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**Research Article**

# Effectiveness of Flood Mitigation Strategies used by residence in the Tamale Metropolis of the Northern Region, Ghana

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| ARTICLE INFO | ABSTRACT |
|---|---|

This study examine the Effective Flood Mitigation Strategies used by residence in the Tamale Metropolis of the Northern Region, Ghana. The study was conducted in the Tamale Metropolis. The study used a descriptive study design for data collection. Primary data was collected from 400 respondents across flood prone areas in the Tamale Metropolis using a questionnaire and interview guide. Flood prone areas in the Tamale Metropolis were selected purposively, these areas are Kobilimahagu, Jakara-yili, Kukuo, Nalung, Sawaba, Dungu, Dungu-Kukuo, Gbanbaya, Bilpela, Gumbihin South, Gumbihini North, and Lamakara. Furthermore, respondents were selected using a simple random sampling techniques. The data was analysed using Kendall's coefficient of concordance to rank the adaptation strategies used in overcoming the challenges associated with flooding. Also, a five-point Likert scale measurement (Strongly Disagree, Disagree, Moderate, Agree and Strongly Agree) was used to measure the degree of effectiveness of adaptation strategies used by residents of the Tamale Metropolis in reducing flood-related vulnerabilities. The study revealed that utilization of flood barriers and sandbags emerges as the foremost adaptation strategy employed to mitigate the impacts of flooding in the Tamale metropolis. The study concluded that flood barriers and sandbags emerged as the most important adaptation strategies used, providing an important defense against the negative impacts of flooding. The study recommends that Ghana metrological service should improve early warning systems to alert communities of impending floods, allowing residents to take necessary precautions and evacuate to safer areas during the raining season.

**Keywords**: Flood, Adaptation Strategies, Residents, Flood Vulnerability, Tamale Metropolis and Ghana.

## 1.0 Introduction

Throughout history, floods have been recurring natural disasters that pose ongoing challenges for humanity. These floods occur when water overflows onto dry land due to factors such as heavy precipitation, snow thaw, or dam failures (Hrushikesh, Gururaj, & Pathak, 2023). The impact of these events is significant and wide-ranging, resulting in loss of human lives, destruction of critical infrastructure, displacement of communities, and long-lasting economic and environmental consequences (Glago, 2021; Onwuka, Ikekpeazu, & Onuoha, 2015). Floods can take different forms, including river floods, flash floods, coastal floods, and urban floods (Sowmya, John, & Shrivasthava, 2015). Among these, river floods are the most common and typically occur when prolonged periods of heavy rainfall or snowmelt exceed the capacity of the river (Pomeroy, Stewart, & Whitfield, 2016). On the other hand, flash floods occur suddenly and with little warning, often in mountainous regions or places with inadequate drainage systems (Kieu & Van Tran, 2021). Coastal floods are triggered by storm surges or tsunamis, while urban floods result from inadequate drainage systems in urban areas (Natarajan & Radhakrishnan, 2020). The impact of floods is significant worldwide. From 1998 to 2017, floods accounted for approximately 43% of documented natural disasters (Tembata et al., 2020). During that time, floods affected over 2.3 billion people globally, causing over 157,000 deaths (Ganguly & Cahill, 2020). Economic losses from flooding exceeded $662 billion (Kurt, 2023). The frequency and intensity of floods are projected to increase due to climate change. These flood events lead to elevated temperatures, more frequent and intense rainfall, overwhelming existing infrastructure and drainage systems (Hassan, Yassine, & Amin, 2022; Pradhan-Salike & Pokharel, 2017). In Africa, flood vulnerabilities are a significant concern due to its diverse geographical features and climatic conditions (Alfieri et al., 2017). Heavy rainfall is the primary cause of floods in Africa, particularly in regions with inadequate water management systems. Insufficient drainage capacity, rapid urbanization, and limited infrastructure worsen flooding during heavy rainfall (Miller & Hutchins, 2017). Deforestation also contributes to flood vulnerability in Africa. By disrupting ecosystems and reducing vegetation's capacity to absorb water, deforestation increases surface runoff and the risk of flooding (Gunnell et al., 2019). The consequences of floods include loss of life, displacement, infrastructure damage, agricultural losses, and waterborne diseases (Mugambiwa & Makhubele, 2021).

In Ghana, floods are a significant concern, with approximately 38% of recorded disasters between 1991 and 2018 being floods. The Upper East, Upper West, Northern, and Volta regions are particularly prone to flooding (Ntim-Amo et al., 2022). However, other regions of the country also experience flooding during the rainy season. In 2015, Accra, Ghana's capital city, experienced severe flooding due to intense rainfall. This event caused over 150 fatalities and displaced thousands of people. Nationwide, over 1.7 million people were affected by the floods, resulting in about $200 million in infrastructure damage, productivity loss, and emergency response efforts (myjoyonline.com, 2023). Tamale experiences a Sahelian climate characterized by a lengthy dry season and a shorter rainy season, typically occurring from May to September (Chagomoka et al., 2018). Unfortunately, this makes the city prone to flooding during the rainy season. However, the issue of flooding in Tamale is exacerbated by urbanization and population growth. As the city's metropolitan area rapidly expands, the demand for housing and infrastructure increases, leading to the encroachment upon open spaces and natural waterways (Mensah, Gough & Simon, 2018). This unregulated urbanization and population growth put immense pressure on the city's drainage infrastructure, worsening the flooding problem. Inadequate stormwater management results in water pooling on roads, residential areas, and agricultural land during heavy rainfall (Kaur & Gupta, 2022). This not only inconveniences the local population but also causes property damage and agricultural losses.

In the long term, floods have far-reaching consequences, including the displacement of communities, loss of livelihoods, increased poverty levels, and social unrest. Additionally, the destruction of infrastructure, such as roads, bridges, and buildings, hampers economic development and recovery (Islam et al., 2018). Furthermore, flooding carries pollutants and contaminants, posing risks to public health and the environment (Crawford et al., 2022). To address these persistent flooding issues, both local and national governments have implemented various flood adaptation strategies to mitigate the adverse effects on livelihoods. In recent years, the frequency of flooding incidents in the Tamale Metropolis has significantly increased, primarily due to heavy rainfall (Atanga & Tankpa, 2021). These recurring floods have had significant ramifications. The main causes behind these recurring floods include deficiencies in the existing drainage infrastructure, unregulated construction practices, widespread littering, and inadequate solid waste management (Mariango, 2017). These factors collectively impede the natural flow of water, making the Metropolis highly vulnerable to flooding (Rogers et al., 2020). The Tamale Metropolis has seen a significant increase in population due to limited availability of land in the area. This influx of people has led to the emergence of informal settlements with poor living conditions. These settlements lack proper permits and sanitation facilities, making them highly vulnerable to flooding (Korah et al., 2017). Additionally, the demand for housing and commercial properties has led real estate developers to construct buildings in areas prone to water-related hazards, further increasing the Metropolis's susceptibility to floods (Sukanya & Tantia, 2023). Building in flood-prone areas consistently exposes the Metropolis to the risks associated with flooding (Abubakari & Twum, 2019). Consequently, the annual occurrence of floods has resulted in loss of life and extensive damage to both private and commercial assets. These events have significant social, economic, and environmental consequences, affecting the livelihoods and overall well-being of the local population. Despite the high likelihood of flooding in the Tamale Metropolis, there is a lack of comprehensive studies exploring the extent of flood vulnerability and evaluating the effectiveness of adaptation strategies in the Tamale Metropolis of the Northern Region, Ghana.

## 2.0 Methodology

The study was conducted in the Tamale Metropolis. The Tamale Metropolitan was formalized through the enactment of a legislative instrument (L.I. 2068). Tamale serves as both the Metropolitan Capital and the Regional capital of the Northern Region. The Tamale Metropolis is classified as one of the 16 Metropolitan, Municipal, and District Assemblies (MMDAs) within the Northern Region. The Metropolis is situated in the middle region of the Region. The Metropolis is situated within the geographical coordinates of latitude $9^{o}16$ and $9^{o}34$ North, and longitudes $0^{o}36$ and $0^{o}57$ West (GSS, 2022). The study used a descriptive study design

for data collection. Primary data was collected from 400 respondents across flood prone areas in the Tamale Metropolis using a questionnaire and interview guide. Flood prone areas in the Tamale Metropolis were selected purposively, these areas are Kobilimahagu, Jakara-yili, Kukuo, Nalung, Sawaba, Dungu, Dungu-Kukuo, Gbanbaya, Bilpela, Gumbihin South, Gumbihini North, and Lamakara. Furthermore, respondents were selected using a simple random sampling techniques. All strategies employed by individuals affected by floods to overcome the challenges associated with such events are referred to as adaptation strategies. A compilation of adaptation strategies was obtained from relevant literature and presented to respondents for the purpose of ranking them in terms of severity. The level of agreement among the ranked scores assigned to the different adaptation strategies by the respondents was evaluated using Kendall's coefficient of concordance. According to Legendre (2005), Kendall's coefficient of concordance (W) serves as a measure of agreement among multiple judges (p) who are assessing a given set of objects (n).
W is an index that quantifies the ratio of the observed variance of the sum of ranks to the maximum possible variance of the ranks. The underlying idea is to determine the sum of ranks for each adaptation strategy being ranked. In the event of perfect agreement in the ranking, the variability among these sums is at its maximum (Mattson, 1986). Thus, the Kendall's concordance coefficient (W) is expressed by the following equation:

$$W = 12S/p2\ (n3- n) – pT \qquad (1)$$

Where W denotes Kendall's Concordance Coefficient, p denotes the number of adaptation strategies, n denotes the number of respondents (sample size), T denotes correlation factor for tied ranks and s denotes the sum of square statistics. The sum of a square statistic (S) is given as:

$$S = \sum (Ri – R)\ 2 \qquad (2)$$

Where: Ri = rows sums of ranks
R = the mean of Ri
The correlation factor for tied ranks (T) is also given as:

$$T = \sum (tk3- tk) \qquad (3)$$

Where: tk = the number of ranks in each (k) of m groups of ties.

$$X2 = p\ (n - 1)\ W \qquad (4)$$

p = number of adaptation strategies
W = Kendall's coefficients of concordance
However, analysis of the effectiveness of existing adaptation strategies used by residents of the Tamale Metropolis in reducing flood-related vulnerabilities was achieved using descriptive statistics, particularly frequency, percentage and means. Furthermore, a five-point Likert scale measurement (Strongly Disagree, Disagree, Moderate, Agree and Strongly Agree) was used to measure the degree of effectiveness of adaptation strategies used by residents of the Tamale Metropolis in reducing flood-related vulnerabilities. However, various adaptation strategies statements such as "The adaptation strategies have significantly reduced flood damage", "Residents feel safer due to the adaptation strategies", "Adaptation strategies have improved community preparedness for flooding" and "Residents believe that the strategies are sustainable". This enabled each respondent to rate their agreement with the statements on a scale of 1 to 5, with 1 indicating strong disagreement and 5 indicating strong agreement.

## 3.0 Results and Discussion

### 3.1 Effective Flood Mitigation Strategies used by residence in the Tamale Metropolis

This objective explores examine the effective flood mitigation strategies used by residence in the Tamale Metropolis.

#### 3.1.1 Flood Mitigation Strategies used by residence in the Tamale Metropolis

This section presents flood mitigation strategies employed by residents in the Tamale Metropolis. The results of Kendall's coefficients of concordance indicate a highly significant agreement among respondents' rank scores regarding the adaptation strategies used to mitigate the adverse effects of flooding within the metropolis. As presented in Table 4.8, the Chi-Square (df = 9) = 1060.809 and asymptotic Significance = 0.000, thereby signifying significant agreement among respondents' rank scores at a 1% level of significance. Moreover, Kendall's coefficient of concordance (W) = 0.795, suggesting that 79.5% of the ranked scores assigned by respondents are in agreement.
Based on the findings in Table 4.8, the utilization of flood barriers and sandbags emerges as the foremost adaptation strategy employed to mitigate the impacts of flooding in the Tamale metropolis. This strategy entails the deployment of physical barriers, such as sandbags and flood barriers, to prevent or minimize the repercussions of flooding. These measures play a crucial role in safeguarding properties and infrastructure against inundation during periods of heavy rainfall or rising water levels. During the qualitative interviews, it was discovered that flood barriers and sandbags are the primary adaptation strategy used in the Tamale metropolis to combat the effects of flooding. Participants highlighted the practicality and localized nature of this approach, describing it as a hands-on response to reduce the destructive impact of floods. The use of these physical barriers was consistently viewed as a proactive measure, reflecting the community's commitment to enhancing resilience against inundation. This adaptation strategy, as expressed by interviewees, stresses on

the collective effort to protect infrastructure and residents, aligning with the broader goal of effectively managing and minimizing the adverse effects of seasonal floods in Tamale.

The annual flooding experiences in the Tamale metropolis in its flood-prone zones, are caused by both natural and artificial, with climate change contributing to the rise in average temperatures and increased rainfall over the last twenty-seven years. Additionally, poor land use, unplanned development of settlements, and indiscriminate disposal of refuse into and on the banks of the river are identified as man-made causes of flooding in the metropolis. In light of these challenges, the deployment of flood barriers and sandbags serves as a critical adaptation strategy to mitigate the impact of flooding in the Tamale metropolis. These physical barriers help protect life and property, prevent inundation, and reduce the socioeconomic impacts of floods in flood-prone zones. Furthermore, the use of sandbags as flood barriers is a cost-effective and practical solution for protecting various areas from flooding. Sandbags are useful for blocking the outer crevices of homes and containing rainfall in low-elevation terrain (Atufu & Holt, 2018), making them a valuable tool for flood protection.

Moreover, the implementation of early warning systems is the second most commonly employed adaptation strategy for mitigating the adverse effects of flooding. Early warning systems play a pivotal role in mitigating flood-related vulnerabilities by promptly disseminating information regarding imminent floods. This enables early evacuation and preparedness, thereby minimizing the loss of life and property damage. In the context of the Tamale metropolis, early warning systems furnish critical information to residents and authorities, enabling timely evacuation and preparedness in the face of impending floods. This significantly diminishes the impact of flooding on communities and infrastructure. Additionally, the utilization of early warning systems is imperative for bolstering disaster risk reduction and enhancing community resilience to flooding. These systems empower communities by raising awareness of flood risks and facilitating the adoption of fundamental strategies to alleviate the impact of flooding.

The third adaptation strategy employed in mitigating the effects of flooding is developing community evacuation plans. Thus community evacuation plans are ranked third. These plans involve establishing procedures for safely evacuating residents from flood-prone areas to designated shelters or safe locations. Effective community evacuation plans are essential for ensuring the safety of residents during flood events. In the Tamale Metropolis, residence in flood-prone areas usually move to higher grounds or even temporarily relocate to stay with their love once till the raining season is over, before they return to their homes (Kuusaana & Eledi, 2015).

In addition, building elevated structures is the fourth-ranked adaptation strategy employed in mitigating the effects of flooding. Elevating structures such as homes, public buildings, and infrastructure above potential flood levels significantly reduce their vulnerability to flooding. This adaptation strategy helps minimize damage to properties and ensures that essential services remain operational during flood events. As a result, residence in flood-prone areas raise their building foundation above sea level as a strategy of preventing runoff water into their homes.

Additionally, the use of flood insurance coverage is ranked the fifth ranked adaptation strategy employed in mitigating the effects of flooding. Flood insurance is a critical adaptation strategy as it provides financial protection to individuals and communities affected by flooding. Flood insurance is considered a mitigation technique because it doesn't reduce damage but compensates the affected individuals or societies for their losses (Mishra & Sinha, 2020). It helps cover the costs of repairing or rebuilding structures damaged by floods, thereby reducing the economic burden on affected households and businesses. Generally, it is businesses in flood-prone areas that tend to use flood insurance more than individuals. This is because businesses often have more assets and property to protect, making them more vulnerable to the financial impacts of flood damage.

Implementing sustainable landscaping is ranked sixth adaptation strategy employed in mitigating the effects of flooding. Sustainable landscaping is a strategy that involves using techniques to promote natural water absorption and drainage, thereby reducing surface runoff and the risk of localized flooding (Collentine & Futter, 2018). This approach also enhances the resilience of flood-prone areas within the Tamale metropolis to extreme weather events. Households with rain gardens are less likely to be greatly affected by flooding as compared to houses with concrete floors. Additionally, specific landscaping designs, such as laying mulch, choosing native plants with high water tolerance, and building rain gardens, help prevent flood damage (Sharath & Peter, 2019).

Supporting local flood control measures is ranked the seventh adaptation strategy employed in mitigating the effects of flooding. This includes advocating for and investing in infrastructure projects aimed at controlling flooding at the local level, such as an expansion of drainage systems within the flood-prone areas. According to the Norizan, Hassan and Yusoff (2021), local flood control measures are essential for reducing the impact of floods and building more resilient communities. NADMO over the years has developed programs geared towards mitigating future losses from floods and other natural disasters.

While the use of emergency supplies is ranked as the least adaptation strategy employed in mitigating the effects of flooding, it is still a crucial aspect of flood preparedness. In the event of a flood, emergency supplies such as food, water, and medical supplies are necessary to sustain individuals and communities during and after the flood event. Philpott and Casavant (2016), recommend having emergency supplies such as sandbags, shovels, and sump pumps assist individuals in overcoming the challenges of flooding.

**Table 4.8: Adaptation strategies in reducing flood-related vulnerabilities**

| Types of adaptation strategies used | Mean Rank | Ranking |
|---|---|---|
| Obtaining flood insurance coverage | 5.84 | 5th |
| Using flood barriers and sandbags | 2.09 | 1st |
| Utilizing early warning systems | 3.81 | 2nd |
| Developing community evacuation plans | 4.26 | 3rd |
| Building elevated structures | 5.31 | 4th |
| Implementing sustainable landscaping | 6.19 | 6th |
| Managing stormwater effectively | 6.83 | 8th |
| Stocking emergency supplies | 7.00 | 10th |
| Participating in community flood preparedness programs | 6.89 | 9th |
| Supporting local flood control measures | 6.80 | 7th |
| **N** | 400 | |
| **Kendall's W** | 0.795 | |
| **Chi-Square** | 1060.809 | |
| **df** | 9 | |
| **Asymp. Sig.** | .000 | |

**Source**: Field Data (2023)

### 3.1.2 Effectiveness of existing adaptation strategies used by residents of the Tamale Metropolis in reducing flood-related vulnerabilities

This section present the perceived effectiveness of the adaptation strategies used by residents of the Tamale Metropolis in reducing flood-related vulnerabilities. The strategies include community outreach and engagement efforts, community investment in flood insurance and financial assistance programs, investment in improved drainage systems, education on flood risks and adaptation measures, and zoning regulation and land-use planning.

From the result in Table 4.9, it was evident that 18% of respondents strongly agreed and 71% agreed that community outreach and engagement efforts improved community flooding resilience. This indicates a high level of perceived effectiveness in reducing flood-related vulnerabilities through community involvement and awareness. Also, 70.3% of respondents strongly agreed and 29.8% agreed that community investment in flood insurance and financial assistance programs helped residents recover from flooding events. This implies that financial measures are considered effective in mitigating the impact of floods on affected individuals. Also, the results indicate that a significant majority of respondents, 70.3% strongly agreed and 29.8% agreed, that community investment in flood insurance and financial assistance programs played a crucial role in helping residents recover from flooding events. Investments in infrastructure, early warning systems, and community-based disaster risk reduction strategies are commonly cited as essential components for effective flood management (Perera et al., 2020).

Furthermore, in terms of investment in improved drainage systems, 41.8% of respondents strongly agreed, while 52.5% agreed that it has effectively reduced the risk of flooding occurrence. This indicates a relatively high level of perceived effectiveness in addressing flood vulnerabilities through infrastructure improvements. In addition, in terms of investment in improved drainage systems, 41.8% of respondents strongly agreed, while 52.5% agreed that it has effectively reduced the risk of flooding occurrence. The high percentage of agreement among respondents regarding the effectiveness of improved drainage systems in reducing the risk of flooding occurrence underscores the importance and impact of such infrastructure investments. This sentiment is supported by a study on the positive outcomes associated with well-designed and maintained drainage systems (McClymont et al., 2020).

A study by Davis and Naumann (2017), claimed that effective drainage systems can significantly reduce the likelihood and severity of flooding events, thereby safeguarding communities, infrastructure, and natural environments from the detrimental effects of excessive water accumulation. By facilitating the efficient conveyance and management of storm-water, these systems contribute to overall resilience against flood-related hazards.

While, on measures regarding education on flood risks and adaptation measures, 37% strongly agreed, 41.5% agreed, and 13.5% were not sure about its effectiveness in reducing the risk of flooding occurrence. The study results indicate that a significant portion of the population recognizes the importance of education on flood risks and adaptation measures. With 37% strongly agreeing and 41.5% agreeing, it is evident that a majority of respondents acknowledge the effectiveness of such educational initiatives in reducing the risk of flooding occurrence. However, it is also notable that 13.5% were not sure about its effectiveness, indicating a need for further clarification and information dissemination.

In addition, the result revealed that zoning regulation and land-use planning were perceived as effective by 40% who strongly agreed, 43.8% who agreed, and 8.5% who were not sure about its effectiveness in reducing the risk of flooding occurrence. Zoning regulation and land-use planning play a critical role in managing flood risk and mitigating the impact of flooding events. The perception of their effectiveness in reducing the risk of flooding occurrence is an important aspect to consider. However, 40% strongly agreed, 43.8% agreed, and 8.5% were not sure about the effectiveness of zoning regulation and land-use planning in reducing the risk of flooding occurrence. This perception of the effectiveness of zoning regulation and land-use planning in reducing the risk of flooding occurrence is an important factor in understanding public opinion and stakeholder views on these measures. This result implies a significant level of agreement on their effectiveness, with a minority expressing uncertainty.

Finally, the construction of flood barriers and levees is also perceived as an effective strategy in reducing the risk of flooding occurrence, although with a slightly lower overall agreement compared to early warning systems and flood forecasting. The positive perception regarding the effectiveness of flood barriers and levees suggests that these physical infrastructure measures have contributed to mitigating flood-related vulnerabilities in the Tamale metropolis. By providing a physical barrier against rising water levels, flood barriers and levees protect communities, infrastructure, and agricultural land from inundation during periods of heavy rainfall or river overflow (Wenger, 2015).

**Table 4.9: Perceived effectiveness of adaptation strategies in reducing flood-related vulnerabilities**

| Types of adaptation strategies used | Perceived effectiveness level of adaptation strategies *f (%)* | | | | |
|---|---|---|---|---|---|
| | **SA** | **A** | **NS** | **D** | **SD** |
| Community outreach and engagement efforts improved community flooding resilience | 72 (18.0) | 284 (71.0) | 44 (11.0) | 0 (0.0) | 0 (0.0) |
| Community investment in flood insurance and financial assistance programme helped residents recover from flooding event | 281 (70.3) | 119 (29.8) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| Investment in improved drainage system has effectively reduced the risk of flooding occurrence | 167 (41.8) | 210 (52.5) | 23 (5.8) | 0 (0.0) | 0 (0.0) |
| Education on flood risks and adaptation measures has effectively reduced the risk of flooding occurrence | 148 (37.0) | 166 (41.5) | 32 (8.0) | 54 (13.5) | 0 (0.0) |
| Zoning regulation and land-use planning has effectively reduced the risk of flooding occurrence | 160 (40.0) | 175 (43.8) | 34(8.5) | 17(4.3) | 14 (3.5) |
| Early warning systems and flood forecasting has effectively reduced the risk of flooding occurrence | 153(38.3) | 204 (51.0) | 23(5.8) | 16(4.0) | 4 (1.0) |
| Construction of flood barriers and levees has effectively reduced the risk of flooding occurrence | 128(32.0) | 170(42.5) | 19(4.8) | 46 (11.5) | 37(9.3) |

**Source**: Field Data (2023) Note: {SA= Strongly Agreed, A= Agreed, NS= Not Sure, D= Disagreed and SD = Strongly Disagreed}

## 4.0 Conclusion and Recommendation

In assessing the adaptation strategies used in mitigating the recurring challenge of annual flooding in the Tamale metropolis. The study concluded that flood barriers and sandbags emerged as the most important adaptation strategies used, providing an important defense against the negative impacts of flooding. The study further concluded that early warning systems, community evacuation plans, elevated structures, flood insurance coverage and sustainable landscaping are all used in mitigating the recurring challenge of annual flooding. Also, it was evident that emergency supplies were ranked least used adaptation strategies. However, its inclusion remains indispensable for effective flood preparedness in the study area. The study further concluded that community outreach and engagement efforts, community investment in flood insurance and financial assistance programs, and investment in improved drainage systems were perceived as effective in reducing flood-related vulnerabilities. Education on flood risks and adaptation measures and zoning regulation and land-use planning were also perceived as effective, although with some uncertainty. Flood barriers and levees were identified as an effective strategy in reducing the risk of flooding occurrence. The study recommends that Ghana metrological service should improve early warning systems to alert communities of impending floods, allowing residents to take necessary precautions and evacuate to safer areas during the raining season. Furthermore, the Tamale Metropolitan Assembly should implement a comprehensive flood risk management policy that prioritizes the use of flood barriers and sandbags as primary adaptation strategies in flood-prone areas of the Tamale metropolis. The implementation of such a policy would significantly contribute to improving community resilience and reducing the negative impacts of flooding in the areas during flooding events.

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**Code availability:** Not applicable

## Declarations

### Ethics approval and consent to participate

All human and/or animal subjects involved in this study were treated in strict adherence to ethical principles and regulations established by the University for Development Studies, Tamale, Ghana. Data collection from participants was carried out with their informed consent, and subsequent analysis adhered to standardized methodologies developed by the Graduate School of the University for Development Studies, Tamale, Ghana. Participants were thoroughly briefed on the purpose and usage of their data, providing explicit consent for its publication. Moreover, the data collection process received approval from the Department of Environment and Sustainability Sciences at the University for Development Studies, Tamale, Ghana.

### Competing interest

The authors declared that they have no competing interests.

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