) were also examined. The study was guided by two main research questions: What are the socio-economic and physical factors found in the study area that have triggered community vulnerability to disasters? What are the community perceptions on the hazards and vulnerability that led to disasters in their area? The following section describes the conceptual framework which operationalized the study.

Conceptual framework of vulnerability to disaster

The International Decade for Natural Disaster Reduction defined disaster as "a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceed the ability of the affected community or society to cope using its own resources" (Wisner et al. 2003). The World Health Organization (WHO) has added emphasis on health in their definition. It defines disaster as "any occurrence that causes damage, ecological disruption, loss of human life, or deterioration of health and health services on a scale sufficient to warrant an extraordinary response from outside the affected community or area" (WHO 2000). Expressed schematically in this study, a disaster refers to a cross-cutting combination of settlements on hazardous areas and a community's capacity. Community capacities are found in resources and skills people possess, develop, mobilize and access, which allow them to have more control over shaping their own future and to cope with disasters (Hambati 2021).

A hazard refers to any phenomenon, substance or situation that has a potential to cause disruption or damage to infrastructure and services, people, their property and environment (Wisner 1998). The magnitude of the phenomenon, the probability of its occurrence, and the extent and severity of its impacts may vary. In many cases, these effects can be anticipated or estimated. Through careful study and understanding of the nature and prevalence of hazards, a

community or public authority could anticipate future hazards and their impacts and minimize their risks. Hazards in informal settlements are categorized into geological (earthquakes and landslides); hydro-meteorological (floods, flash floods, storm and drought); biological (severe epidemic in humans, plants and animals); and technological (accidents).

In the context of this study, vulnerability refers to the susceptibility of a community to a hazard and the prevailing condition, including physical, socio-economic and political factors that adversely affect its ability to respond to hazards or disaster events. The community and its members may or may not be contributing intentionally or directly to the prevailing conditions. However, altogether, they create factors and situations that define the vulnerability of the community. Vulnerabilities can be manifested as physical, social, or attitudinal. The disruption of a community can be reduced if it is better prepared, e.g. if there are suitable infrastructure and human systems and coordination. Vulnerability to disasters is the function of past and present social, economic and political factors that may have influenced people's capacity to anticipate, cope with, resist and recover from the impacts of hazards (Fekade 2000). Wisner et al. (2003) links people's differential access to resources as a primary determinant of their level of vulnerability to hazards.

It is widely agreed that development and disaster preparedness interventions must operate at the level of the relatively small entities that are commonly called *communities*. The goal of such interventions is generally to support the design of programmes (for national-level priorities) and activities (with the communities themselves). However, an important part of the intervention is to stimulate a process that empowers the people in the community and supports their capacity to alter their own situation. This does not suppose homogeneity in the community. For instance, Aalsta et al. (2008) admit that although the term 'community' means a certain degree of peoples' homogeneity, they also accept the variations in their socio-economic and physical vulnerability to disasters. Thus, a community in this study is defined as people who happen to live together in a particular location, mutually supportive to each other, or a collection of people in a particular area with the same interests and different capacities to access resources.

Figure 1 exposes key relationships, makes feedbacks explicit, and helps identify key gaps in the knowledge of the important relations in the population living in the informal settlements and vulnerability to disasters. It also helps to show key drivers that may affect overall system functioning and can help to identify where potential thresholds or tipping points occur that are likely to trigger disasters.

Figure 1 shows elements and arrows (which are called causal links) linking these elements. It also includes a sign (either + or −) on each link. These signs have the following meanings: A stands for causal link from one element A to another, while element B is indicated as positive (that is, +) if either (a) A adds to B or (b) a change in A produces a change in B in the same direction. For instance, in Arusha, more stone quarrying and mining leads to more vulnerability and disasters. A causal link from one element A to another element B is negative (that is, -) if either change in A produces a change in B in the opposite direction. For instance, all things being equal, more exposure to hazards leads to less population in the long run and vice versa, in an area. The rest of the article describes the study area; this is followed by a description of the specific steps used in Community Participatory Vulnerability Assessment (CPVA) and in eliciting community perspectives on vulnerability. The study results and discussions are then presented, followed by conclusion and recommendations of the study.

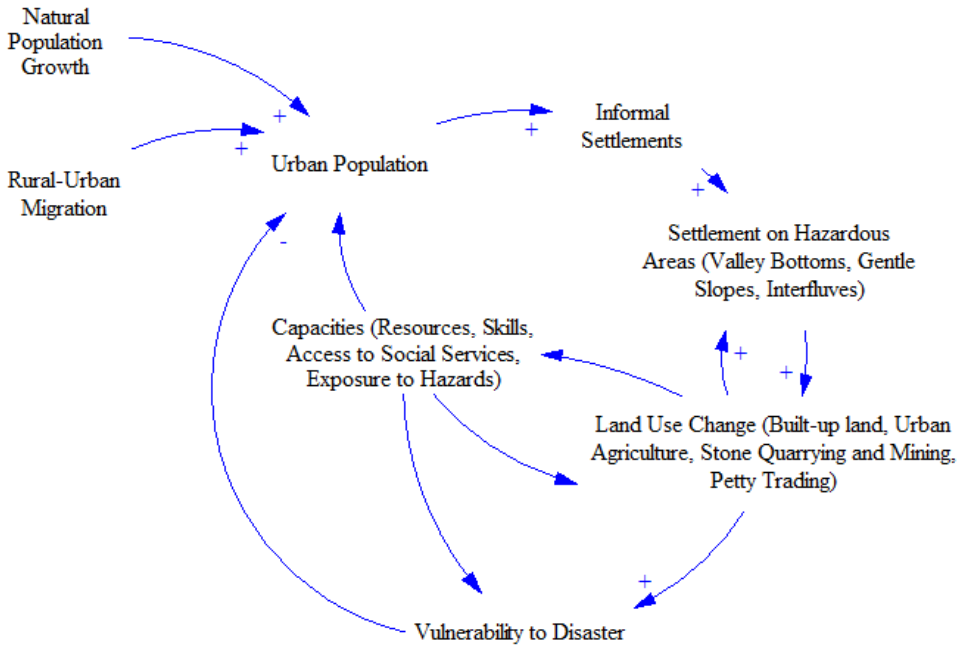

Figure 1: Population increase in informal settlements and vulnerability to disasters.
Source: Authors' creativity.

Materials and Methods

Description of study area

Arusha City is located on the North-Eastern part of Tanzania with a population of 416,442 plus 323,198 in the surrounding Arusha Rural District (URT 2012). The city is situated between latitudes 3° 20' S and 3° 33' S and between longitudes 36° 35' E and 36° 45' E (Figure 2). It was selected because it is relatively insufficiently researched on matters related to informal settlements vulnerability to disasters. Most of the studies on informal settlements in Tanzania have been conducted in Dar es Salaam (see, e.g. Kironde 2000, Kiunsi et al. 2008). Secondly, Arusha has a high population growth rate of 3% and rural-urban migration of 12% per annum, which puts severe pressure on the urban poor to access housing, infrastructure, services and environmental resources. Thirdly, a large portion of the city's landscape is ecologically vulnerable, characterized by highly dissected steep slopes, narrow interfluves and river valleys which have been settled by poor people without appropriate hazards and disasters mitigation measures. Thus, being a tourist centre in Tanzania, the city renders itself an appropriate case study so as to reveal its vulnerability to hazards and disasters in order to create awareness to the government and development partners for early mitigation and preparedness measures.

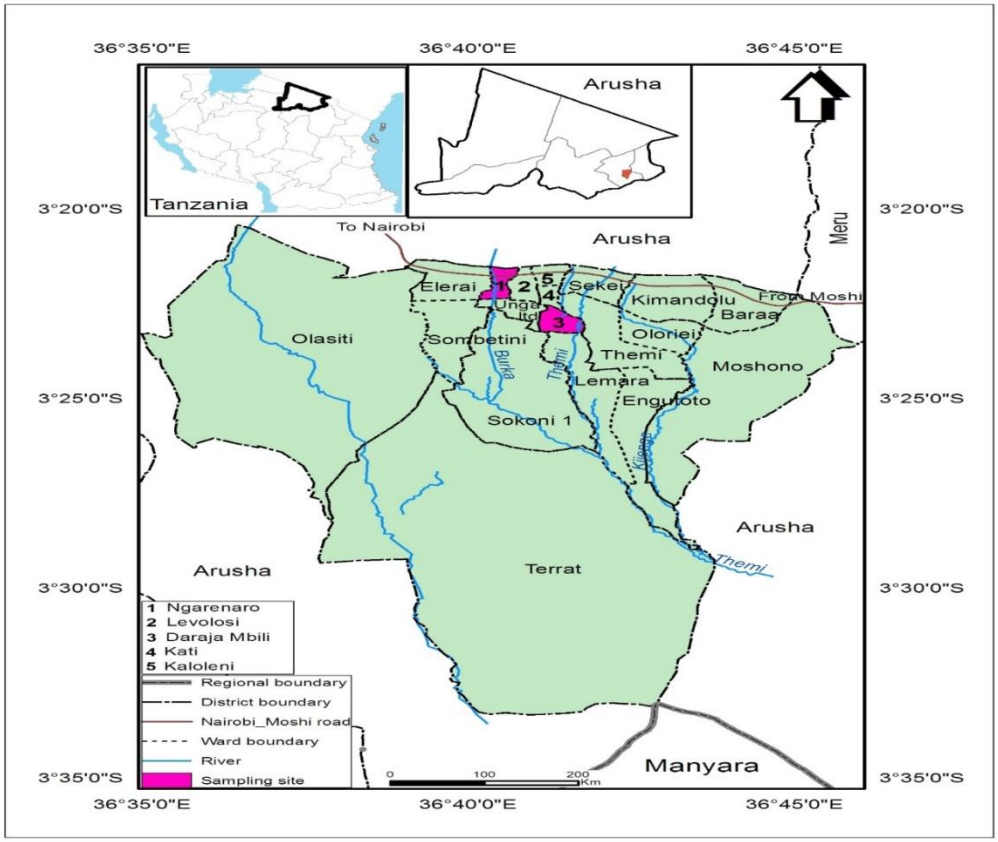

Figure 2: Arusha City administrative boundaries and the sampled study wards.
Source: Cartographic Unit, University of Dar es Salaam (2022).

Research design

The study employed Community Participatory Vulnerability Assessment (CPVA) in evaluating the vulnerability to disasters of Arusha City. CPVA team is made up of both government and community leaders at street, ward and district levels. They included: street chairman, street executive officer, ward councillor, ward executive officer, two influential people from each ward (male and female), one Non-Governmental Organisations (NGOs) representative, one Civil Society Organisation (CSO) representative, district disaster coordinator and district executive director. CPVA is capable of capturing the dynamics in information at the community level and their surrounding environment (Longhofer et al. 2012). CPVA also includes focus group discussions, household surveys and field observations at later stages of the research, for information and data verification at the household and individual levels.

Sampling frame and determining sample size

The research sample frame included all the households living in hazardous areas in Arusha City. However, due to time limit and financial resources, only two wards (Ngarenaro and Daraja Mbili) were selected to represent the entire sample frame for this particular study. The wards were selected on the basis of recent hazard, good internal community organization, being representative of other hazard-prone communities in the city, use of indigenous knowledge in addressing environmental disasters and some degree of openness to outsiders in order to

facilitate interactions. A stratified sampling of the city landscape was carried out based on hazardousness and the typology of its land units, i.e. interfluves, steep slope, gentle slope and valley bottoms. In each of these land units, a random sampling of households was conducted with the help of the street leadership, to get households for interview. The households interviewed were further clustered into different land uses (built-up land, urban agriculture, petty trading, stone quarrying and mining) in the aforementioned land units, to mark specific livelihood vulnerability to a specific disaster in the selected informal settlements. This study drew a sample size of 10% of 1920 households (192 households) living in the hazard-prone informal settlements. As described by Abarquez and Murshed (2004), a sample size of 10% is sufficient in community participatory vulnerability assessment methodology to reveal the reality in any geographical phenomena. This idea is also supported by Aalsta et al. (2008) in research that involved community participatory vulnerability assessment.

Sampling procedures and CPVA operationalization

Based on the criteria mentioned in the previous section, the CPVA team came up with the top two ranked wards that were highly at risk from natural and human made disasters in Arusha city. The selected wards were Ngarenaro and Daraja Mbili [located in Arusha municipality] (see Figure 2). These two wards met the criteria set about the recent natural/human made disasters, good internal community organization, their representativeness of the hazard-prone communities in the city, and some degree of openness to outsiders, in order to facilitate interactions. A schema of the activities carried out in the CPVA over a six-day period is as shown in Table 1.

Table 1: Structure and steps of the CPVA in Arusha Municipality

Day	Morning	Afternoon
Day one	Welcome participants and introduce key concepts: hazard, vulnerability and disaster	Identify causes and effects of hazards on settlements in hazardous areas (land units) and which groups/elements are at vulnerability and why.
Day two	Identify Arusha's informal settlements' primary hazards and the idea that people may have on vulnerability and disasters.	Identify the seasonal patterns and cycles (time of year, month, week or day) of each hazard.
Day three	Build understanding of the frequency and scale of previous disaster events and relate these to changes in the settlement over time.	Strengthen understanding of local vulnerability factors (socio-economic and physical), as well as social and institutional capacities that reduce disaster impacts.
Days four and five	Establish the spatial extent of disaster risks in the settlement and map the location of houses, roads, rivers and other features, as well as the situation of key services.	Improve understanding of factors that generate and drive vulnerability through field observation and interviews. Integrate understanding of priority hazards and the factors that reduce vulnerability.
Day six	Identify the disaster risk management capacities and strategies used and build a vision of a safer area.	Provide feedback to key stakeholders (Individuals, community, government, NGOs, CSOs etc.) and agree on mechanisms to implement disaster risk reduction priorities in the area.

Source: CPVA Team (2021).

To identify the physical vulnerability of the wards within the city, the study employed Geographical Information System (GIS) techniques. Through the use of the GIS techniques, three main factors were considered (landscape, distance and population) in assessing the vulnerability of community to natural hazards and disasters, like flooding. For example, in Arusha city, a number of stream channels have been settled and developed. These areas are obviously at risk to flooding during extreme rainfall events. Of course, elevation does not tell the whole story of flood risks, while this is perhaps a good indicator of lowland flooding. Nearness to the stream is also a significant factor. Hazard and vulnerability assessment in this study took into consideration the distance from stream channels to households.

Existing stream channel data from national census (URT 2012) was found to be extremely inaccurate and unsuitable for this investigation. Streams were manually digitized using the 1 Meter IKONOS imagery, and at a scale of 1:6000 which resulted in acceptable accuracy of the stream channels (Cf. Figure 3). Streams were identified along visible channel features; when the channel was obscured by vegetation/construction or clouds, its position was estimated closely following additional visual clues especially riparian vegetation. Streams were digitized as continuous poly-lines. No indication of culverts or other potential channel barriers was recorded for the streams. In the study area, streams were buffered at 100 meters (see Figure 3). Our model is additive with higher values indicating progressively higher threats for flooding. The highest risks for flooding are in areas within 100 meters of a mapped stream; as the distance from stream channel and elevation increases, the flood risk decreases. The number of house units and community properties that fall within the lines of 100 m buffer from stream channels (inlands) are also assumed to be at higher risk to flooding in the study areas, hence vulnerability to disasters.

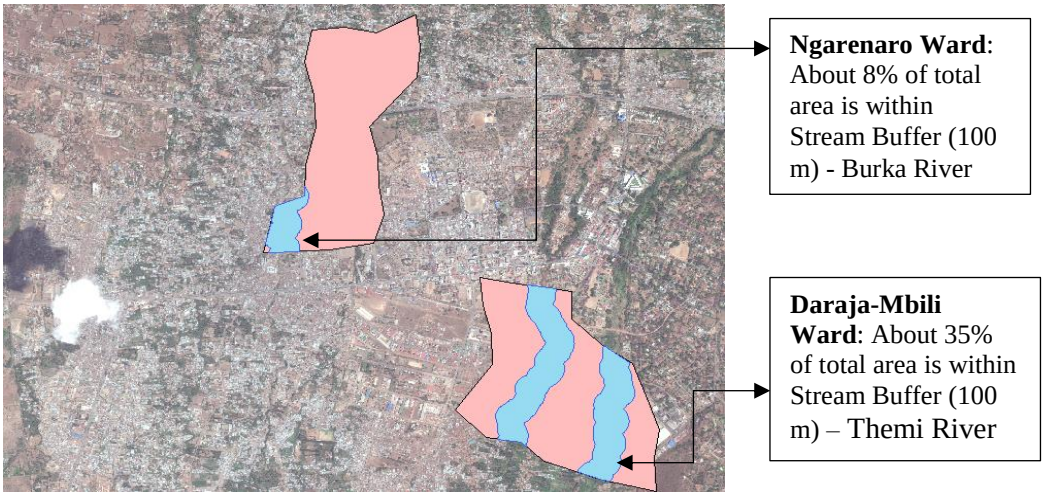

Figure 3: Areas within the flood prone areas in the study wards in Arusha City.
Source: Landsat Imagery (2021).

Data collection techniques

In this study, the author used secondary data at ward level, which was the most detailed level data in Tanzania (URT 2012). These data included general information about socio-economic characteristics and the existing infrastructure such as housing conditions and public facilities. The study also used Focus Group Discussions (FGDs), household surveys and field observations to

verify the information acquired from the secondary data and public at large. The study employed both secondary and primary data to crosscheck and triangulate the information collected to arrive into reality and conclusion on the subject matter under study.

Data processing and analysis

Data and information acquired from the field, which had been verified by the CPVA team, were coded electronically to facilitate analysis and evaluation. The issues that contribute to vulnerability and disasters in the communities were disaggregated into socio-economic and physical factors. The study used the IBM Statistical Package for Social Sciences (SPSS) Version 20 software to process the coded data and derive tables of frequencies, percentages, histograms and pie charts.

Results and Discussions

Vulnerability to disasters in informal settlements in Arusha city

Vulnerabilities to disasters in the informal settlements in the study area were categorized into socio-economic and physical factors. These are elaborated in the sections that follow.

Socio-economic factors

Socio-economic parameters inevitably play a key role in community's vulnerability and resilience to hazards and disasters. These parameters included: migration and settlement on hazard prone areas, age and gender characteristics, education level, marital and employment status.

Natural population growth and rural-urban migration

The population of Arusha City is estimated to be 416,442 people with an annual growth rate of 4% and rural-urban in-migration of almost 12% (URT 2012). The population density is 1,560 persons per km^2. The rapid growth of population in Arusha City resulting from natural increase and rural-urban migration has instigated the needs for more housing and other social services that have exceeded the capacity of the city authority. This situation has led to the invasion of hazardous areas by the poor urban dwellers that are susceptible to natural, human-made and human induced disasters. The influx of rural-urban migrants into Arusha city has been an influencing factor on hazardous area invasion. The household surveys have shown that only 10% of the interviewed were indigenous inhabitants of the city. Of the 10%, only 6% were residing in valley bottoms, while 4% were residing on mixed-planned settlements. Most of the household interviewed (90%) were migrants from other regions in Tanzania. According to the households interviewed, the influx of migrants into the hazard prone areas started since 1975, and the situation became tense in 1990's. As perceived by the people interviewed, the influx of rural-urban migration could be attributed to the changes in agricultural policies and the reform programmes that were introduced in Tanzania since 1975 to early 1990s.

As indicated in the study by Mbonile (2002), in the mid-1980s, Tanzania adopted the Structural Adjustment Programme (SAP) as a way of improving the country's economy. However, one of the conditions of SAP was to remove subsidies on agricultural inputs, hence leaving a great burden on the farmers. The returns have decreased due to low production since most of the farmers cannot afford the high costs of farm inputs and implements. The interview with one of the city council members (male aged 54 years) revealed that, for the younger generation, agriculture has no better future. He further said, "*The younger people are looking for better opportunities in the cities hoping to find something better than agriculture"*. Moreover, the prices and demands of some agricultural exports have gone down in the world market due to discovery of low-cost substitutes or alternative products, such as synthetic fibres in place of products like sisal and cotton, which were among the country's highest foreign income earning products. Another factor that could explain rural-urban movement in Arusha city as noted by Hambati and Rugumamu (2005) was 'urban

biases' in development. Most of the rural areas have been neglected by the government in terms of service provision, such as roads, hospitals, schools and worst of all employment opportunities. The lack of provision of social services increased the community vulnerability to hazards and disasters.

Age and gender

Gender and age were important parameters in determining community vulnerability to hazards and disasters in the area. Table 2 shows that most of the respondents (62%) were aged between 18–35 years, followed by 35% aged between 36–59 years. The study by Hambati and Yengoh (2018) noted that in the community members in Tanzania, those aged between 18–59 years make the bulk of the labour force in the community. The work they are engaged, in one way or another, has some implications on natural resources utilization and disaster risks in the area. Out of 192 respondents interviewed, 54% were female and 46% were male. This shows that most of the women were at home compared to men who are the bread earners in most African families. This implies that, during a rapid onset of disasters such as floods or flash-flooding (in the day time), women and dependent populations are more at risk compared to men. This idea is also supported by Hambati (2021) whereby women had to evacuate dependent people (children, the sick and elderly) during the earthquake disaster of 2016 in the North-western, Tanzania. Indirectly, these results show that women and children are more at risk and vulnerable to disasters compared to men because they spend most of their time in hazardous areas compared to men.

Table 2: Age of respondents

Age, N = 192	**Years**					
	18–35		**36–59**		**60+**	
Arusha	N	%	N	%	N	%
	118	62	68	35	6	3

Source: Field data (2021).

Education

Education in the study area was categorized into three major forms, namely, formal, informal and non-formal education. According to the households interviewed, education level determined the occupation of the household. Those with formal education were employed in decent and well-paid jobs and had access to land in planned areas. On the other hand, those with informal and non-formal education were self-employed in the informal sector with low returns and were located on marginal areas. Sometimes, marginal areas (valley bottoms) are unsafe for human settlements because of lack of social services, security and insurance. Figure 4 shows the summary of the respondents' education levels. Slightly less than half of the household interviewed (46%) had attained primary education, while 40% had secondary school education. Few respondents (6%), had attained certificate education after their secondary school education. Only 4 % were diploma and degree holders, respectively According to the households interviewed, those who had secondary education and above, had been employed in the formal sector; whereas, those who had informal and primary education had the least access to formal employment.

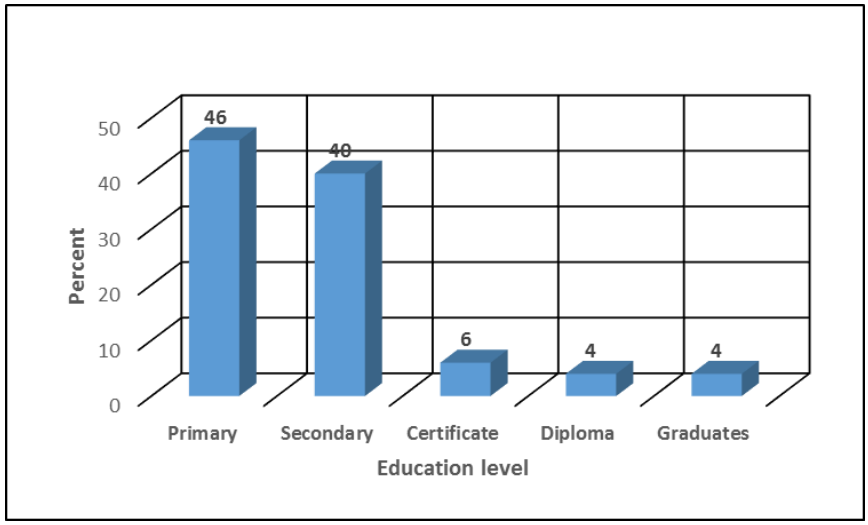

Figure 4: Education level of the respondents. **Source:** Field data (2021).

As indicated in the study by Masud (2011), the education status and skills of an individual is an important dimension of vulnerability assessment. Apart from determining the occupational status, education also has a key role to play in understanding and interpreting preparedness measures (i.e. vulnerability assessment, public education, training and alert systems) on the expected hazards and disasters. The more the knowledge on disaster impacts and preparedness measures, the less the loss and the sooner the recovery, while the opposite is also true.

Marital status

Family bond (father and mother) is an important socio-economic characteristic in explaining household vulnerability and resilience to disasters because household income depends on the head of the household (father/mother or both). According to discussions with the households, the more the unity and equal sharing of household resources, the greater the resilience to hazards and disasters. Families that were either single, unmarried, or married and married with children, all perceived hazards and disasters differently. In the studied sample as indicated in Figure 5, 39% of the respondents were married and had children; while about 36% were single or unmarried; and 25% were married and widowed.

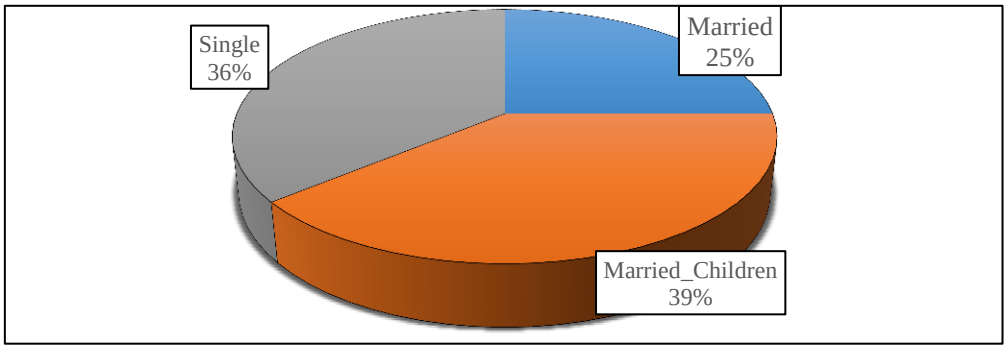

Figure 5: Marital status of the respondents. **Source:** Field data (2021).

Most of the widows, widowers and divorced household members interviewed (78%) had been living in hazard-free areas before getting divorced or widowed, while 22% were living in hazardous locations. One of the respondents (a widow) affirmed said: *"My husband and I lived in a planned area near the city centre. My husband by then was an employee of a textile factory, while I was a housewife. After his death, three years ago, I and my five children were not able to pay for house rent in that area. We decided to move into this area because the rent was cheaper, though the area is prone to floods"*.

The disclosure implies that the people at risk were aware of the hazardous sites they were living in. However, because of social and economic constrains rooted far beyond the household's capacity, they had been forced to settle in hazardous areas. From the profile of the household interviewed, widowhood was concentrated on those who were 50 years old and above, while divorcees were sporadically scattered in the different cohorts above 30 years of age. As noted by Smith (2003), this could be attributed to the fact that while widowhood is likely to increase in older age cohorts, divorcees are an outcome of socio-economic attributes such as confrontations, conflicts and economic hardship. This lack of social unity exposed households to hazards and disasters especially in their old age.

Employment status

Formal employment is a source of income in the household. The heads of household who are employed either by the government or private companies have got different perceptions on how to deal with hazards and disasters over time and space. The ones who are seeking employment have also got their views and priorities on disaster mitigation and preparedness. The results on the surveyed households in Figure 6 revealed that about 72% of the respondents were self-employed and illegally operating their livelihoods activities within the city, so their livelihoods activities might be subjected to demolition. Thence vulnerable to property and income losses which ultimately expose them to hazards and disasters.

The results revealed that the surveyed communities in study wards were subjected to hazards and disasters as they lacked a strong economic base to take mitigation measures against disasters. This idea of household economy level and vulnerability to disasters in the informal settlements is also noted in the study by Hambati and Gaston (2015) who observed that the occupation of an individual has a role to play in determining his/her income which will be used to fight against crisis and disasters. On the other hand, income can determine access to resources and quality of social, economic and political relations within a society. Occupation as a source of individual incomes, is categorized into formal for those who are working in the formal sector, and informal for those who are working in the informal sector. Formal sector occupation has security in terms of wage payment, land tenure and insurance, while informal sector occupation has none of these. Thus, people whose employment depends on the informal sector are vulnerable to loss of income and are susceptible to natural and human-made disasters.

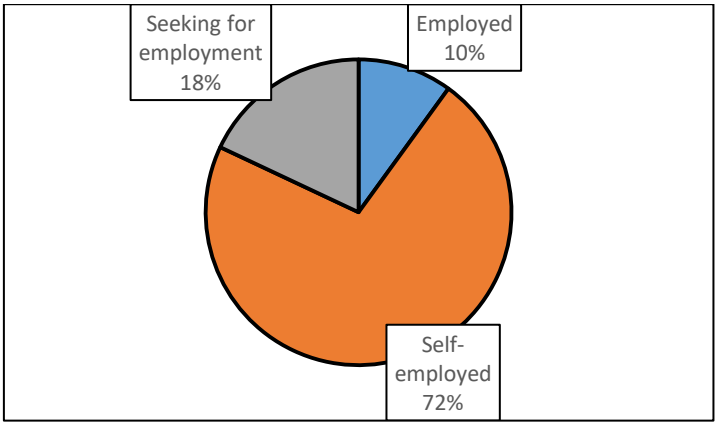

Figure 6: Employment Status of the Respondents. **Source:** Field data (2021).

Physical factors

The community in the study area was able to identify fifteen types of hazards classified into three main categories: natural, human made and human induced hazards (Table 3). The community has also indicated the location of each particular type of hazard along the landscape and the degree of community vulnerability to those hazards. Ranking of each category of hazard was also done in respect to the expected loss or damage of the elements at risk such as houses, farms and community social services such as dispensaries and schools should a disaster occur. As indicated in Table 3, natural hazards such as flood, flash-flood, landslide and storm are location specific. These hazards vary in the probability of occurrence and the degree of community vulnerability across the landscape. As indicated in the study by Hambati and Yengoh (2018), such variations were mainly attributed to the slope, aspect and the configuration of land surface. In contrast, the probability of occurrence of other hazards (epidemics, human-made and human-induced) did not vary spatially across the landscape and hence did not provide sufficient differentiation to address the degree of risk to disaster (see table 3). During discussions with community members involved in hazard mapping, this situation was attributed to the difficulties in estimating the probability of their occurrence and the linkage of such hazard events with social, economic and environmental conditions at the community level. Through the weighting of hazard and expected disaster impacts as indicated in Table 3, the community ranked natural hazards at the top compared to other hazards and disasters.

The ranking and weighting factors were in terms of the number of people, houses and public services that were likely to be affected. During the household survey, most of the respondents (90%) confirmed that they had been affected at least by one of the natural hazards listed in Table 3, while 10% who were in the category of high-income earners had not suffered any natural hazard. The whole process of hazard mapping and vulnerability assessment in the study area revealed that in each land unit there was a dominant hazard. The common and dominant hazards denoted high vulnerability of the community in the particular land unit(s) to disasters in the area ('xxx') (see table 3). During community hazard mapping, the valley bottoms were identified as areas with high probability of flood and flash-flood hazards events. This is also in line with the findings from the household interviews, where 34% of the respondents who were living on the ravines and in flood plains areas reported to have been affected by flash-flood and flood hazards.

Table 3: Community participatory vulnerability and hazard assessment chart

Type of hazard	**Location/ land units (LU):** Vb = Valley bottom; Gs = Gentle slope; Ss = Steep slope; Int. = Interfluves				Ranking of overall hazard type in respect to expected disaster impact(s)
Natural hazard	Vb	Gs	Ss	Int.	
Flash flood	xxx	xx	x	x	1
Flood	xxx	xx	x	x	
Storms	x	xx	xxx	xxx	
Landslides	x	xx	xxx	xxx	
Epidemic hazard					2
Malaria	xx	xx	xx	xx	
Cholera/diarrhoea	xx	xx	xx	xx	
HIV/AIDS	xx	xx	xx	xx	
Human-made hazard					
Fire	xx	xx	xx	xx	3
Accidents	xx	xx	xx	xx	
Robbery/Stealing	xx	xx	xx	xx	
Drug addiction	xx	xx	xx	xx	
Human-induced hazard					4
Air pollution	xx	xx	xx	xx	
Water pollution	xx	xx	xx	xx	
Deforestation	xx	xx	xx	xx	
Soil erosion	xx	xx	xx	xx	
Key: **x** = Low vulnerability; **xx** = Medium vulnerability; **xxx** = High vulnerability					

Source: Field Survey (2021).

According to the households interviewed and focus group discussions, elements at risk to flash-floods and floods in the valley bottoms included people, houses, vegetable gardens, garages and petty businesses. Table 3 also shows that there was medium vulnerability of community to floods and flash-flood hazards on the gentle slopes. However, during their life time, these hazard events had not occurred on the steep slopes and interfluves; which means that ravines and flood plains areas are more vulnerable to flash-flood and flood hazards, respectively. As indicated in Table 3, there is high community vulnerability to storm hazards on high elevated areas and interfluves. However, 95% of the respondents on hill slopes and interfluves disclosed that they had located their houses on the hillsides to avoid frequent flooding and flash-flooding in the flood plains and on the ravines though they were subjected to storms. Apparently 55% of the households interviewed affirmed that they had experienced storm hazard events in the area, also attributed to convectional rainfall which falls mainly in the form of showers, storm or thunderstorms. These findings confirmed that storm hazard was common in the study area. Furthermore, most houses were temporary, with roofs patched with pieces of tin or corrugated iron sheets and walls built of stones and mud. Fekade (2000) and Goudie (2006) observed similar findings on the materials used in house constructions in the informal settlements, that most of them were susceptible to damage if storm and strong wind hazards occur. The stones placed on the roof to hold the iron sheets in place, provide evidence that storms and strong wind are common in the study area. This was affirmed by 72% of the households interviewed. Such types of houses were vulnerable to storms and flash-floods; while people living in there were likely to

lose their properties and lives. However, the stones are potential projectiles in the event of storms.

Based on Table 3 on the community participatory vulnerability and hazard assessments chart, physical vulnerability at household level is classified into four main categories. These included: Built-up land, urban agriculture, stone quarrying/sand mining and petty business. These categories are discussed in the sections that follow.

Built-up land

The informal settlements were also susceptible to biological hazards such as cholera, dysentery and typhoid. This is mainly because there was no space for the development of public and household infrastructure such as sewerage, water pipes and sanitation facilities (bathrooms and toilets). This is because the entire households' area is occupied by house(s). The houses are mostly accessible through footpaths; this suggests that in case of disaster (e.g. fire), households in the area cannot be reached easily. According to the community vulnerability and hazard assessment, epidemics is ranked at medium vulnerability (see Table 3). About 97% of households interviewed admitted to have experienced at least one of the epidemic hazards listed in Table 3. Out of the 97%, 57% had suffered malaria, twenty seven percent (27%) had been affected directly or indirectly by HIV/AIDS, while 13% had mentioned prevalence of cholera and diarrhoea. These findings from the households interviewed, concur with the information given by Kithiia and Dowling (2010) whereby the frequency of these epidemics hazards in the informal settlements, particularly cholera and diarrhoea, were attributed to domestic water pollution caused by discharge of liquid wastes from pit latrines into streams and rivers.

Human-made hazards e.g. fire, robbery, accidents and drug addiction are evenly and spatially distributed in the study area (see Table 3). During community hazard ranking, these hazards were ranked third in severity and magnitude compared to other hazards. According to the interviews, there has been an increase in the incidences of robbery and drug addiction in the city since 1990s. About three quarters of the households interviewed (74%) attributed the prevalence of these hazards to the increase in number of in-migrants into the city who are unemployed and remain jobless. According to the community hazard mapping team, human-induced hazards, e.g. pollution, deforestation and soil erosion are spatially evenly distributed in the study area. This is also in line with the findings from the households interviewed. About 39% of interviewees mentioned soil erosion, while 52% mentioned air and water pollution. These results show that the severity/magnitude of these hazards is least when compared to other hazards at household level; while in reality water pollution and soil degradation in the study area have been sources of conflicts and epidemic hazards. In other words, the impacts of these hazards have been around for a long period of time, so they may not be noticed easily. The community hazards mapping team noted that the accurate perceptions of the relationship between human actions and physical environment is a key component in disaster and vulnerability assessments in the informal settlements within the cities in Tanzania.

Urban agriculture

Urban agriculture is the second major land use in the study area. Of the total respondents, 43% were engaged in agricultural activities. The urban agriculture was mainly small-scale farming, and very few households (5%) engaged in livestock keeping. Vegetables are some of the major crops frequently grown in the valley bottoms, as indicated by 23% of the respondents. Common vegetables grown include spinach, cabbages and eggplants; other important crops are cereals, as cited by 21% of the respondents. These include rice and paddy, and to a greater extent, maize and beans. Bananas (3%), tubers (2%), and fruits (1%) are also cultivated in the valley bottoms. The crops and vegetables in the valley bottoms are susceptible to flood and flash-flood disaster during the rainy season. These

findings concur with the one by Hambati and Yengoh (2018) whereby plots on marginal lands such as valley bottoms that were formally used for urban farming, were turned into building land, thus exposing people and their properties to floods and flash-flood hazards in valley bottoms and ravines, respectively. This led to the loss of properties and vulnerability to disasters in such informal settlements.

Stone quarrying and sand mining

Marginal areas such as valley bottoms and hillsides with outcropped rocks are popular sites for sand extraction and stone quarrying, respectively. Though only 9% of the total respondents mentioned mining as one of the major economic activities practiced, observations showed that it was one of the major economic activities taking place in the area. Stone quarrying was mostly conducted on the hillsides.

This activity in the area has aggravated the whole process of rock-fall and soil erosion on the hillsides and ravines in Kisongo area. Thence, the areas have been susceptible to landslides and soil erosion over time and space. The rock fragments and pebbles are further crushed into gravel using hammers for the supply to construction industries. The land where rocks and sand were mined was normally not filled. The rocks above the slope are left hanging making the whole area risky of landslides (rock-fall). In case of a landslide disaster, households have to spend some resources for medication and recovery. The similar observation was also made by Barbier et al. (2010) whereby disaster victims spend more than 75% of their household resources for rehabilitation and reconstruction of their household structures. This situation has increased the vulnerability to disasters, especially to the low-income poor families living in informal settlements in the city.

Petty business

Due to activities such as urban agriculture, sand extraction, mining and building activities in the study area, secondary related informal activities such as food vending/selling, second-hand cloth and cigarette vendors were spotted in the area. This shows that although formal employment is limited in the area, the unemployed have in fact found ways to cope with the hardships of urban life through whatever little skills or knowledge they have and can use. As indicated in the studies by Tran et al. (2010) and Hambati (2021), informal businesses in the city are illegal and temporary as the traders are often subjected to eviction and demolition of their structures. The eviction of traders who engage in small scale businesses will lead to loss of properties and increased social as well as physical vulnerability to disasters.

Conclusion and recommendations

The results have demonstrated that, the community living in the informal settlements in Arusha city are vulnerable to disasters. The community vulnerability to disasters in the area is triggered by their intrinsic socio-economic and physical factors. This study has revealed that, informal dwellers in the city have scanty resources to withstand the adverse impacts of hazards and disasters. It is evidenced that hazards and disasters have threatened and destroyed poor household economies, both in terms of their frequency and the severity of damage associated with them. These shocks, in addition to causing death and injury, also gave rise to long-lasting damages to buildings, homes, business and infrastructure. They also divert scarce resources to cope with rehabilitation and reconstruction activities. This, in one way or another, increases household's socio-economic and physical vulnerability to disasters. The community perceives that vulnerability to disasters is the function of both past and present social, economic and physical constrains that have influenced people's capacity to anticipate, cope with and recover from the impacts of disasters.

Therefore, effective hazards and disasters risk management are pressing concern for the community living in the informal settlements. Indeed, the extents to which resources are effectively applied to mitigating and coping with hazards have

immediate consequences for human safety and development. The capacity of a community faced with the risk of disasters can be defined as the vulnerability of a community before disaster strikes and its resilience after the event. Furthermore, the adaptive capacity of a community towards disasters is not in fact externally determined, but related to its level of local knowledge development over time and space. The study recommends that, the community capacity in terms of skills and resources should be improved through short and long term training on disaster risk reduction and resources mobilization interventions at the community level. In addition, measures and strategies aimed at reducing disasters should address the whole set of issues leading to poverty and exposure disparities within the community and society at large in Tanzania.

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