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Community perceptions, knowledge, and coping mechanisms concerning perennial climate change-related disasters along the Volta estuary of Ghana, West Africa

Memuna M. Mattah [a,c,*], Precious A.D. Mattah [b], Adelina M. Mensah [c], Francis Adarkwah [c], Justice Mensah [d], Kwasi Appeaning Addo [c]

[a] Department of Economics and Development Studies, Central University, Miotso, Ghana
[b] Africa Centre of Excellence in Coastal Resilience, University of Cape Coast, Cape Coast, Ghana
[c] Institute for Environment and Sanitation Studies, University of Ghana, Legon, Ghana
[d] Directorate of Academic Planning and Quality Assurance, University of Cape Coast, Ghana

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ABSTRACT

Communities along the Volta estuary of Ghana remain vulnerable to perennial tidal wave attacks, coastal erosion, and flooding because of increasing sea level rise from climate change. Using both qualitative and quantitative methods, community knowledge, and perceptions on disasters and disaster risks were explored. We also investigated perceived factors contributing to increase disasters, how communities' knowledge and perceptions informed their preparedness and response to the disasters. Focus group discussions, key informant interviews and households survey were conducted in nine selected communities from two adjoining districts located immediate east and west of the Volta estuary. Results indicated that communities were knowledgeable about the perennial climate change-related disasters occurring in their districts. A z-test conducted on the respondents' knowledge of key environmental threats revealed significant variations between the two districts. With much experience, households were able to tell when a weather phenomenon could be disastrous. Households over the years have devised various strategies to predict, cope with and reduce the effects of disasters. Some strategies for predicting the occurrence of disasters included watching the size and position of the moon, watching for, and listening to the chirps of certain birds and observing the patterns presented by clouds in the sky. Other strategies for coping with disasters include reliance on social capital to support the vulnerable in society as well as migrating out of the study areas. Overall, 53.5 % of the households interviewed confirmed that between one (1) and four (4) members of their households had migrated to other places in Ghana and outside the country. The study concluded that communities in disaster-prone areas have good knowledge of their environment and should therefore be collaborated with to reduce the impact of disasters as stated in the Sendai Framework.

Introduction

Community development is faced with several complex challenges which are embedded in societal functions [1]. Natural hazards

* Corresponding author.
E-mail address: mmattah@central.edu.gh (M.M. Mattah).

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such as erosion, floods, and storm surges expose many estuarian communities to the challenge of disasters [2,3]. These challenges seriously disrupt the proper functioning of communities due to the widespread human, material, economic and/or environmental losses which exceeds their ability to cope using their own resources [4,5,6].

In the south-eastern coast of Ghana, disaster occurrences from floods, tidal waves and storm surges continue to increase due to sea level rise [3,7]. The Volta Delta, in the southeastern coast of the country is fragile and prone to multiple hazards from both physical and socio-economic dimensions. The influence of various social, environmental, cultural, economic and historical factors on the vulnerability and resilience of the communities within the Volta estuary has been identified by earlier studies (Appeaning [8,3,9]). Even though these studies objectively measured the vulnerability status of communities along the Delta, little is being done to subjectively assess the extent to which communities' indigenous knowledge, beliefs, norms, and perceptions have contributed to their ability to cope and adapt to the threats of environmental hazards over the decades.

Communities' perceptions therefore remain an important component in disaster risk reduction (DRR) because it depicts how communities and\or individuals make sense of their physical, social, and environmental interactions [10–13]. Their perception to natural, spiritual and social phenomena are socially constructed over time [10,11] which informs actions and responses to disasters. To successfully implement a disaster risk reduction policy, it is essential to evaluate risk based on objective and subjective perspectives [14,15].

The objective of the study is to explore community knowledge and perceptions on disasters and disaster risks, factors contributing to increase in disasters, as well as the coping and\or adaptation mechanism for such hazards in the Volta estuary. The research questions are:

1. What is the level of communities' knowledge on environmental risks and hazards along the Volta estuary.
2. How do the communities understand disaster risk associated with these environmental hazards?
3. What are the communities' perceptions on the category of people at risk during disasters.
4. What are the communities' perceptions on the factors contributing to risks from climate-related hazards?
5. How do the communities' cope with or adapt to the climate change-related hazards?

The study supports the understanding of multidimensional climate change-related risks and hazards, and their spatial dynamics from communities' perspectives. The findings would help develop policies, strategies and best practices to minimize the level of vulnerability to climate change-related hazards, as well as the impacts of such hazards on affected communities.

Literature review and conceptual framework

Literature review

Knowledge on causes and impacts of climate change is on the increase through earth observations and scientific research. Studies have linked the increased in frequency and intensity in the occurrence of environmental hazards such as floods, erosion and storm surges [16–19]. There is also empirical evidence on the importance of community's' perception and knowledge on climate change, disaster management and environmental hazards such as flood risk [12,13,20–25]. Adams et al. [26] emphasized that perceptions on climate change has contributed to strategic planning towards adaptation and sustainable development in developing countries. Similarly, Asher et al. [27] has revealed the influence of perceptions on the level of preparedness and preventive actions taken by individuals and communities towards risk reduce.

Results from the study conducted by Asher et al. [27] on flood risk perception stipulated that, perception based on past experiences contributes to shaping behavioral changes among affected people. Rana et al. [17] in their study indicated that, although there is a conventional disaster risk management cycle, limited enforcement of disaster management rules has resulted in both institutions and affected communities in Pakistan approaching disaster management in a more reactive manner. Although there is evidence of both scientific and indigenous knowledge on the causes and impact of climate change, as well as disaster risk reduction, communities and government institutions have operated independently to satisfy their objectives [26]. Adams et al., 2022, therefore emphasized the need for integration of scientific and indigenous knowledge to ensure collaboration and harmonization for development to ensure community resilience to climate change related hazards.

Due to how risky climate related hazards are and their impact on vulnerable communities, the actual and perceived risks have become important parameters in climate change management. Researching on characterizing flood risk perception in urban communities of Pakistan, Rana et al. [17] maintained that actual risk is measured by experts based on hazard, exposure, sensitivities, and capacities of communities, while perceived risk is based on exposure, past experiences, community/individual understanding, and cognitive thinking. Estuarine shorelines have been found to be highly dynamic and may increase disaster risk in vulnerable communities. Disaster risk reduction strategies are needed to deal with the vulnerabilities of such communities. This require understanding of the nature of the hazards and the factors that account for them, especially in less developed economies where the adaptation and coping mechanisms are weak and limited. It is important to monitor the nature of social and physical drivers of disasters and how they combine to pose risk to vulnerable communities. In this regard, Okaka & Odhiambo, [22] argue that much of the existing literature on climate-related risk management has focused mainly on the physical aspects of their nature and occurrence. This shows how crucial the physical aspect is for improving disaster risk communication to inform effective local mitigation policies, but the community perception and knowledge is important in understanding these dynamics, especially in developing countries such as Ghana, West Africa.

Annan et al. [28] observed that factors such as poverty and lack of social amenities, including hospitals, educational facilities, roads, predispose climate-induced disaster victims, including women and children, to risk. There are several strategies, however, for reducing the impact of climate- induced disasters in vulnerable communities. According to Mattah et al. [3], in the vulnerable coastal communities the strategies include relocation, use of early warning systems, and other coping mechanisms such as stacking sandbags around their homes and the beaches, beach nourishment and heaping refuse at the riverbanks and around their homes. Several studies [29–32] emphasise that community knowledge and perceptions regarding environmental risks and hazards is important because it helps them to understand the risks associated with these environmental hazards. Also, it helps the vulnerable communities in all countries to cope with or adapt to the climate change-related hazards, although every country may have systems in place to support the affected communities.

In Ghana, the National Disaster Management Organization (NADMO) is mandated to manage disasters [33] however, like many other government agencies or institutions in the country, their scope of work is limited by their dependence on Government subvention . In many cases, governments prioritize resource allocation towards sectors which are considered most important, such as agriculture and water. This prioritization process is echoed by Boholm [14], who states that, risk and safety issues have become political and controversial in recent times. Many governments have linked disaster risk reduction and management issues to achieving political goals to win the citizens' confidence, support, and votes [14]. This has therefore over the years left many coastal communities dependent on past experiences in developing their indigenous knowledge and coping and adaptation mechanisms to survive threats from environmental hazards, especially in estuarine communities in Ghana.

The largest estuarine jurisdiction in Ghana is the Volta delta. The delta is at the lower portion of the basin of the River Volta, which is defined as the 5 m contour within the Accra-Ho-Keta Plains (Appeaning [8]). The delta is characterized by a fairly uniform, moderately steep shoreface with a gradient of between 1:120 and 1:150 down to 15 m, [34]. The delta front is shaped by the action of the ocean waves. The energy dissipated when the waves break generate longshore currents that transport sediment alongshore from west to east, which causes one of the highest rates of annual unidirectional longshore sediment drift in the world [35].

Conceptual framework

The study was underpinned by The Sendai Framework [36], The framework emphasizes an all-inclusive stakeholder involvement in disaster management to ensure a successful disaster risk reduction in the phase of climate change. The conceptual framework for the study (Fig. 1) was adapted [37,30] to discuss a broader perspective of disaster risk reduction in the Volta Delta of Ghana and the role of all stakeholders. The resilience of delta communities to disasters from multiple hazards was illustrated using both the objective and

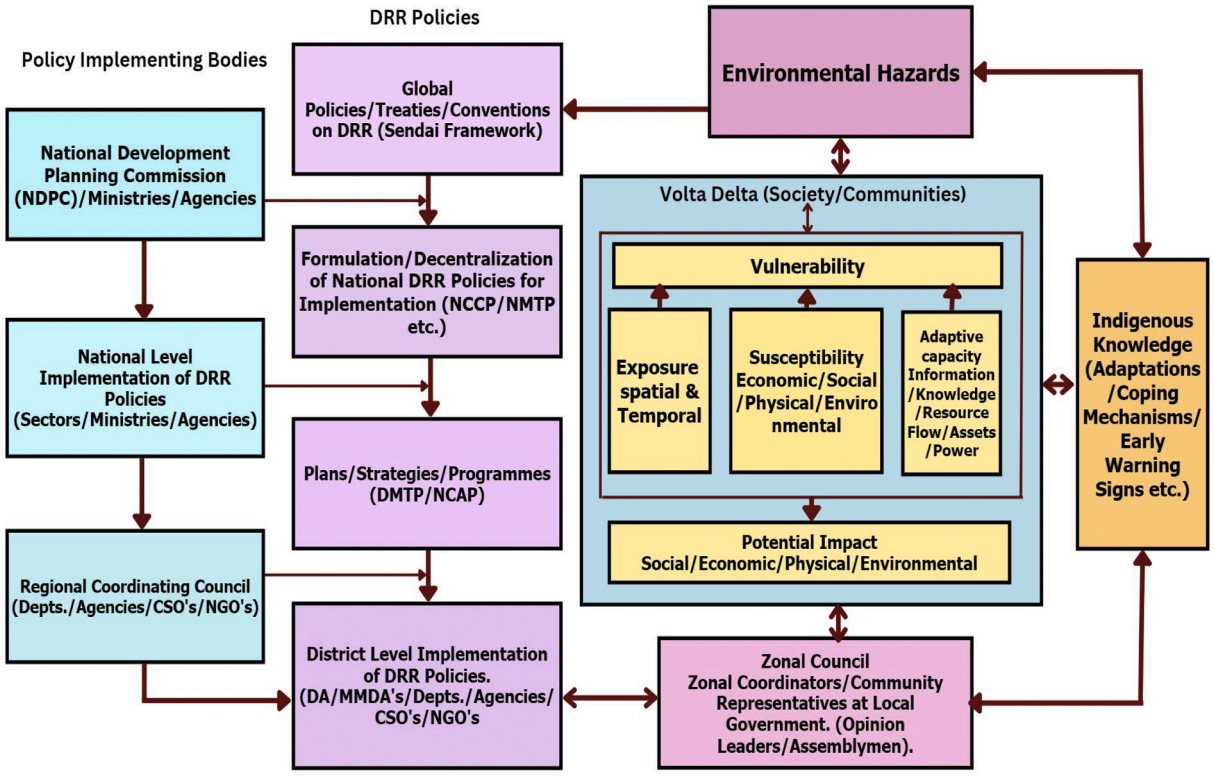

Fig. 1. Conceptual framework for the study.
Source: Adapted from Birkman et al. [37]; Jackson et al. [30].

subjective risk perspective to address disaster risk reduction. Objective risk assessment is the probability based on facts and figures available on the situation while the subjectiveness is socially constructed [15]. It is how risk is perceived based on beliefs, norms, perceptions, and community knowledge.

The framework explains how global policies are formulated and translated into national policies to address disaster risk issues at the community level. This is based on factual figures and community coping and adaptations mechanisms such as beliefs, opinions, indigenous knowledge based on past experiences and perceptions and early warnings. While the objective risk assessment provides information on the phenomena and potential harm based on facts and figures, the subjective risk acknowledges people's beliefs and opinions that may cause deviations from the standards. The subjective risk assessment looks at people's understanding and judgment of risks regarding locally defined conditions, values, and concerns [14,38,15]. It encompasses their knowledge, degree of novelty and familiarity, and their capacity to deal with the situation. This paper, therefore, evaluates the contributions of community's perceptions, indigenous knowledge, coping and adaptation mechanisms of communities along the Volta estuary in Ghana in addressing perennial climate change related disasters and risks in the Volta Delta and the larger global community.

Methodology

Study area

The study was conducted among nine communities in the two districts (Anloga and Ada East) located to the immediate east and west of the Volta estuary (Fig. 2). Three communities, namely Fuveme, Agorkedzi and Attiteti, were selected from Anloga District located at the immediate east of the Volta Delta while the remaining six, Kewunor, Azizanya, Ayigbo, Lolonyakope, Otrokpe and Azizakpe, were sampled from the immediate west of the delta in the Ada East District. These communities were purposively selected because they were geographically located within five (5) kilometers east and west of the Volta Delta (Fig. 2). The two districts constitute part of the disaster hotspots on the eastern coast of the country which are prone to coastal flooding and erosion [3,9,39,40].

Study approach

The study employed the mixed methods approach using both qualitative and quantitative data for a study [41]. This approach was adopted to ensure complementarity and/or confirmation of diverse views from the various respondents or participants. As observed by Gorard & Taylor, [42], combining the two types of data helps to benefit from contextualized insights of both qualitative and quantitative data, thereby enabling the strengths of one type of data to mitigate the weaknesses of the other. Thus, in accordance with the tenets of the mixed methods approach, both quantitative and qualitative data were collected, analysed, and interpreted to inform the results, discussions, conclusions and recommendations. Data collection was progressive, following the exploratory sequential design as

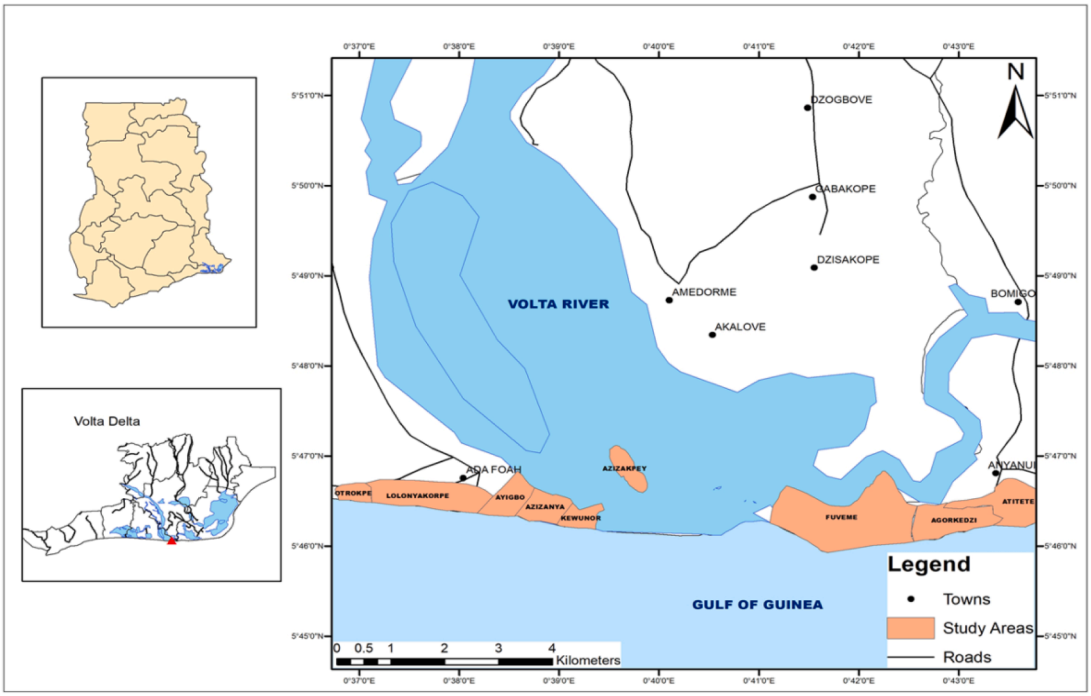

Fig. 2. Map of the study area.
Source: Mattah et al. [3].

illustrated in Figs. 3 and 4. Based on this design, qualitative data was gathered first to pre-inform quantitative data capture, in terms of the design and use of questionnaires for the household survey. Two sets of instruments were designed and utilised for the qualitative data, namely in-depth interview (IDI) and focus group discussion (FGD) guides. While the IDI guides were used to collect data from individual perspectives, the FGDs were used to capture group perspectives. Structured household questionnaires were developed and used to gather the quantitative data. The instruments were pretested before being used for the main data collection. For purposes of triangulation, the issues covered in the IDI guides, FGD guides and questionnaires shared commonalities. The issues centred on communities' knowledge and understanding of environmental hazards pertaining to their communities, how they perceived these hazards, and the coping and adaptation mechanisms employed over the years to survive. In addition to the data collected through FGDs, IDI and questionnaires, observations were carried out through a transect walk using a checklist developed for the excercise.

Data collection and sampling procedures

Data collection took place between April 2020 to October 2020. It began with a reconnaissance survey for the research team to acquaint itself with the study area and to identify contact persons at the respective district offices to provide support to the study. Through the contacts persons from the two district offices of the National Disaster Management Organization (NADMO), communities for the study were identified and listed for the study. Subsequently, community entries were made to identify the leaders and other community members to participate in the study. Appointments were later scheduled with dates to commence FGDs and IDIs. Table 1 & 2 shows the composition of the FGDs and the IDIs held during the studies. Qualitative data collection continued until data saturation was attained. Table 3 shows the estimated population of all the communities. The number of households per community were obtained from the Ghana Statistical Service 2010 population census (Ghana Statistical Service [[43], 2013]. Using the proportional-to-size sampling technique [44], the total number of households sampled for each community was calculated and a total of 324 households were sampled for the study Table 3, [3].

$$n = \frac{N}{1 + N(\alpha)^2}$$

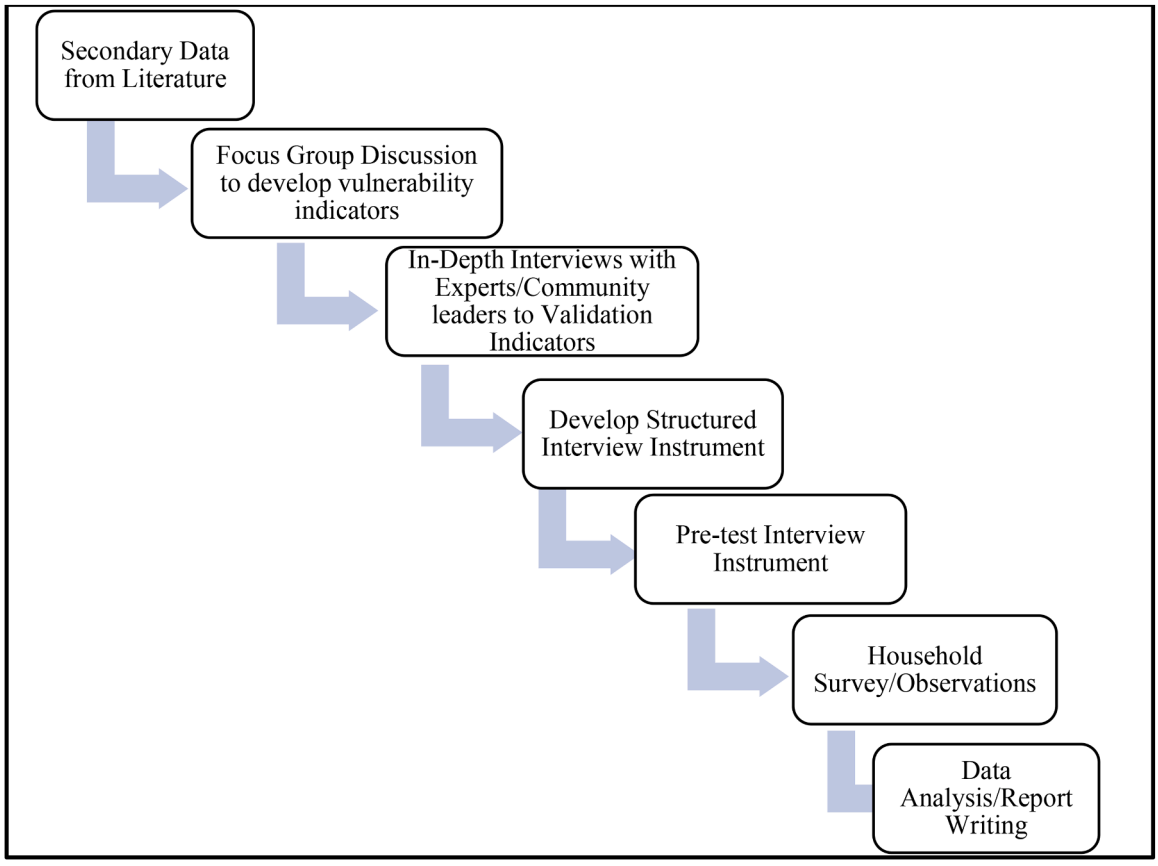

Fig. 3. Sequential flow chat for data collection.
Source: Authours.

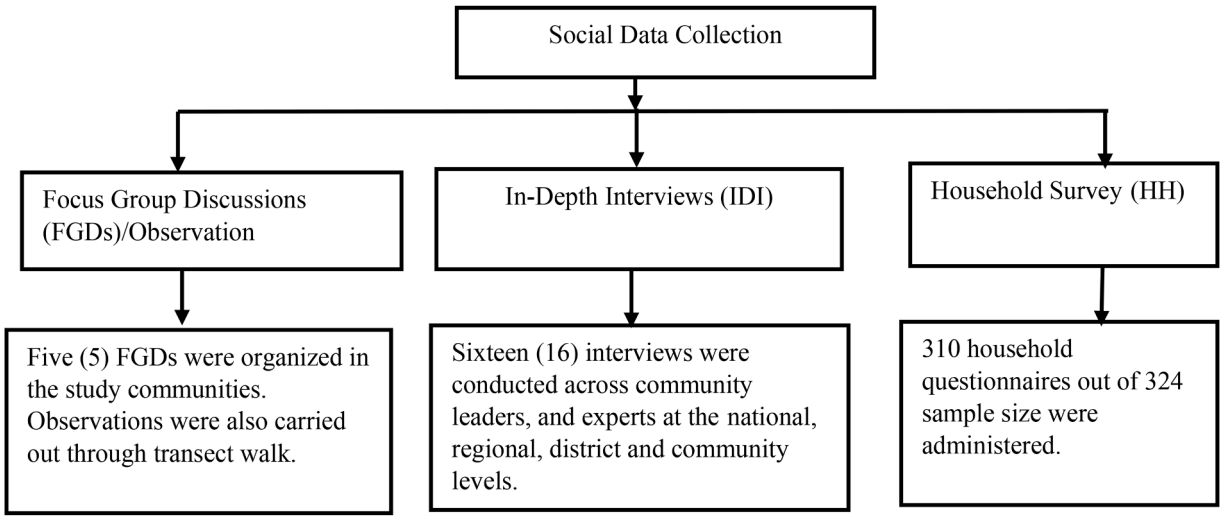

Fig. 4. Types of data collected.
Source: Authors.

Table 1
Composition of the Focus Group Discussion at the various communities.

Community	FGDs		
	Number of Men	Number of Women	Total
Fuveme-Agorkedzi (FAG)	4	4	8
Attiteti (AT)	3	4	7
Azizakpe (AZ)	5	3	8
Kewunor & Azizanya (KA)	4	4	8
Lolonyakope (LO) & Ayigbo (OY)	5	3	8
Total	21	18	39

Table 2
Composition of in-depth interviews conducted in the study area.

	In-depth Interviews				
Stakeholders	Ada	Anloga	Regional Office	Head Office	Total
Community leaders	2	3		–	5
Local authority staff	4	5		–	9
Regional level			1		1
National level	–	–		1	1
Total	6	8	1	1	16

Table 3
households sampled for each community.

Districts	Communities	Male	Female	Total	No. of Households	Sample Size
Anloga	Agorkedzi (AGO)	–	–	74	15	3
	Atitteti (ATI)	419	525	944	202	38
	Fuveme (FUM)	400	436	836	232	44
Ada East	Azizanya (AZN)	765	759	1524	242	46
	Kewunor (KEW)	207	199	406	83	16
	Ayigbo (AYI)	649	657	1306	233	44
	Lolonyakope (LOL)	1160	1283	2443	435	82
	Azizakpe (AZK)	–	–	590	107	20
	Otrokpe (OTR)	438	445	883	167	31
Total				9006	1716	324

Source: Mattah et al. [3].

$$n = \frac{1716}{1 + 1716(0.05)^2} = 324$$

Where N = sample frame,
n = desired sample size, and
'α' = margin of error (5 %).
Source: [44]

In each community, household sampling started from the west and ended at the eastern part of the community, given that housing structures in all communities selected were having east to west orientation following the direction of the coastline. Every 3rd housing structure was selected and where there are were more than one household in the housing structure, the household head of every first household in the structure was interviewed [3].

Ethical issues

Ethical clearance was sought from the College of Basic and Applied Sciences at the University of Ghana, Legon. ECBAS 058/19–20 was obtained to clear the research to be conducted. Informed consent was obtained from all subjects who participated in the study.

Data analysis

Both qualitative and quantitative data were collected for this study. Qualitative data gathered through the in-depth interviews and FGDs were recorded, transcribed and thematically analysed. The analysis was done manually, identifying recurring themes in the data, establishing typologies of the themes, and finding the variations and associations between and within the themes. These were organized based on themes and nodes for the write-up (intepretation of the results). Some direct quotes from the study participants' narratives, as well as pictorial evidence were used to support the findings.

The quantitative data that was collected using the structured survey instrument was keyed in, cleaned, and managed using IBM Statistical Package for Social Science (SPSS) Version 21. The data was cross-checked with the original questionnaires, edited, and coded for analysis. The cross-check was done purposively to make corrections, where necessary. Descriptive statistics were used to decribe the demographic and socioeconomic characteristics of the respondents. Results were used to compare the proportions and frequencies of respondents, respectively, between districts and among communities. P-values < 0.05 % were regarded as significant.

Results

Demographic characteristics

Three hundred and twenty-four (324) household heads in the study area were sampled to administer the structured interview instruments. However, 310 household heads were available and agreed to respond to the instrument (Table 4), giving a response rate of 95.7 %. Overall, 130 (48.4 %) of the total respondents were females. Communities in the Anloga District, including Attiteti, Fuveme and Agorkedzi, have more female-headed households, 48 (56.5 %) out of 85 households interviewed.

Table 5 shows various characteristics of households engaged during the quantitative data collection stage. The age of the respondents in the two districts was between 40 years and 95 years. In the Anloga District, respondents' ages ranged between 40 and 88 years while those of Ada East ranged between 40 and 95 years. On the distribution of the age of the respondents in the two districts combined, more than 80% of them were 40 to 49, 50 to 59 and 60 to 69. The years ranged from ten (10) to 95 years on how long respondents lived in their respective communities. In the Anloga District, respondents had lived in their communities between 10 and 88 years while those in Ada East had inhabited the area for between 10 and 95 years. Overall, seventy-four per cent (74 %) of the respondents had lived in their communities for about 60 years, and about 23 % for between 61 and 80 years. Regarding the educational status of the household heads who were interviewed, an average of 41 % had no formal education. In communities like Fuveme,

Table 4
Respondents gender distribution by communities.

District	Community	Male	Female
Anloga	Atiteti	13	25
	Fuveme	23	21
	Agorkedzi	1	2
Sub-total	37	48	
Ada East	Azizakpe	13	7
	Lolonyakope	37	32
	Ayigbo	31	13
	Azizanya	24	22
	Otrokpe	11	19
	Kewunor	7	9
Sub-Total	123	102	
Total	160	150	

Table 5
Socio-demographic characteristics of respondents.

District	Community	Age Group (% of Respondents)						N
		40–49	50–59	60–69	70–79	80–89	90–99	
Anloga	Attiteti	42.1	26.3	13.2	13.2	5.3	0	38
	Fuveme	31.8	22.7	29.5	9.1	6.8	0	44
	Agorkedzi	33.3	33.3	33.3	0	0	0	3
Ada East	Azizakpe	35	40	15	10	0	0	20
	Lolonyakope	7.2	59.4	31.9	1.4	0	0	69
	Ayigbo	25	45.5	11.4	13.6	4.5	0	44
	Azizanya	21.7	43.5	21.7	10.9	0	2.2	46
	Otrokpe	33.3	26.7	13.3	16.7	6.7	3.3	30
	Kewunor	12.5	18.8	50	12.5	6.3	0	16

District	Community	Number of years respondents lived in the community (%)					N
		20 and Below	21–40	41–60	61–80	81 and Above	
Anloga	Attiteti	7.9	15.8	52.6	21.1	2.6	38
	Fuveme	11.4	9.1	50	22.7	6.8	44
	Agorkedzi	0	33.3	33.3	33.3	0	3
Ada East	Azizakpe	0	10	70	20	0	20
	Lolonyakope	10.1	8.7	59.4	21.7	0	69
	Ayigbo	9.1	6.8	68.2	13.6	2.3	44
	Azizanya	8.7	8.7	56.5	23.9	2.2	46
	Otrokpe	6.7	10	50	23.3	10	30
	Kewunor	0	0	37.5	62.5	0	16

District	Community	Educational Status of Respondents (%)					N
		Tertiary	Secondary/Vocational	Middle/JHS	Primary	No Education	
Anloga	Attiteti	2.6	29	5.2	21.1	42.1	
	Fuveme	0	13.6	4.5	31.8	50	38
	Agorkedzi	0	0	66.7	33.3	0	44
Ada East	Azizakpe	0	20	20	20	40	3
	Lolonyakope	0	5.8	0	47.8	46.4	20
	Ayigbo	2.3	6.8	0	45.5	45.5	69
	Azizanya	0	6.5	0	37	56.5	44
	Otrokpe	0	3.3	13.3	20	63.3	46
	Kewunor	0	12.5	12.5	43.8	31.3	30

Azizanya and Otrokpe, over 50 % of households had no formal education. The majority (33 %) of those who had formal education ended up in primary school. Nevertheless, in communities such as Lolonyakope (47.8 %), Ayigbo (45.5 %), and Kewunor (43.8 %), over 40 % of the respondents were educated up to the primary level. Only 13 % completed either Middle School or Junior High School (JHS). Another 11 % had some form of secondary education, and few had tertiary education from the Polytechnic. Further analysis of households' compositions in the study areas revealed wide variations in distribution of people above the age of 65 among the communities and between the districts. About 28 % of all households studied had at least one member who was 65 years and above (Table 5). Few households had two or more of 65 or more years in them. The frequencies of children of basic school-going age in both districts varied significantly ($\chi^2 = 306.88$, df=32, $p < 0.001$) as well as in communities of the individual districts (Anloga: $\chi^2 = 57.78$, df=8, $p < 0.001$; Ada East: $\chi^2 = 179.89$, df=20, $p < 0.001$), generally, with majority of the households having at least one person in a basic school. The data showed that a minimum of 20 % of households had at least one child in basic school. Some specific communities had interestingly, more children of basic school-going age than the rest. In Otrokpe, for example, 33.3 % of households had four (4) or more children in basic school.

The frequency distribution of households with children under-five (5) years was significantly different among the communities of both districts (($\chi^2 = 165.85$, df=32, $p < 0.001$). Variations were also observed among the communities in the separate districts (Anloga: $\chi^2 = 35.65$, df=8, $p < 0.001$; Ada East: $\chi^2 = 123.12$, df=20, $p < 0.001$).

Community knowledge on environmental hazards

Respondents to the in-depth interviews were queried on their community's types of hazards, frequency, and intensity. Environmental hazards or threats mentioned by the respondents included: (i) floods from the Volta River, (ii) tidal waves (storm tides from the sea), (iii) floods from the sea, (iv) coastal erosion and (v) floods from rains. Although minor and mainly human-induced, other environmental threats mentioned included sand winning and plastic waste. The composite data from the two study areas revealed that most of the respondents (32 %) considered floods from the Volta River as the most critical. In contrast, 21 % viewed tidal waves as the most important. Twenty per cent (20 %) of the respondents considered sea erosion and floods from the sea as most critical, while 7 % mentioned floods from rainfall as critical (Fig. 5).

Regarding respondents' knowledge of the types of environmental hazards in their areas, the eastern part (Anloga District) of the

Volta estuary communities experiences more sea erosion (96.5 %), tidal wave (87.1 %) and flooding from the river, (70.6 %), while respondents from the western part (Ada East) indicated flooding from the river (79.6 %), sea erosion (42.9 %) and flooding from the sea (24.9 %) as critical (Fig. 6). A z-test conducted on the respondents' knowledge of key environmental threats revealed significant variations between Anloga and Ada East districts. Significantly higher number of respondents in Ada East indicated that flooding from the river and flooding from heavy rains than respondents from Anloga (Flooding from the river: $z = -11.375, p < 0.001$; Flooding from heavy rains: $p < 0$ 0.05), whereas significantly higher number of respondents in Anloga stated flooding from the sea, sea erosion and tidal waves than their counterparts in Ada East (Flooding from the sea; Sea erosion; $z = 8.617; p < 0$ 0.001; Tidal waves; $z = 10.81; p <$ 0.001).

The qualitative data revealed that the environmental hazards affected both tangible and intangible things. The tangible things include housing structures, infrastructure facilities (like school buildings, markets, roads), livestock, household properties etc., and the intangible but essential things are livelihoods, ecosystem services, children's education, and business (trading) activities.

During the FGD at Attiteti in the Anloga District, the frequency of the gravity and impact of the destructive power of the sea and tidal waves on communities' livelihood activities was described and compared to the destructive effects of an angry person.

"The sea mostly becomes angry twice a year, making fishing expedition difficult" (FGD participants, Atitteti).

The frequency of occurrence of environmental hazards or threats varies among the residents of the communities in the study areas. Respondents to the structured interviews stated that hazards occurred twice in a year (32 %), another 28 % felt they occurred about four times, and 19 % felt they occurred thrice in a year (Fig. 7). The majority (32 %) of responses conforms to the historical data gathered from the National Disaster Management Offices at the study areas which indicated that most disasters occurred in May/June and August/September.

Respondents were ascribed several reasons for the causes of the environmental threats (Fig. 8). This ranged from the poor construction of the Ada Sea Defense structure to a complex state of combined factors such as nature, spillage of the Akosombo Dam and high tides. Most respondents in the Anloga District (41.2 %) mentioned the poor nature of the Ada Sea Defense construction, and 38.2 % of respondents in Ada East attributed natural causes. They explained that during torrential rains or heavy down falls, more fresh water enters the sea, causing tidal the waves to be high. They also observed that the rains, on many occasions, are accompanied by storm surges that threaten lives and property. Both Ada East and the Anloga Districts agreed that the Akosombo Dam's spillage (22.2 % and 10.6 %, respectively), is a cause of environmental hazards. Other factors mentioned included religious beliefs, sand winning and climate change (Fig. 8).

Communities' understanding of disaster risk associated with environmental hazards

According to community leaders, although they were familiar with the occurrences of hazards, they had now become more frequent with disastrous impacts such as the loss of their homes, personal belongings, livelihoods, and displacement from their homes. On what

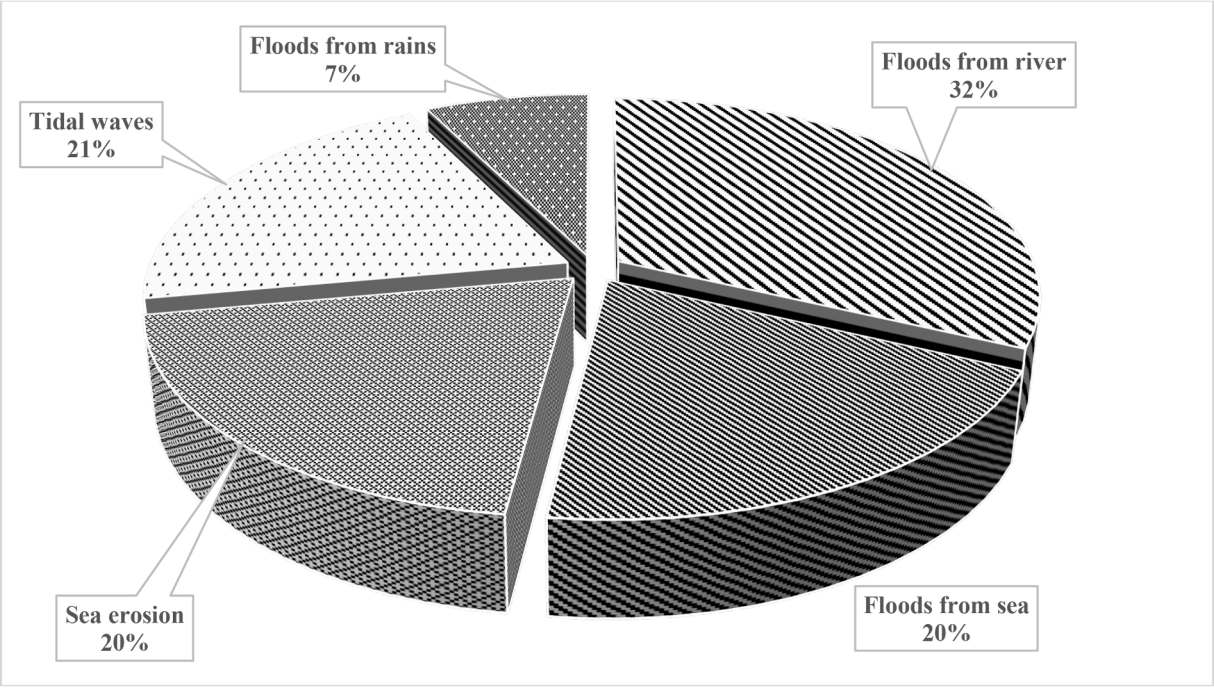

Fig. 5. Key environmental threats to communities in the study areas.

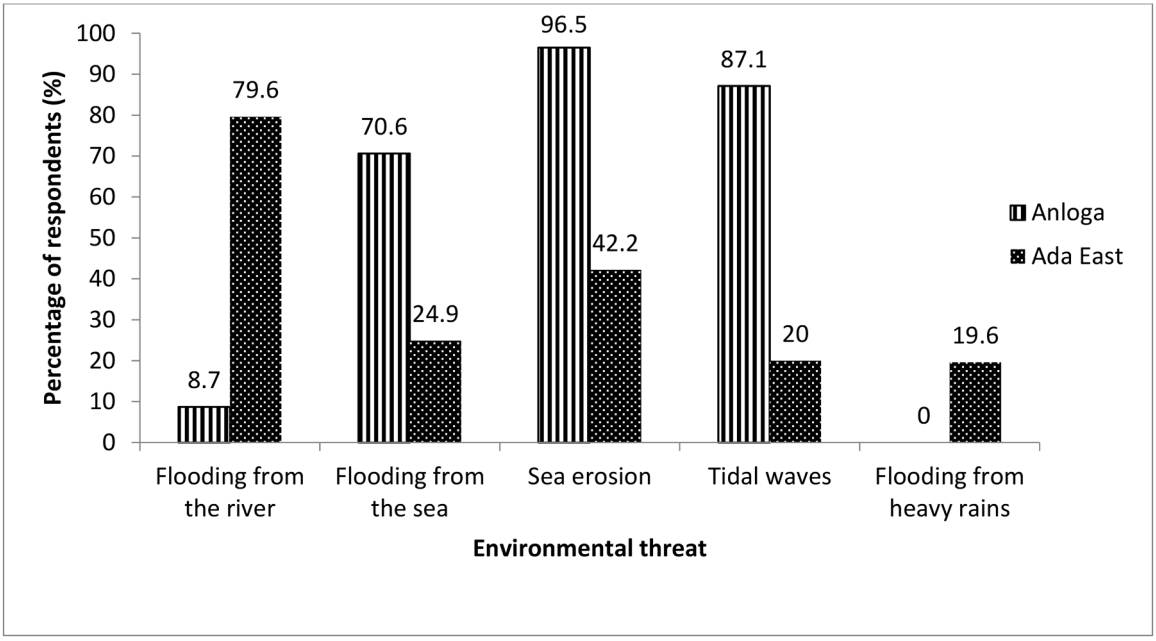

Fig. 6. Knowledge of respondents on environmental hazards in the two districts.

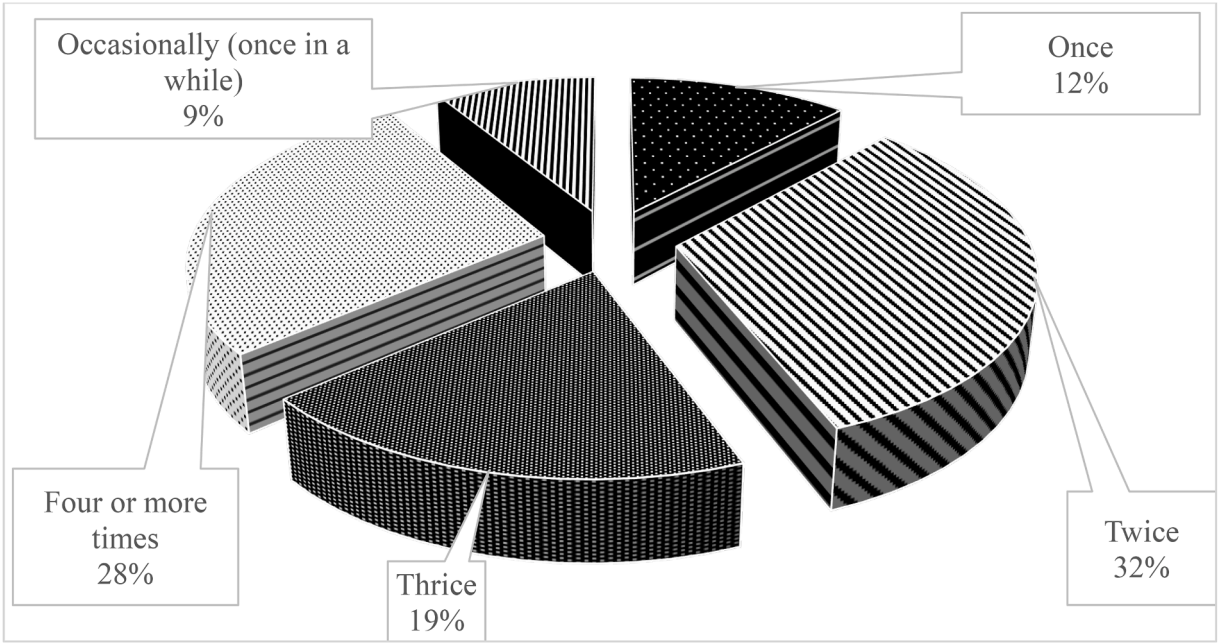

Fig. 7. Rate of occurrence of the environmental threats per year among communities.
*Note: Environmental threats are the same as environmental hazards in this study.

was considered a disaster in their communities, some of the statements captured from among the community leaders include:

> "Now we have realized that it is dangerous to live here. Previously, because the tidal wave and the flood waters were not entering our homes, it was convenient for us to stay here. The occurrence of *erosion from the tidal wave used to happen perennially (once a year), and the sand will build back again. At times, the deposition of sand will form lakes but now, because of the uncompleted sea defense structure at Ada, the sea has become very destructive. Tidal waves have completely eroded two communities, namely Fuveme and Kporkporgbo"* (Community leader, Atitteti).

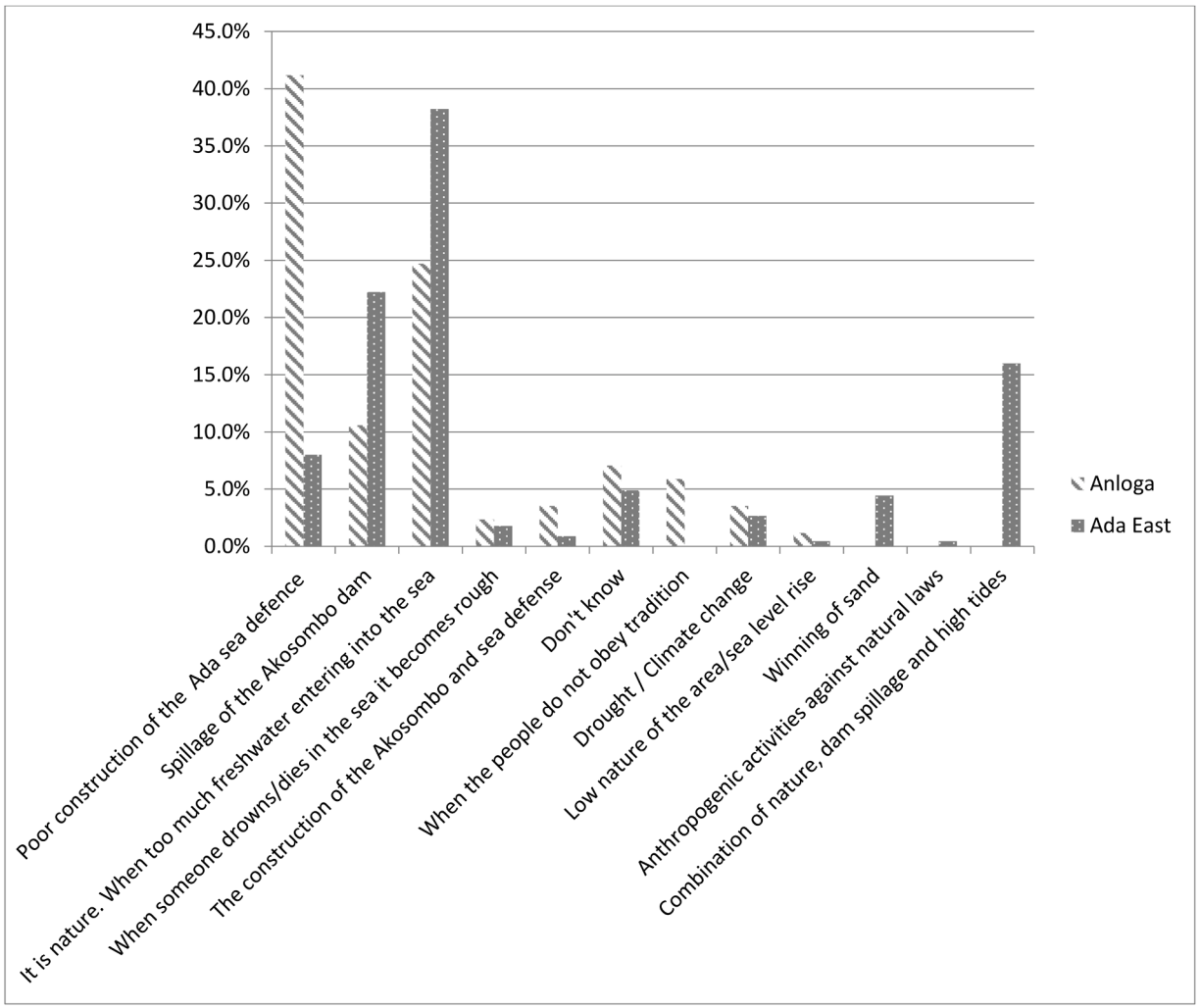

Fig. 8. Respondents' view on the causes of the environmental threats.

"*We consider a hazard to pose as a threat or risk of causing disaster when our livelihoods, which is also our source of income, are being threatened*" (A statement that run through all the FGD and IDI's).

In terms of community's perception on disaster risk, 44 % of the total respondents perceived that a combination of all factors such as displacement, loss of livelihood, loss of property and impact on human life from environmental hazards could pose a disaster risk to a community (Fig. 9). Thirty-one per cent (31 %) were, however, more concerned when the impact causes displacement, with 19 % focusing on the loss of their properties. Only one per cent (1 %) did not know when a hazard phenomenon could be considered a disaster, and 5 % thought that only when the hazard was a threat to human life, could it be considered as a disaster. that the concept of disaster risk only as a threat to human life was consistent during all the FGDs. Disasters associated with the environmental threats did not cause casualties since their occurrence was a gradual process, usually accompanied by early warning signs to inform them that there was the possibility of a disastrous event. Many community members are able to evacuate to safety before the disaster occurs, thereby minimizing the number of casualties associated with the disaster.

On indicators used in the various districts to sense danger or potential risks associated with an environmental hazard, participants in the Anloga District identified the rate of erosion and its associated damage, such as destruction of homes, livelihoods, and property and the relocation of many people to other places such as open spaces, neighbouring communities, or relatives' homes and the high frequency of tidal waves with accompanying water coming into their homes.

In the Ada East District, identified indicators were flooding and collapsing of homes, damage to working equipment such as boats, fishing nets and landing beaches from storm surges and sand winning. It is worth noting that in both districts, a few participants were not able to identify any indicators of potential risk in their respective communities with the reason that, the event usually happen at nigh taking them by surprise.

Further question on whether they felt that living in their community was a risk, the responses were in the affirmative. Respondents

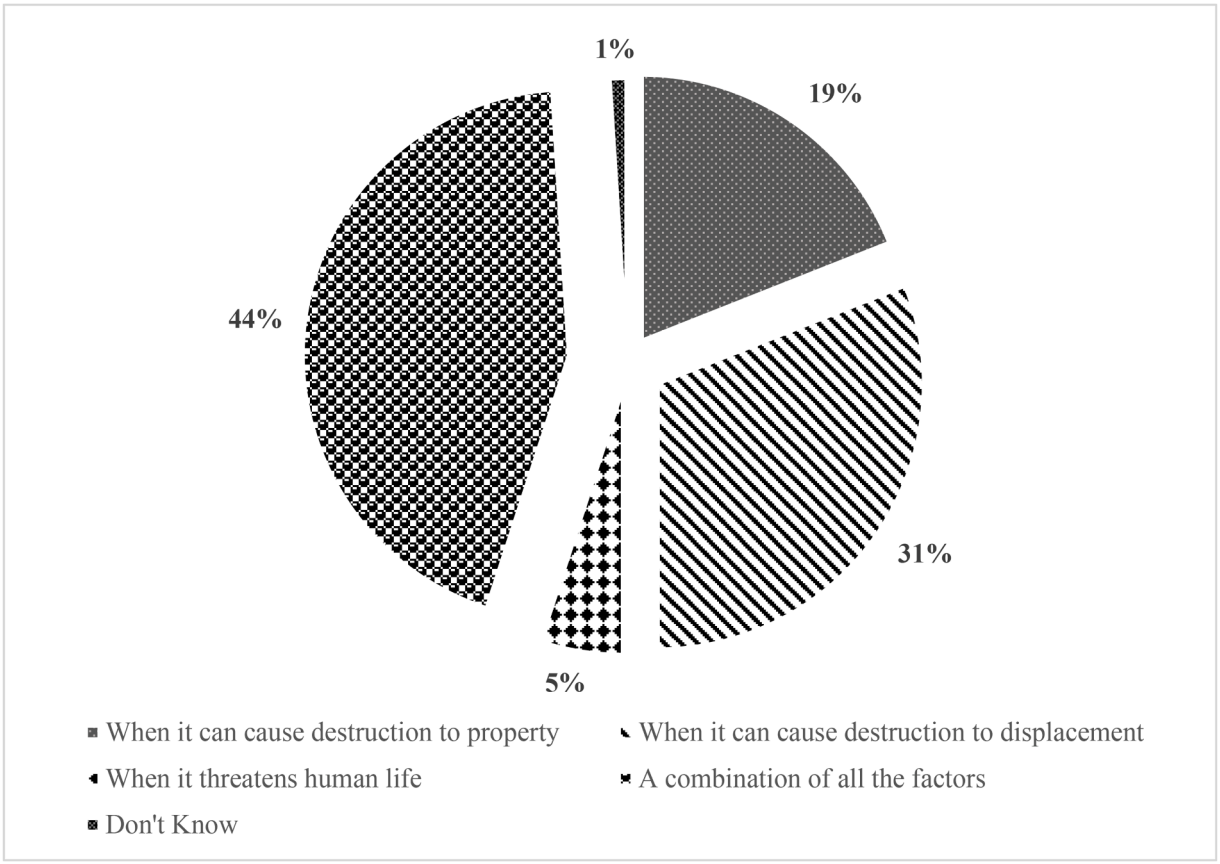

Fig. 9. Community perception of when a phenomenon poses a potential disaster risk.

indicated that they were aware of the extent of risk involved in their current place of abode. they have proactively tried to address the risks by informing the authorities at the district assembly and in some cases, sending requests to the government to extend the Ada Sea defense wall, however, no feedback has been provided. An alternative view was provided by the Fuveme Assemblyman who did not foresee any risk in living in their communities, especially since their livelihoods depended on the coast Respondents from Lolonyakope and Ayigbo mentioned that, before the construction of the sea defense structure, the types of housing structures in the area had been determined by the level of risk in the area. They would only consider putting up a structure that was less expensive to minimize the cost when a disaster occurred. The statements below summarize views of respondents regarding the risks associated with living in the communities:

> "*Because our livelihoods depend on the coast, we do not see or assume living here to be a risk*" (A community leader at Fuveme).
>
> "*The people consider living here as risky and that is what has informed the number and type of structures, they put up here. Before the sea defence wall, only a few people invested heavily in block housing structures because, at a point in time, they were afraid of losing their investment in the form of a major building to erosion or floods from the sea. The potential of losing everything was high*" (Community leaders at Loloyakope and Ayigbo).
>
> "*Yes, we know that living here, our lives are at risk, but we have no choice but to stay here because all our land has been eroded. We have no land again left to relocate to*" (Community leader at Azizzakpe).
>
> "*Yes. We know that living here is risky. That is why we are crying for the sea defence project to be completed*" (Community Leader of Agorkedzi).

Community's perception on the category of people at risk during of disasters

It was perceived among all the communities during interviews and FGDs hierarchically that children, older people, and women were more affected during disasters. Among reasons participants provided to support this claim was that children's education tends to be affected when school buildings and roads to the schools are damaged. In another vein, tidal waves, high tides, and floods endangered the lives of school-going children who otherwise relied on canoes to travel across the estuary system to school in

neighbouring communities. The elderly were left at the mercy of social capital since many could not help themselves during disasters. Narrating the plight of an elderly woman at Azizakpe, she was trapped in her flooded bed until she was salvaged by a neighbor. Aside from children, women were also said to be more affected because disasters affected their sources of income, especially in the destruction of coconut trees, livestock (domestic animals), and petty trading. Pregnant women were also at risk, especially when they were in labour at night.

Perceived factors contributing to communities' level of risk from environmental hazards

Three main factors were identified as contributing factors to the level of risk from the environmental hazards namely socio-economic, environmental, and cultural.

Socio-economic factors

The main socio-economic factors mentioned were poverty, lack of social amenities and community infrastructures such as lack of access to health facilities, educational facilities, roads and communication networks, and transportation system. The destruction of fisheries grounds and landing beaches were also stated as a major factor affecting their fishing which is their main livelihood and economic activity. Distance to health and educational facilities was mentioned as a factor exposing community members, especially children and pregnant women, to disaster risks. The statements below summarize participants' sentiments on the lack of infrastructure:

> "*Because there is no access road and clinic in the community, it becomes fatal when there is an emergency*" (General statement that cuts across all the FGD's).

> "*When there is an emergency here, because of the inaccessible nature of the place, the canoe owners charge exorbitant prices*" (FDG's at Azizakpe and Agorkedzi).

Interactions with the various stakeholders during the study indicated that poverty is a determining factor in decision making processes of households before, during and after disasters. It informed how prepared they are before disaster strikes, how they were handled and life after the disaster events. Poverty was a determining factor in the reconstruction processes of disaster victims. The ability of households to improve or afford facilities such as health, electricity and temporary shelters were also affected.

Participants at Agorkedzi/Fuveme stated that poverty had contributed to their inability to undertake alternative livelihood options when their primary occupations were affected by disasters. They stated that their primary occupations in the area, such as fishing, fish mongering, rearing of livestock and coconut oil production, were affected by disasters, contributing to their vulnerability to the risks. They could not reconstruct their housing structures due to lack of financial resources and land. They explained that the fishing business has become less lucrative, reducing their incomes, and rendering them poor. Secondly, due to their constant movement from one place to another and constantly erecting temporary shelters, they were unable to pay for their children's school fees and cater for them: A quote from a participant at Agorkedzi which represents the views of all the participants.

> "*Because of our continuous movement from one place to another, poverty has become a serious and a major contributory factor to everything we do. Our fish catch has reduced. We only catch seagrass when we go fishing. The women's livestock rearing has also been affected by the floods, thereby rendering us continually poor. And because of poverty, our children have dropped out of school. Many people find it difficult sending their children to school. Even buying food for the family is a major problem"* (Agorkedzi FGD and Fuveme and Agorkezi interviews).

Environmental factors

The main environmental factor contributing to the susceptibility of the communities was mostly limited land due to the devastating effects of coastal erosion. When a question was asked if resettlement could be an option to resolve the problem of landlessness and reduce the impact of disasters and potential risk on the communities, it generated a debate among the participants. While some believed that resettlement was the best option, others took a contrary view, arguing that since they were predominantly fisher folk, their livelihood would be negatively affected if they were to be resettled. Below are some statements which capture the views of some participants:

> "*Limited land is the major challenge that predisposes us to risk of disaster"*. (All FGD).

> "*Please, we do not have money, but the major problem is land. If they give us some land somewhere, we will go. Even if they are thatch houses, we shall construct and stay in*". (All FGD)

> "*We could stay at our new place and come to fish at our old place during the day*" (FGD Lolonyakope and Azizakpe).

Even though the participants were in support of resettlement, except for, Lolonyakope and Azizakpe, the remaining communities were against resettlement away from the coast. They believed that the sea defence should be completed to minimize their risk level. They also stated that it would resolve their land issues since accretion would occur over time.

> "*How will we fish if we are resettled far from the shore?*" (Statement from communities not in favour of resettling away from the coast).

Cultural factors

The Physical and Development Planning Officers at the Ada East District Assembly indicated that, efforts to relocate people of Kewunor was futile due to cultural issues. The main cultural issues raised by the various community leaders for their refusal to relocate included chieftaincy, the sense of belonging and livelihood issues. The planning officers indicated that some of the chiefs had refused resettlement locations for fear of conflict or due to power dynamics relating the land. They also mentioned the fact that they would not leave their ancestors behind. However, the people of Fuveme in the Anloga District did not have an option other than resettlement. Their old place had been completely submerged under the sea, having them move to their current place at Agrokadzi. The community elder for Fuveme indicated that,

> *"Since we relocated to Agorkedzi, we are not allowed to build permanent structures due to land issues. The district assembly has since not been able to compensate the landowners therefore our denial the permit to build"* (FGD at Agorkezi & Leaders).

Community coping and adaptation mechanisms towards environmental hazards

Community strategies to reduce the impact of disasters and improve disaster risk reduction (DRR) included relocation, use of early warning systems, and other coping mechanisms such as stacking sandbags around their homes and the beaches, beach nourishment and heaping refuse at the riverbanks and around their homes [3] (Fig. 10). Other strategies include manual dredging of the river, cleaning community drainage systems, and protecting the beach from sand winning activities.

Relocation of community members

Community leaders in both districts indicated that the primary community strategic intervention in the study area is to keep relocating to higher ground to reduce disaster fatalities. It was identified that, the relocation is in stages, starting from placing their thing on higher objects, moving the children and their belongings to relatives' homes, movement of the whole family to havens (open spaces and schools), and finally to neighbouring communities and the big cities. The statement below was the slogan for all the affected

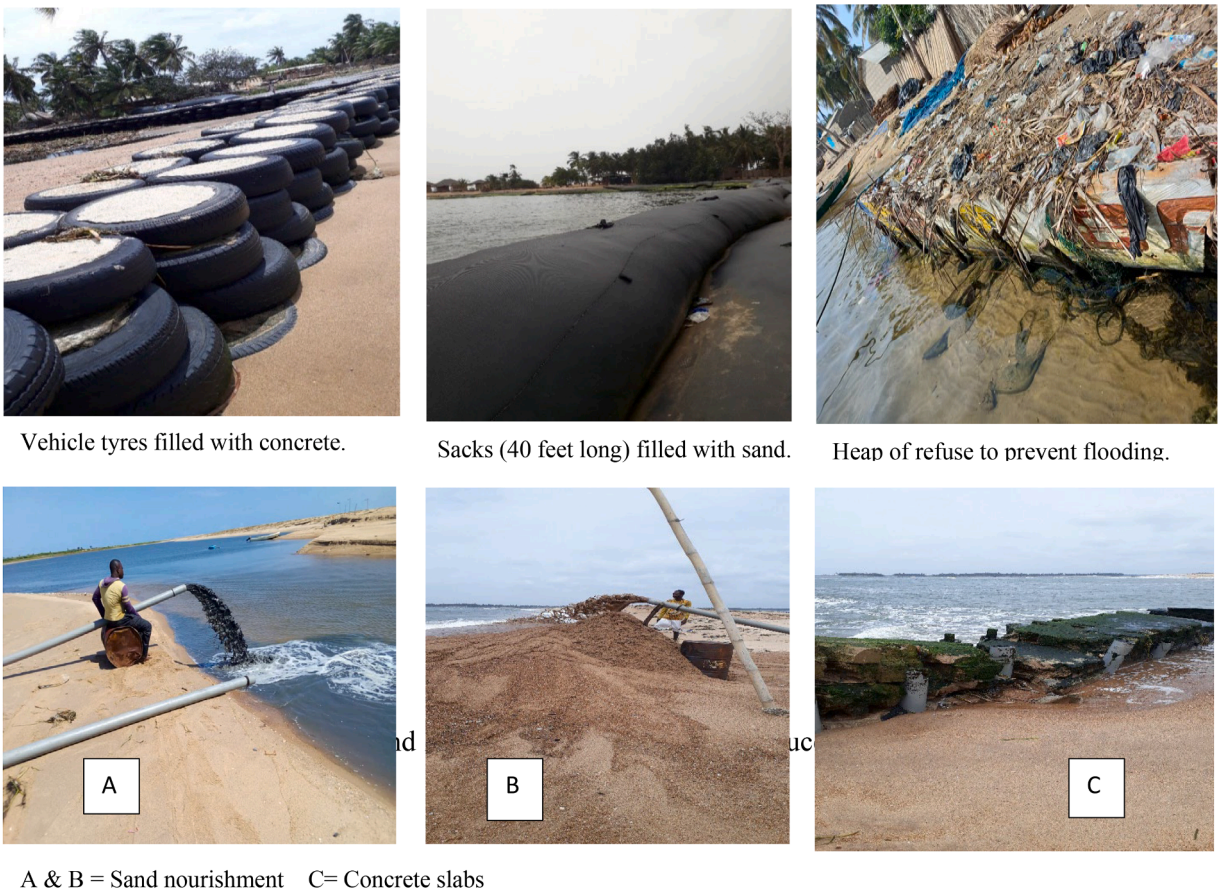

Fig. 10. Community Coping and Adaptation Mechanisms to reduce impact of Environmental Hazards.

communities:

> "*The only way we respond to disasters is to keep moving from one place to another. There is nothing we can do. We cannot fight the sea*" (Extracts from Agorkezi, Atittei, Azizakpe and kewunor FGDs and interviews).

Fig. 11 represents the number of respondents who have relocated in the past ten (10) years. The figure shows that there had been some movement in all the communities. Significantly higher number of respondents in Fuveme (44 participants indicating 100 %) and Azizakpe 80.2 % (Azizakpe, $z = 7.2$, $p = 0.007$) reported to have relocated than not in the past ten (10) years. Other communities with high proportion of participants indicating that they had relocated in the past ten (10) years include Otrokpe (46.7 %) and Kewunor (37.4 %), Agorkedzi (33.3 %) and Azizanya (32.6 %).

In terms of relocation as an adaptive measure to reduce disasters, 54.5 % of Fuveme respondents and 33. 3 % at Agorkedzi responded to have relocated about four times. Fifty per cent (50 %) of the respondents at Azizakpe had relocated thrice, while 30 % had moved, at least once in the past 10years at Otrokpe. Kewunor, Again, 25 % of respondents had moved thrice within the stipulated 10 years period. The communities with less movement include Lolonyakope, Ayigbo, Azizanya, and Atitteti. Their low numbers are explained by their geographical location and government intervention in the Ada East Sea defence structure. Atitteti is less close to the coast, and Lolonyakope, Ayigbo and Azizanya are all Ada Sea defence beneficiaries.

Using community early warnings

The movement of community members is pre-informed by several factors. Indigenous early warning systems and past experiences are essential to resident communities in the study area. People in the community can predict when a disaster will strike the community through indigenous early warning signs. Some of the early warning signs used to predict disasters include chirps of unique birds (such as *Cuculus canorus* which is locally known as "Koekoek Vio" in Ewe and "Konyue" in Dangme), the size and position of the moon, the pattern of tides on the clouds, the position and movement of clouds, and the velocity of the river's flow. These were captured throughout all the FGDs and community leaders' in-depth interviews:

> "There are early warnings. Some individual community members can study over time and know if there will be a disaster at night and they pass on the information for us to prepare. We would *therefore stay awake, and when the sea strikes, we can wake the children up early enough to flee".*
>
> *"We also construct dikes to protect ourselves, but sometimes the dikes are unable to withstand the strength of the waves".*

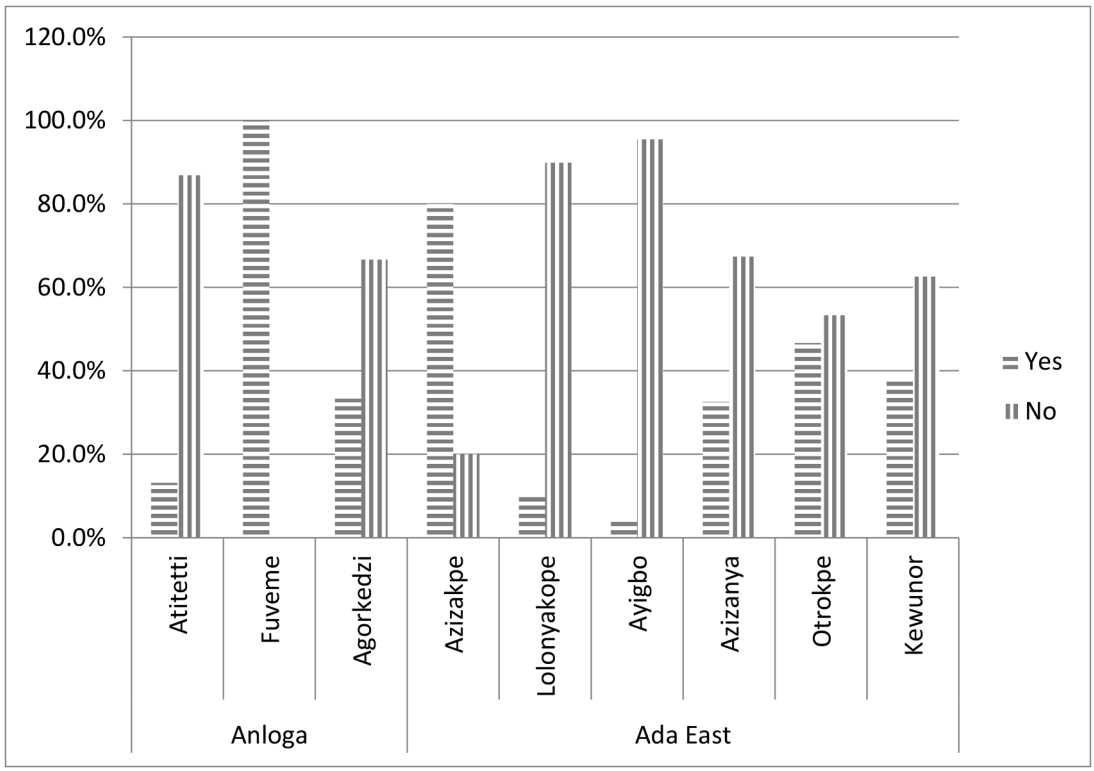

Fig. 11. Number of respondents who have relocated in the past ten (10) years.

"We also do communal labour to dredge waterways for free flow". (Extracted from the Attiteti, Agorkedi and Azizakpe and Kewunor FDGs and interviews with their leaders).

"We are informed whether to go fishing or not depending on the weather signs. Some of the signs include the pattern of tidal waves in the clouds, the size of the moon, and the position of the moon" (Extracted from All FGD's and leaders' interviews).

*"We are able to tell if there will be a disaster through the chirp of some special birds" (*All the communities*)*

Discussions

Knowledge of respondents on climate change-related hazards and their associated risk

Indigenous knowledge is important for effective disaster management [45,46]. Findings in this study indicate that respondents were knowledgeable of their environment. They knew the type of hazards and the associated risk affecting their community. They were also aware of the times and the seasons linked to disaster occurrence. Therefore, from all the data sources, it was observed that participants' level of knowledge of their environment, and risk associated with hazards pertaining in the area, contributed to a reduction in the number of casualties during disaster occurrences in the area. This is affirmed by Asher et al. [27] in their study on flood risk perception and communication where findings indicated that, perceptions influenced the levels of community preparedness and preventive actions towards risk reduction. Their ability to indicate signs associated with possible disaster occurrences both at home and on the high sea confirmed the trends in disaster occurrences from the analysis of the secondary data gathered from the NADMO offices from 2005 to 2020 [3]. Mattah et al. [3] discovered that, in both Anloga and Ada East districts, although the number of disasters associated with hazards such as tidal waves and floods was high, the number of injuries and casualties was relatively lower. The explanation for this phenomenon was that the injuries occurred in the process of salvaging their belongings during disaster events. The casualties are lower because of the adaptation strategy of moving from areas of danger to havens. Resettlement was identified as a strategy to minimize disasters. They waste no time to evacuate the most vulnerable in the community, such as children and the elderly, to relatives' homes and higher ground such as schools and open fields whenever they identify signs of possible disaster occurrence. The emphasis by earlier studies on the integration of indigenous and scientific knowledge for effective disaster risk reduction ([26,47,48, 49,17,13]) becomes relevant and prudent.

The environmental threats or hazards mentioned by respondents included floods from the river, tidal waves, floods from the sea, coastal erosion, and floods from rains. This is confirmed by earlier studies, including Appeaning Addo et al. [50] and Appeaning Addo, et al. [8,51]. The study findings revealed that, while coastal erosion, tidal waves and flooding from the river were the major were the major environmental threats among communities in the Anloga area, flooding from the river was found to be the threat among communities such as Lolonyakope, and Ayigbo in the Ada East districts. These communities have benefited from the sea defence; therefore, tidal waves and coastal erosion were found to be minimal. However, some communities such as Azizakpe Azizanya, and Kewunor communities in Ada East District also suffered multiple effects from floods, tidal waves, and erosion because of their geographical location closer to the mouth of the estuary while Otrokpe suffers from sea erosion because the Sea defence structure is not extended to that community.

Other environmental threats mentioned during the community interviews and FGDs at Ada East included sand winning and plastic waste pollution in the sea. Both community members and leaders at Lolonyakope and Ayigbo were of the view that sand winning at the beaches and plastic waste in the sea were major environmental threats to their communities. This was expected because the sea defence was extended to these communities, thereby reducing the impact from tidal waves, and erosion. It is also reflected in the type of community interventions. At Lolonyakope and Ayigbo, a community task force was instituted to monitor the beaches to reduce the risk of disasters. An earlier study by Jayson-Quashigah et al. [52] confirmed that sand winning was taking place along the coast of Ada and Ningo-Prampram. Similarly, studies have also shown that mismanagement of plastic waste and the rate of accumulation in the aquatic environment is a global problem [53,54] even though the effect might vary from one region to the other. From this study, the fisher folks at Ada East indicated that plastic waste is a threat to their fishing activities because it reduces their fish yields and increases their cost of buying premixed fuel as well as increase the man-hours spent on the sea toiling for fish. They mentioned that, in recent times, their nets catch more plastic waste than fish. whenever they go fishing.

Contrary to what is happening at Ada, participants (especially the fisher folks) at Anloga indicated that seaweed was of a significant concern. The weeds turn to flood their nets and their coast. They stated that it does not only reduce their yields and increase cost of operation, but it also poses a threat because the seaweed attracts and serve as breeding ground for dangerous reptiles. Key areas identified to be affected by disasters from these environmental threats included communities' livelihoods such as fishing, their settlements, education, trading and almost all aspects of their lives. Fishing grounds have been affected by disasters; therefore, fishers would have to travel several kilometres to access deep waters for their fishing activities. They explained that fishing activities are obstructed by debris [31] from broken blocks, tree stumps, and other damaged household items from disaster events. They stated that the destruction of their nets and sometimes outboard motors increases their cost, which corroborated the finding by Vegter et al., [31] on a similar issue. Instead of fish catch, they also indicated their nets rather catch plastics. The destruction of landing beaches from coastal erosion was also mentioned to be a major concern. In a similar study by Gomez et al. [29], the proximity of landing beaches and settlements close to the shoreline [30] were used as indicators for the exposure index for vulnerability assessment. This study revealed that about 77.4 % of the respondents were employed in the fishing industry; therefore, any negative impact on the fishing occupation could be fatal for the area's sustainable development. The many challenges faced by the fishing industry could explain why the income

of many respondents was <500 Ghana cedis per month. The population in the study area is confirmed to be concentrated with school-going pupils (GSS, 2013). Findings from the study indicate that disasters interrupt the educational activities of children of school-going age. The lives of school children were also mentioned to be at risk when they have to travel, especially using a boat, to neighbouring communities to access these facilities. The impact of disasters on their settlements was visible having the whole of the Fuveme community relocated to Agorkadzi a neighbouring community. Other communities severely affected by hazards include Azizakpe and Kewunor due to their geographical location at the mouth of the estuary.

Community understanding and perceived knowledge of disaster risk

Findings from the study revealed that communities' understanding of risk was linked to their livelihoods rather than to mortality rates. This could be justified from the responses provided during the qualitative study and the disaster data gathered from the NADMO offices. Even though the number of recorded disasters was high, the casualty rates were observed to be relatively low. This could be ascribed to communities' knowledge of indigenous early warning systems. They understood the times and seasons during which disasters take place. They also knew the accompanying signs for disaster occurrences which increased their level of preparedness in anticipation of disasters.

Respondents' perceived knowledge of risk indicated that any hazard that could affect their livelihoods, such as their jobs, personal belongings, livestock, working environment and equipment, was considered a potential risk. The study revealed that risk levels are higher than in the past because of the increase in the frequency and intensity of environmental threads leading to disaster occurrences in the area. The respondents indicated that this phenomenon had a ripple effect on their lives because their hard-earned gains, such as buildings and personal effects like electrical gadgets, could be destroyed quickly. This was confirmed with over 30 % and 19 % respectively of the household respondents, indicating that anything that could cause displacement or damage to property was considered a risk. Only 5 % of the respondents linked risk to a threat to human life. The statement accurately reflects the low casualties reported by the NADMO offices. Just 1 % of respondents were unaware of what and when a phenomenon poses a risk. The findings further buttress that respondents were not oblivious to what was happening in their communities.

Furthermore, this could contribute positively to disaster risk reduction by integrating indigenous and scientific knowledge for proper disaster management. Participants' knowledge of their environment would also positively increase DRR through their level of preparedness and response to disaster risk and or disasters. It was evident during the interviews and FGDs sections when participants indicated that they were aware of the risk of living in their current communities. Their inability, however, to relocate was linked to factors such as limited or lack of land, financial constraints, and royalty of belonging. The analytical view of the participants indicated that their communities played a significant role as buffer zones for the safety of many other communities on the eastern coast of the estuary. They further indicated that, if their communities are wiped away by erosion, it affects other communities within the environs, including Keta, the proposed location to house a harbour on the east coast of Ghana as promised by the current government. Therefore, this could truncate governments' intention to expand economic development in the country to generate revenue. Therefore, the study findings call for stakeholder collaboration for effective management of disaster risk [55] due to the complexities in ensuring disaster risk reduction [56].

The study confirms earlier vulnerability studies by Gomez et al. [29], Jackson et al. [30] and Yankson et al. [32] on the category of people perceived to be affected by disasters and risk from climate change-related hazards, including children, women and older people. Participants indicated that disaster risk could affect or terminate children's education if not adequately managed. They explain that children's lives are at risk when disasters occur. Therefore, they absent themselves from school, especially in communities where the educational facilities are not available, or where children must travel by boat or on foot to neighbouring communities. Consequently, this could lead to the continuous vicious cycle of poverty among coastal communities. During this study, it was revealed that women, especially widows without support, were primarily dependent on social capital when disasters occurred. At Kewonor, where social capital was observed to be low, it could further aggravate the risk factor of the vulnerable group, especially the elderly people and widows. This was the contrary at Fuveme where the vulnerable group benefited from social capital from the whole community during and after disaster periods. They explained that the men and youth were always more than willing to assist and restore the vulnerable in the community by packing and erecting shelters for the affected.

Factors such as poverty and lack of social amenities, including hospitals, educational facilities, roads, and many others, predispose residents to risks. The findings confirmed an earlier vulnerability study by Annan et al. [28] that lack of access to the amenities mentioned above-predisposed communities to disasters. Roads for accessibility to and from the communities during disaster events were essential for the evacuation of disaster victims as well as provision of relief items to victims. The delay in those mentioned above could lead to an increase in fatalities. Apart from limited land in affected communities, some respondents indicated their inability to acquire lands elsewhere to relocate despite the high-risk level of their current abodes due to financial constraints. At Azizakpe, there was divided opinion residents' readiness to relocate if the local authorities could acquire land elsewhere. While many would be willing to relocate, others, believed that their livelihoods were attached to the coast, which made it impossible to live elsewhere. The Fuveme community identified poverty as a limiting factor for their overdependence on the fisheries industry, although the job is becoming less attractive because of exposure to hazards. Alternative livelihood, therefore, becomes very important to reduce the risk for coastal communities with high exposure to risk. The study revealed that, in the absence of alternative livelihoods in the communities, they resort to migrating to other places for jobs and safety, as indicated in Appeaning Addo et al. [57] and Codjoe et al. [9].

Conclusions

Based on both the qualitative and quantitative data, five major environmental hazards or threats were identified, namely, (i) floods from the Volta River, (ii) tidal waves, (iii) floods from the sea, (iv) coastal erosion and (v) floods from rains. Knowledge of respondents interviewed on the frequency of occurrences of the environmental hazards indicated twice in a year (32 %), four times in a year (28 %) and three times in a year (19 %). These mainly occurred in April/May and August/September each year. The major causes of the environmental hazards perceived by the local communities were (i) poor construction of the Ada Sea Defence, (ii) nature, (iii) spillage from the Akosombo Dam and (iv) a combination of factors.

Community understanding of disaster risk was as a combination of multiple effects from environmental hazards such as destruction of livelihoods (44 %) and property (19 %), displacement (31 %), and impacts on human life (5 %). At the Anloga District, major indicators which inform community preparedness and response to risk were the rates of erosion with its associated destruction of property and homes, the ceding of space to nature and complete relocation [58,2]. On the same question, participants at Ada East mentioned flooding and collapsing of buildings, and increasing damage to homes and working equipment such as canoes, boats, fishing nets, fishing grounds and landing beaches sand winning (12.4 %).

The major community adaptation mechanism to ensure disaster risk reduction from environmental hazards was relocating to safe havens. The strategy involved the movement of items to higher levels/objects at home to the movement of children to neighbours at safe and higher grounds, movement of the entire family to safe havens such as schools, churches, open spaces with the hope to return when the situation normalizes and finally relocating to neighbouring or far communities or to other towns and cities in stern scenarios.

During disaster occurrences in both districts, the community members identified women, children, and older people as the most vulnerable groups. The major socio-economic factors influencing the vulnerability levels of communities are poverty and limited access to social amenities and infrastructure. With over 77.4 % of all respondents engaged in fishing and fishing-related occupations, there are limited alternative sources of income during disaster events. Mattah et al. [3] indicated that, with income levels for most household heads in the study area peaked between 0 and 499 Ghana Cedis per month and most communities without potable drinking water, electricity, access roads, and educational facilities, there is the need for more work towards disaster risk reduction to ensure the attainment of the Sustainable Development Goals.

The major cultural factors contributing to community vulnerability levels in the study area were identified as the sense of belonging and chieftaincy issues. In Ada East, most communities, except Lolonyakope, were not ready to relocate because they explained that their current place of living was their ancestral home, and their chiefs were of higher status than places proposed for settlements. Fuveme in the Anloga did not have any option because their community had completely submerged under the sea. Based on the conclusions drawn, this paper strongly recommends community engagements by the government and/or other development partners such as NGO's, CSO, international organizations like the World Bank etc. prior to any policy and/or physical interventions. This would allow for the blend of indigenous with the scientific knowledge to improve the implementation process to ensure sustainability and improved livelihoods among affected communities.

Contribution, limitation, and suggestion for further research

The study contributes to the literature on African disaster complexities, not only in terms of the framing of key disaster risk management concepts, but also on understanding the dynamics of disasters within the context of community perceptions, knowledge, and coping mechanisms on perennial climate change-related disasters. The limitation is that it was a case study involving only one estuary — the Volta estuary of Ghana, West

Africa. Although the findings could inform the development and application of policies, strategies and practices to minimize hazards and vulnerabilities in the study area, there are other estuaries in the country and West African sub-region that could have been involved in the study but were not, due to inadequate resources, including funds and time. Involving multiple estuaries would have provided a more comprehensive picture for the generalization of the findings. Therefore, further studies could be carried out to examine the dynamics of the complexities of climate-related disasters within the context of community knowledge and perceptions in Ghana or West Africa, using more disaster-prone estuaries simultaneously, so that the results or findings could be compared, and generalized conclusions drawn.

Funders

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Institutional review board statement

Ethical clearance was sought from the College of Basic and Applied Sciences at the University of Ghana, Legon. ECBAS 058/19–20 was obtained to clear the research to be conducted.

Informed consent statement

Informed consent was acquired from all subjects who participated in the study, following ECBAS's guidelines.

Data availability

The authors do not have permission to share data.

CRediT author statement

Conceptualization, M.M.M &; P.A.D.M methodology, M.M.M. and P.A.D.M.; formal analysis, M.M.M. and P.A.D.M; validation, J.M, F.A, P.A.D.M, A.M and K.A.A; writing—original draft preparation, M.M.M; writing—review and editing, J.M, F.A, P.A.D.M, A.M.M. and KA.A; supervision, A.M.M. and K.A.A. All authors have read and agreed to the published version of the manuscript.

Declaration of competing interest

The authors declare that they have no financial nor personal interest which is competing or influencing the data published in this study.

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Further reading

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