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# Flood Disaster Risk Perception and Urban Households' Flood Disaster Preparedness: The Case of Accra Metropolis in Ghana

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**Abstract:** Flood disaster has gained global attention due to the huge impact it has on human lives, economies, and sustainable environments. Flood disaster preparedness, which can significantly be influenced by disaster risk perception, has been highlighted as an effective way to manage flood disaster risk, as many other means have proved futile, yet no study has attempted using multiple dimensions to analyze this relationship in Ghana. Therefore, this study, using a survey of 369 households in the most flood-prone region, Accra Metropolis, analyzed the influence of flood disaster risk perception on urban households' flood disaster preparedness. Based on the Protective Action Decision Model, the empirical models were constructed and estimated using the Tobit and binary logistic regression models. The results show that the majority of households (60.16%) were unprepared for flood disasters, and the perception of flood disaster risk and the sustainability risk posed by floods significantly affect flood disaster preparedness behaviours of households in a positive direction. The total number of flood disaster preparedness behaviours adopted was significantly related to probability, the threat to lives, sense of worry, and sustainability risk perceptions. Finally, income, education, and house ownership, among other household and individual characteristics, had significant positive effects on preparations for flood disasters. These findings suggest that effective policies to mitigate flood disasters must incorporate risk communication to boost households' flood disaster preparedness.

**Keywords:** disaster preparedness; flood risk perception; natural disaster; flood; sustainability; flood disaster management

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## 1. Introduction

Mitigating natural disaster risks is a major policy concern across the globe, particularly in developing nations suffering from the economic and human losses caused by natural disasters due to their vulnerability [1]. Developing nations' increased susceptibility to natural disasters is caused by residing in high disaster risk areas with poor housing, inadequate disaster warning systems, and poor infrastructure [2]. The world experienced an estimated US$ 150 billion loss and 9000 deaths in the year 2019 inflicted by 820 natural disaster occurrences [3]. The first half of the 2020 catastrophe year according to data also shows US$ 68 billion total losses and 2900 fatalities from natural disasters [4]. Global warming and climate variability have a negative influence on natural systems, with rapid consequences and several potential catastrophic occurrences [5]. Although particular disastrous occurrences cannot be straightforwardly linked to climate change [6], this is making it easier for natural catastrophes to occur by increasing the frequency and intensity of natural disasters [7].

Natural meteorological, hydrological, climatological, and geophysical phenomena cause severe negative incidents like earthquakes, landslides, hurricanes, wildfires, droughts, and sea-level rises. The Center for Disaster Epidemiology Research (CRED)'s statistical report for annual disasters highlighted floods as the deadliest natural disaster in the year 2019 [8]. The report further emphasizes the dominance of floods globally, accounting for almost half of the total natural disasters in the CRED database. Lokonon [9] explained that the causes of prevalent flood disasters are attributable to intense rainfalls triggering overflowing of streams, lagoons, and rivers. The research also indicated that impacts of flood disasters are escalated by settlements on floodplains and flood-prone zones making residents in these areas more susceptible to flood disaster risk.

Accounting for 517 fatalities, $615,192,000 total estimated damages, and affecting 5,016,292 lives from the year 1900 to the first half of 2021, flooding ranks as the most prevalent among natural disasters in Ghana and falls behind only epidemics in fatalities caused, as shown by Figure 1 [10]. The majority of flood disasters in Ghana and the biggest toll on properties and lives is recorded in Accra, the most urbanized metropolis which doubles as both the capital city and major economic center [11]. Twerefou et al. [12] showed that over 90% of areas prone to flood disaster in the region are unplanned and informal settlements characterized by low socio-economic conditions and physically deficient structures. Flooding has been a major hindrance to sustainable development in the country as governments and individuals bear so many losses inflicted by flood disasters. Thus, if the country is to improve sustainable development, flood disaster mitigation is a necessary tool for the implementation of effective policies. 3 June 2015 has been marked as one of the darkest days in the country's history with the experience of a fatal flood disaster with over 150 lives lost and massive economic and environmental costs. Since this experience, a huge focus has been shifted to providing effective solutions, but there have yet not been much significant improvements in flood disaster management. Hence more pragmatic strategies need to be put in place and empirical research like this study is very necessary in this regard to effectively mitigate flood disasters and the economic, psychological, physical, and social effects related to them. From 1980 to 2020, daily rainfall exceeding 20 mm (heavy rain) in Accra Metropolis has shown a rising trend, indicating a significant likelihood of future flood threats [12]. Such a troubling projection forewarns authorities and households of the substantial flood disaster risk (FDR) they are bound to face in the future and the need to adopt flood disaster preparedness (FDP) behaviours for effective flood disaster management (FDM). This research thus seeks to provide effective strategies by analyzing FDR perception and urban households' adoption of FDP behaviours.

Many empirical studies have been conducted on disasters and the consequences faced by households, and the various modes with which people respond to disasters, such as disaster preparations, relocation, and evacuations, etc. [12–21]. Using binary logistic regression, Cannon et al. [22] revealed that the likelihood of having flood insurance is associated with past flood damage and socioeconomic status. Osberghaus [23] employed a probit regression model to analyze the determinants of flood mitigation by private individuals and found that the likelihood of mitigating flood damage increases with past damage experience and damage expectations for the future. Among the response of households, disaster preparedness has been found to be an effective strategy to reduce the effects of disasters, as findings from significant studies [24–26] have shown. Therefore, enhancing FDP in flood-prone zones is vital to solving the issue of flood disasters in Ghana. Improvement in FDP behaviour also reduces economic costs, and Han et al. [24] and Godschalk et al. [27] found in their studies that investing in disaster preparations and mitigation could cut economic losses. Hence, adopting FDP behaviours is vital to achieve a sustainable environment. In this respect, many disaster studies have focused on factors influencing a household's disaster preparedness. An example is the study by Xu et al. [17] whose research using both tobit and logistic regression found that disaster risk perception positively influences disaster preparedness. Despite the efforts to understand the factors underlying disaster preparedness, studies have confirmed that households' level of preparedness for flood disasters has not seen a significant improvement [28–30]. Thus, there is an urgent need for further research to examine other important factors that have not been critically studied regarding flood disasters and the adoption of FDP behaviours to promote the resilience of households to flood disasters.

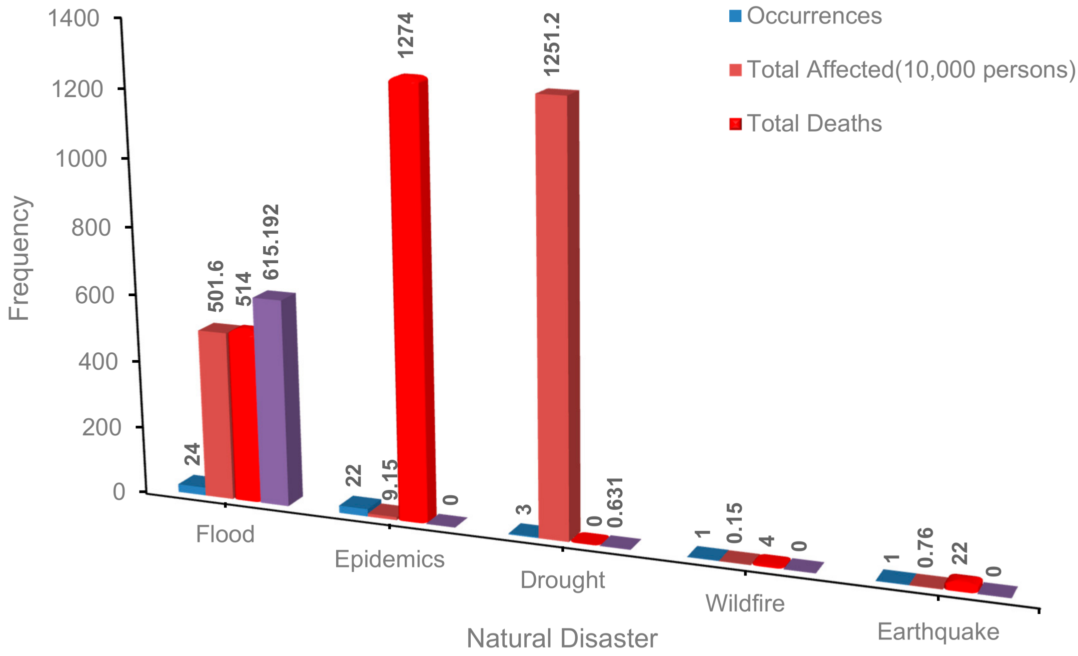


**Figure 1.** Natural disasters in Ghana by frequency and impacts (1900–2020).

Despite understanding the factors influencing FDP, little empirical research has been conducted on this issue in developing nations, and in the case of Ghana very little is known. Furthermore, the country has been left out of the significant attention researchers across the globe have paid to flood risk perception and the role it plays in FDM, with the existing studies highly focused on the causes, nature, and effects of flood disasters [11,31–38]. Other studies have also paid attention to the roles of institutions and stakeholders in communities in making effective decisions and strategic plans [31,39]. Flood disaster risk perception is an important factor in FDM, as researchers have identified it as an essential element in flood risk disaster awareness and response [40–42]. Pidgeon [43] and Botzen et al. [44] reiterated that flood disaster risk perception has practical significance in implementing effective FDM policies because the way households behave towards flood disaster is influenced by their risk perception attitude [15].

The Accra metropolis has been highlighted as a major flood-prone region and the gap in flood disaster studies considering disaster risk perception necessitated the current study analyzing flood disaster risk perception and urban households' flood disaster preparedness. This research is novel in Ghana and many other developing countries, first because it considers five dimensions of risk perception (probability, severity, worry, threat, and controllability) and also critically measures five distinct FDP behaviours. The study further controls for the adoption of at least one of the FDP behaviours and the total number of FDP behaviours adopted to understand the complex dimensions of preparedness and how each of these is influenced by flood disaster risk perception and other factors to control for household and individual characteristics. This study also adopts more than one econometric regression method (Logistic and Tobit) to produce consistent and robust estimates, and will contribute significantly to the literature on FDM and provide pragmatic steps towards effective flood disaster policies. The study aims to:

1. Examine households' FDP level in the Accra metropolis.
2. Examine the influence of flood disaster risk perception of households on the adoption of FDP behaviour.

3. Examine the influence of perception of floods impact on the sustainable environment on the adoption of FDP behaviour.

## 2. Materials and Methods

### 2.1. Study Area

Accra, the most urban city and the capital of Ghana, has grown from a population of 190,000 when the country gained independence in 1957 [45] to 5,055,883 in the region as of 2020 according to the Ghana statistical service [46]. The city, with eleven sub-metropolises, is a low-lying area between latitude 00°06′ W and longitude 05°35′ N with the highest elevation 200 feet above sea level and an area of 181 $km^2$. The region's terrain ranges from flat to gently sloping up to 246 feet in the foothills, with some isolated hills and rock outcrops. The area has two rainy seasons and is located in the dry coastal equatorial climate zone. The first season runs from March to July, followed by the second season, which runs from September to November [47]. The average yearly rainfall is 810 mm. Short storms generally provide plentiful rain, resulting in annual local floods especially in areas where drainage systems are lacking or blocked [48]. The yearly average temperature in the area is 26.8 degrees Celsius, with monthly temperatures ranging from 24.7 degrees Celsius in August to 33 degrees Celsius in March [49]. The drainage density estimates are very high, ranging from 149 to 1117 $m/m^2$, indicating strong runoff converging regions. The region has a high drainage density of 1117–1702 $m/m^2$, indicating a high runoff convergence spot. In the city, water flows from elevated areas to low-lying areas, increasing surface runoff [50]. Similar to many Sub-Saharan African cities, Accra continues to experience a substantial amount of unplanned urbanization, with the population growing at a significant rate yearly and with growth in informal settlements, slums, and squatters. Karley [51] explained further that the informal urbanization growth rate and increased unplanned settlements in dangerous wetlands and flood plains expose the city and the populace to perpetual flood disaster threats. Several researchers have discussed the current vulnerability and future risks the city faces from the river and coastal floods [11,12,31–36,38,39,51]. Nyarko [52] used hydrological models and geographic information systems in his study on floods and concluded that the city's spatial coverage is composed of 6.1% very high-risk zones, 35.7% high-risk zones, and 41.8% zones exposed to flood danger. Much havoc has been wreaked by floods in the city over the last decade with more than 300,000 people affected, over 100,000 livelihoods ruined and 600 fatalities [11,38]. A devastating flood and explosion at a gas station in Kwame Nkrumah Circle, a significant landmark in the city, killed over 150 people and injured over 60 more on 3 June 2015 [53,54]. Floods in Accra are anticipated to become more frequent and intense as a result of climate change's predicted impact on extreme precipitation and sea-level rise [55,56]. Ahadzie [57] reported that the city of Accra, including the communities chosen for this study, does have a general absence of evacuation plans and well-structured risk awareness according to their findings, which revealed that 7.98% of attempts were made toward educating households, particularly in terms of safety awareness and evacuation plans. He further explained that residents were instructed on particular areas to assemble, and what to do with critical documents and valuables such as certificates and personal files, in one such news release from the NADMO, and emergency phone numbers were given as parents were also urged to teach their children about flood safety precautions. Thus, choosing Accra for this study on flood disaster and urban households' adoption of FDP behaviour is ideal to correctly represent the population of flood-prone areas in Ghana and produce results that can be effective in other regions blighted by flood disasters globally. Figure 2 below shows pictures of some flood occurrences in Ghana designed by the authors with reference guide from the study by Songsore [58].

**Figure 2.** Pictures of flood occurrence in Accra.

*2.2. Data*

A structured questionnaire was designed and administered through a face-to-face survey from February to March 2021. Questionnaires were administered by economics graduates who had been trained in data collection and had in-depth knowledge of disaster risks and management. The research survey focused mainly on flood disaster risk perception, sustainability risks from floods, FDP, evacuation willingness of households, and other household and individual characteristics. Secondary data was sourced from the Emergency Events Database (EM-DAT) of the Centre for Research on the Epidemiology of Disasters (CRED) to explore the trend, cost, and intensity of flood occurrences in Ghana and the region of study, in order to make an informed choice in the sample selection. The study presents a flood risk map of Accra constructed by the authors using the flood risk map from the Centre for Remote Sensing and GIS (CERSGIS) [59] as reference, in order to clearly buttress the choice of the study area selected by this study, which is more prone to floods as shown in Figure 3.

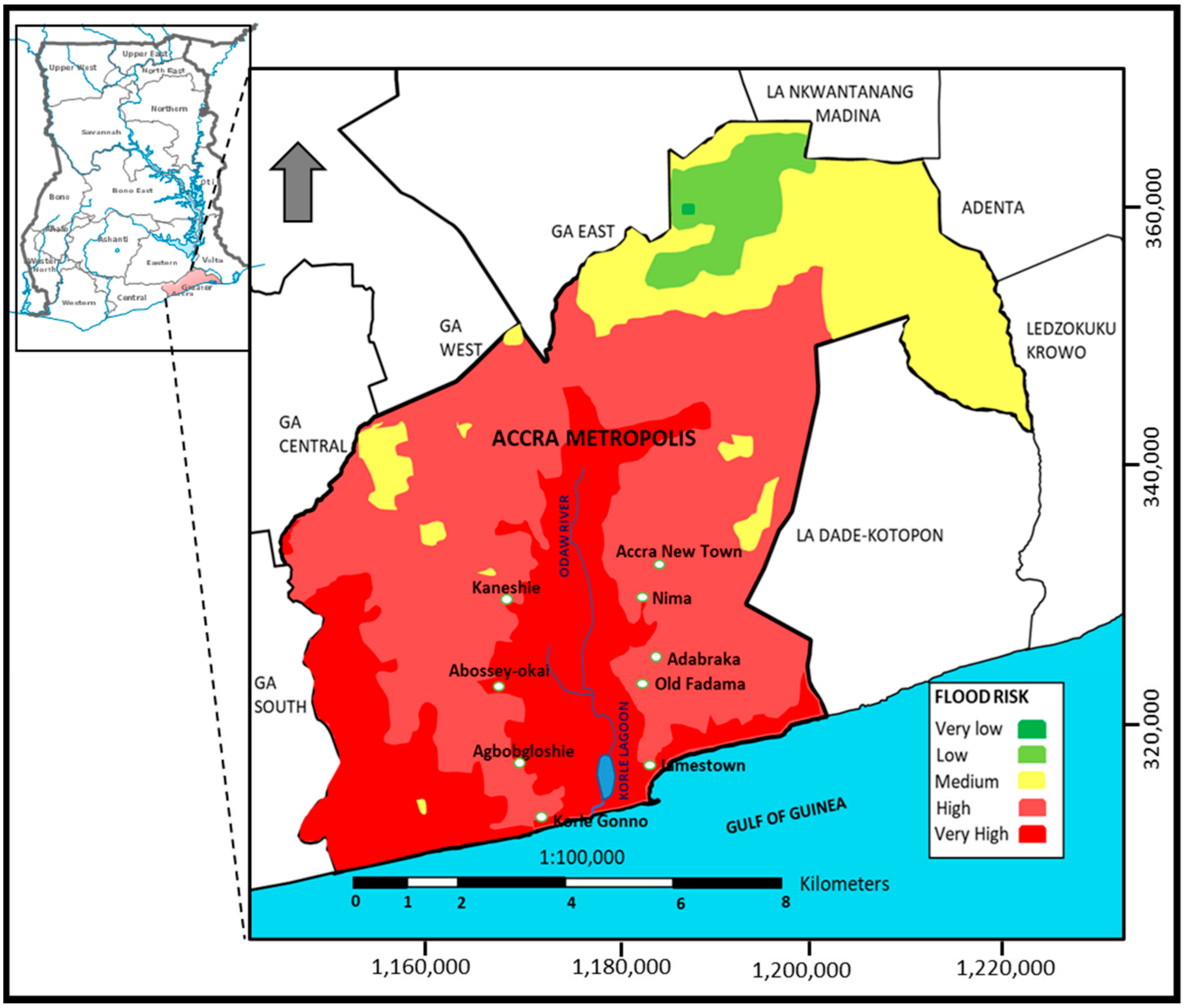


**Figure 3.** Flood risk map of Accra Metropolis indicating selected areas.

The study adopted the multi-stage sampling method. The information about flood-prone zones obtained from the EM-DAT was used to purposively select communities with major flood disaster occurrences and prone to floods. Secondary information gathered from the National Disaster Management of Ghana (NADMO) was then used to select nine (9) communities flagged as red zones for flood disaster management in Accra. These communities represent a true sample for the purpose of this study because they are exposed to perennial floods and have intensively engaged government institutions for more than twenty years (20) regarding flood disasters and the need for a working plan to mitigate floods. These communities are also within the Odaw river catchment area which is the most polluted river in Ghana and is recognized as among the most highly polluted and flood-prone rivers. The selected communities as shown in Figure 4 included Accra Newtown, Kaneshie, Jamestown, Korle Gonno, Agbobgloshie, Nima, Adabraka, Abossey-Okai, and Old Fadama. Simple random sampling was used at the second stage of sampling to select 42 households each from the nine communities. After interviewing the household heads of all 378 respondents, 369 household questionnaires were collected, as some households opted not to respond while others failed to provide all answers needed for the study. Hence, a valid total number of 369 questionnaires obtained made up the sample size for this study. Compared to numerous empirical studies on natural disasters [9,14,15,17,60–63], the sample of 369 is of an adequate size which can truly produce accurate results to represent the population.

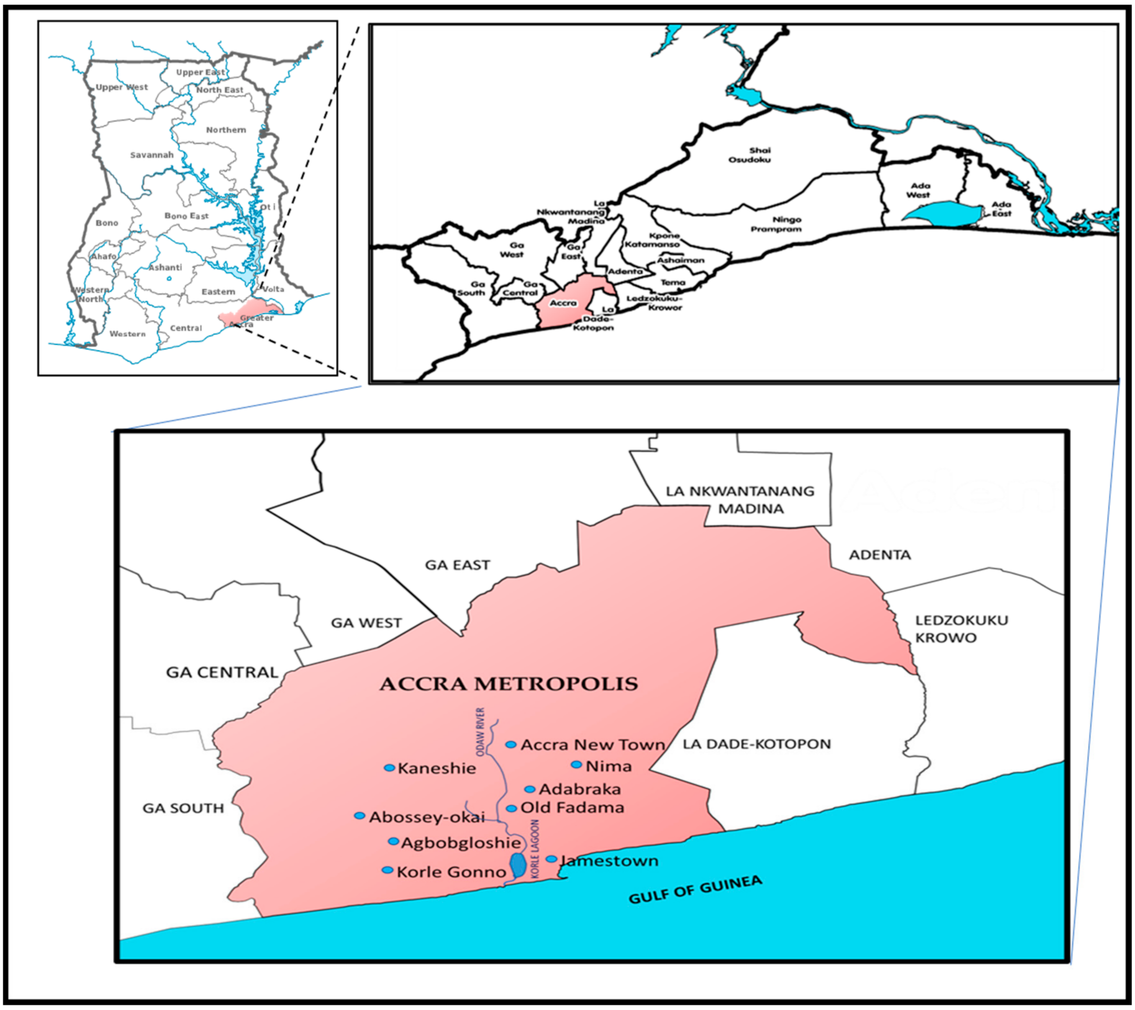


**Figure 4.** Map of Accra Metropolis showing study communities.

### 2.3. Theoretical Framework and Empirical Model

The theoretical foundation of this research is based on the well-known Protective Action Decision Model (PADM) in natural disaster studies. Based on the rational utility theory in economics, the PADM uses the value expected by people to explain how they adapt to disasters. The theory explains that households disaster risk perception influences behaviour and decision making, and factors including information, environmental characteristics, household, and individual characteristics also play important roles in risk perception and behavioural response to disasters [64]. Theoretically, households are expected to act rationally by adopting FDP behaviours when they perceive the risk of flood disasters. Empirical research has further proved that adopting measures for disaster preparations is the most effective strategy to mitigate disaster impacts [61]. Based on this, the study constructs the relationship given by the economic and econometric models below:

$$\text{FDP} = f(\text{FDRP, SRP, Household, and individual factors}) \tag{1}$$

where FDP refers to seven dimensions of flood disaster preparedness behaviours adopted by the households, based on the study on earthquake preparedness by Xu et al. [17] For each of the five distinct FDP behaviours (household cleans drainage, waterways and desilt gutters to enhance water flow when it rains heavily; household provides sandbags to protect the residence from flood water; household learned about flood disaster management; household reinforced buildings or raised elevations of the house to obstruct the entry of floodwaters; household insured against flood disaster), each household adopted at least one, and the total number of FDP behaviours adopted by the household is also given. Each distinct measure of FDP has a different level of effectiveness in mitigating flood disasters, as respondents in the region indicated that households with reinforced buildings or raised elevations to obstruct the entry of floodwaters had the highest efficiency in flood disaster mitigation, whereas houses with flood insurance received payoffs to cater for a major share of costs incurred during flooding. The remaining three were placed in order of effectiveness respectively given as: household provided sandbags to protect the residence from flood water, household cleaned drainage, waterways and desilt gutters to enhance water flow when it rains heavily, and household learned about flood disaster management. FDRP represents the five dimensions of flood disaster risk perception of households (probability of floods, severity of floods, sense of worry, threat to lives, and controllability). SRP represents households' perception of the effects of floods on their sustainable environment. Household and individual factors included as control variables include age, income, and years of formal education of household head, information about floods, house ownership, household size, and proximity of residence to the Odaw river/Korle lagoon. Most of the households who adopted cleaning drainage and waterways and who desilted gutters to enhance water flow when it rained, strongly indicated their closeness to the Odaw/river and Korle lagoon catchment area as the reasons for their choice. The topography of communities also played a major role, as residents in low lying areas where drainage flowed from higher elevations chose to raise elevations of the house, whereas other households provided sandbags to protect the residence from flood water. This clearly indicates that some of the FDP measures are clustered in specific spaces, as the topography and characteristics areas in the communities leads to similar adoption patterns.

For the purpose of analysis, equation one is transformed into an econometric model for estimation as shown below:

$$\text{FDP}_i = \beta_0 + \beta_{1i}\ \text{FDRP}_i + \beta_2\ \text{SRP} + \beta_{3i}\ \text{Control}_i + \mu_i \quad (2)$$

where $\beta_0$ is the constant term and $\beta_{1i}$, $\beta_2$, $\beta_{3i}$ are the estimated parameters, $\text{Control}_i$ represents household and individual characteristics and $\mu_i$ represents the residual of the model. The first six measures of FDP behaviours adopted are dichotomous variables and the seventh dependent variable is a count variable measuring the total number of adopted FDP behaviours. Hence, the logistic regression model was used for the dichotomous dependent variables for the first six models of the study and the Tobit regression model was used for the count variable in model 7.

### *2.4. Data Analysis*

After the models of the study were constructed, descriptive statistical analysis was conducted for the variables employed in the model. This was followed by the test of difference in mean, to understand the variations in variables between households that adopted at least one FDP and households that adopt none. To begin the empirical analysis in order to estimate the model in Equation (2), the variance inflation factors of all the independent variables were estimated to test multicollinearity among the variables first, before estimating the model for robust estimates. Finally, the logistic regression model and the Tobit regression model were estimated to analyze the influence of flood disaster risk perception on the adoption of FDP behaviour. The estimation employed robust standard errors to avoid heteroskedasticity and odds ratios and Hosmer-Lemeshow goodness of fit were estimated for the logistic models. The analysis was done using the Stata 15.0 software and graphs were drawn using Origin 8.5 software.

## 3. Results

The empirical results section presents a brief descriptive summary of the variables used in the econometric models. The analysis further compares the mean differences between these variables for two groups of households (adopters of at least one FDP and non-adopters) to examine the statistical significance of the differences in mean using the *t*-test. The final part of this section constructs econometric models to investigate the effect of flood disaster risk perception on urban household's FDP adoption.

### *3.1. Frequency Distribution of Urban Households' FDP Behaviour*

The frequencies of FDP behaviours implemented by households are presented in Table 1. From the results displayed, the most commonly adopted FDP behaviours were cleaning drainage, waterways and desilting gutters to enhance the flow of water after a heavy downpour of rains. Among the total 369 respondents, 113 households (30.62%) adopted these behaviours. In contrast, purchasing insurance against flood disasters was the least common preparedness behaviour adopted by households with only 10 households (2.71%) employing this FDP strategy. This vast disparity between the most and least commonly adopted FDPs highlights the role of income in flood disaster resilience and emphasizes the need to inculcate cost-effective measures in FDP policies. The rest of the FDP behaviours were distributed as follows: 48 households (13.01%) provided sandbags to protect the residence from flood water, 36 households (9.76%) learned about flood disaster management and 32 households (8.67%) reinforced their buildings or raised elevations of the house above flood level to obstruct floodwater from entering their homes.

**Table 1.** Frequency distribution of urban households' flood disaster preparedness behaviour in the Odaw river flood plains study area (*n* = 369).

| Household Flood Disaster Preparedness Behaviour Adopted | Frequency | Percentage |
|---|---|---|
| Household cleaned drainage, waterways, and desilt gutters to enhance water flow when it rains heavily. | 113 | 30.62 |
| Household provided sandbags to protect the residence from floodwater. | 48 | 13.01 |
| Household learned about flood disaster management. | 36 | 9.76 |
| Household reinforced buildings or raised elevations of the house to obstruct the entry of floodwaters. | 32 | 8.67 |
| Household insured against flood disaster. | 10 | 2.71 |

### *3.2. Frequency of Urban Households' Total Number of FDP Behaviours Adopted in the Odaw River Flood Plains Study Area*

The frequencies of urban household's total proportion of FDPs adopted are shown in Table 2. Among the total sampled households (369), 60.16% (222 households), representing the majority, did not adopt any of the five FDPs and no household was prepared in all five FDP behaviours to mitigate flood disaster risk. Regarding the rest of the total number of FDP behaviours implemented, 2.17% (8 households), 4.34% (16 households), 10.57% (39 households), and 22.76% (84 households) adopted 4, 3, 2, and 1 total number of FDP behaviours, respectively.

**Table 2.** Frequency of urban households' total number of flood disaster preparedness behaviours adopted in the Odaw river flood plains study area (*n* = 369).

| Total Number of Flood Disaster Preparedness Behaviors Adopted | Frequency | Percentage | Cumulative |
|---|---|---|---|
| 0 | 222 | 60.16 | 60.16 |
| 1 | 84 | 22.76 | 82.93 |
| 2 | 39 | 10.57 | 93.50 |
| 3 | 16 | 4.34 | 97.83 |
| 4 | 8 | 2.17 | 100 |
| 5 | 0 | 0 | 100 |
| Total | 369 | 100 | - |

### 3.3. Definition and Descriptive Statistics of the Variables Used in the Model

The descriptive summary of the variables used in the models is presented in Table 3. For the dependent variables used in the logit model, the descriptive shows that about 31% of households cleaned drainage, waterways, and desilted gutters, 13% of households used sandbags, 10% of households learned about flood disaster management, 9% of households reinforced buildings or raised elevations of their houses and only 3% on average insured against flood risk. The average number of households that adopted at least one FDP behaviour was about 40%. For the total number of FDP behaviours employed in the Tobit model as the dependent variable, the mean score was 0.66.

**Table 3.** Definition and descriptive statistics of the variables used in the model.

| Category | Variable | Description and Measure | Mean | SD |
|---|---|---|---|---|
| Dependent Variables (Models) | Drain Model (1) | Household cleaned drainage, waterways, and desilt gutters to enhance water flow when it rains heavily (0 = no, 1 = yes) | 0.31 | 0.46 |
| | Sandbag Model (2) | Household provided sandbags to protect residence from flood water (0 = no, 1 = yes) | 0.13 | 0.34 |
| | Knowledge Model (3) | Household learned about flood disaster management (0 = no, 1 = yes) | 0.10 | 0.30 |
| | Reinforce Model (4) | Household reinforced buildings or raised elevations of the house to obstruct the entry of floodwaters (0 = no, 1 = yes) | 0.09 | 0.28 |
| | Insure Model (5) | Household insured against flood disaster (0 = no, 1 = yes) | 0.03 | 0.16 |
| | At least 1 Model (6) | Household adopted at least one flood disaster preparedness behaviours (0 = no, 1 = yes) | 0.40 | 0.49 |
| | Total Model (7) | Total number of flood disaster preparedness behaviours adopted (0–5) | 0.66 | 0.98 |
| Disaster Cognitive factors and Risk Perception | Prob | Probability of floods (0 = low, 1 = high) | 0.59 | 0.49 |
| | Sev | Severity of floods (0 = low, 1 = high) | 0.48 | 0.50 |
| | Threat | Flood poses a threat to lives (0 = no, 1 = yes) | 0.21 | 0.41 |
| | Worry | Worried about flood disaster (0 = low, 1 = high) | 0.71 | 0.46 |
| | Control | Floods can be controlled to reduce disasters (0 = no, 1 = yes) | 0.35 | 0.48 |
| Sustainable Environment factor | Sustainability | Flood damage social infrastructures and homes (0 = no, 1 = yes) | 0.54 | 0.50 |
| Individual and Household Characteristics | Age | Household head age | 58.43 | 15.07 |
| | Edu | Years of formal education (years) | 6.26 | 3.35 |
| | Gen | Gender (0 = female, 1 = male) | 0.56 | 0.50 |
| | HHsize | Household size | 4.23 | 1.73 |
| | HHincome | Household income level (0 = less than 2000 cedis, 1 = 2000 and above) | 0.45 | 0.50 |
| | Ownership | House is owned by household head or family (0 = no, 1 = yes) | 0.67 | 0.47 |
| | Odaw/Korle | Residence in Odaw river/Korle lagoon floodplains | 0.44 | 0.49 |
| | Information | Receives information ahead of heavy rainfall and flood occurrence | 0.37 | 0.48 |

For the regressors, the first category is the disaster cognitive and flood disaster risk perception factors. The results of the descriptive summary showed that 59% of household heads perceived a high probability of flood occurrence while 48% of household heads perceived the probability of severe future flood occurrences. The average for households with a sense of threat, worry, and perception that floods can be controlled was 21%, 71%, and 35%, respectively. This indicates that most households were worried about flood disasters whereas only a few households perceived floods as a threat to their lives. The second category of regressors which considers how households perceive the effect of flood disasters on the sustainable environment had an average of 54% of total respondents agreeing to the destructive effects of flood disasters on their environments.

For the last group of regressors which assessed household and individual characteristics, the summary showed 54.43 years as the average age of household head, 56% male household heads, an average household size of 4.23 people, and 6.26 years of formal education averagely. Some 67% of the households were house owners or lived in a family-owned house and 45% of the household heads had an average income above GH 2000 per month. About 37% of households had received information about rainfall intensity and flood warnings ahead of time and 44% of households resided close to the Odaw river/Korle lagoon flood plains.

### 3.4. Mean Differences of Selected Variables According to Household's Adoption of at Least One FDP Behaviour

To begin the empirical analysis, the study analyzed the differences in means of variables used in the models between households that adopted at least one FDP and households that did not adopt any FDP behaviours. Table 4 presents the results of the mean differences among these two groups of households and the respective means and standard errors for each variable. The averages for Probability, Threat, and Worry were significantly higher for households that adopted at least one FDP behaviour than households that did not adopt any of the five FDP behaviours. The mean perception of severe floods was lower for households that adopted at least one FDP behaviour than households that did not adopt any of the FDP behaviours.

**Table 4.** Mean differences of selected variables according to household's adoption of at least one flood disaster preparedness behaviour.

| Variable | Household Adopted at Least One Flood Disaster Preparedness Behaviour | Household Did Not Adopt | Mean Differences |
|---|---|---|---|
| Prob | 0.79 (0.03) | 0.45 (0.03) | 0.34 *** |
| Sev | 0.24 (0.04) | 0.63 (0.03) | −0.39 *** |
| Threat | 0.31 (0.04) | 0.14 (0.02) | 0.17 *** |
| Worry | 0.92 (0.02) | 0.56 (0.03) | 0.36 *** |
| Control | 0.35 (0.04) | 0.36 (0.03) | 0.01 |
| Sustainability | 0.74 (0.12) | 0.41 (0.16) | 0.33 *** |
| Age | 60.48 (1.12) | 57.08 (1.07) | 3.40 ** |
| Edu | 10.64 (0.26) | 8.78 (0.24) | 1.86 *** |
| Gen | 0.60 (0.04) | 0.53 (0.03) | 0.07 |
| HHsize | 4.18 (0.20) | 4.09 (0.12) | 0.09 |
| HHincome | 0.59 (0.04) | 0.36 (0.03) | 0.23 *** |
| Ownership | 0.85 (0.03) | 0.55 (0.03) | 0.30 *** |
| Odaw/Korle | 0.61 (0.04) | 0.34 (0.03) | 0.27 *** |
| Information | 0.50 (0.04) | 0.29 (0.03) | 0.21 *** |
| Total | 147 | 222 | 369 |

**, ***: Significant respectively at 5% and 1%.

Among households who agreed to the assertion that floods are destructive to their sustainable environment, the average was higher for adopters of FDP behaviour than non-adopters of FDP behaviour. Other variables including age, education, household income level, ownership, information, and residents close to the Odaw river/Korle lagoon were averagely higher among adopters of at least one FDP than non-adopters of at least one FDP.

### 3.5. Household's Adoption of FDP Behaviours—Regression Results

Multicollinearity tests were conducted before the models were constructed to produce robust estimates. The results from Table 5 showed that the variance inflation factors (VIF) for all the regressors in the models were below 10. This implies that the models had no multicollinearity and the VIFs fall within a normal range, indicating all variables used are truly independent and the average VIF (1.36) was not significantly greater than 1.

**Table 5.** Variance inflation factors.

| Variable | VIF | 1/VIF |
|---|---|---|
| Sev | 2.19 | 0.45658 |
| Odaw/Korle | 2.05 | 0.486854 |
| HHincome | 1.39 | 0.721793 |
| Worry | 1.37 | 0.727374 |
| Threat | 1.32 | 0.758885 |
| Ownership | 1.31 | 0.763381 |
| Age | 1.23 | 0.810265 |
| Sustainability | 1.22 | 0.822239 |
| Control | 1.2 | 0.830856 |
| HHsize | 1.19 | 0.842103 |
| Edu | 1.17 | 0.8531 |
| Prob | 1.17 | 0.853806 |
| Information | 1.12 | 0.891637 |
| Gen | 1.11 | 0.904556 |
| Mean VIF | 1.36 | - |

Table 6 presents the logistic and Tobit regression results for models 1 to model 7. The logistic regression was used for models 1–6, as models 1–5 examined the factors influencing adoption of the five FDP behaviours, whereas model 6 analyzed the factors influencing the adoption of at least one of the five FDPs. Model 7 used the total number of FDPs adopted by households against the regressors in the Tobit regression model. The fitness of the models was also tested using the Hosmer-Lemeshow test (goodness of fit). The $p$-values ($<0.05$) of all the models indicate that the models are statistically significant.

The regression results for all the models indicate that flood disaster risk perception significantly affects household's adoption of FDP behaviours. Notwithstanding this, the significant effects differ according to the flood risk perception dimension and the FDP behaviour adopted. From the first and third models, Probability, Severity, and Worry have significant positive coefficients. The odds for a household to clean drainage, waterways, and desilt gutters or learn about flood disaster management as FDP behaviours are higher for households that have a sense of worry about flood disasters, households that perceive a high probability of floods, and households perceiving future floods to be very severe, compared to households without a sense of worry about floods and who perceive low probability and severity of future floods. Only Probability has a significant (positive) coefficient among the risk perception factors in the second model. Holding every other regressor constant, the odds of adopting the use of sandbags as an FDP increases by 2.86 for every one-unit increase in probability. The severity of future floods and sense of worry both have positive coefficients with "Households reinforced buildings or raised elevations of the house" in model 4. Holding every other regressor constant, the odds of reinforcing house building or raising elevations as an FDP increases by 3.85 and 5.46 for every one-unit increase in Severity and Worry, respectively. In model 5, only Severity as a flood disaster risk factor has a significant coefficient with "Household insured against flood disaster". Households that perceive severe floods in the future are 18.83 times more likely to purchase flood disaster insurance than households without a perception of severe future floods occurrence.

**Table 6.** Household's adoption of FDP behaviours—regression results.

| Variable | Logit Models | | | | | | Tobit Model |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Prob | 2.86 *** (0.50)<br>17.51 | 1.05 ** (0.41)<br>2.86 | 0.99 * (0.53)<br>2.68 | −0.08 (0.41)<br>0.92 | 1.31 (0.94)<br>3.70 | 2.48 *** (0.43)<br>11.89 | 0.50 *** (0.10) |
| Sev | 2.13 *** (0.57)<br>0.12 | 0.85 (0.59)<br>2.34 | 1.98 ** (0.41)<br>7.22 | 1.35 ** (0.59)<br>3.85 | 2.94 ** (1.24)<br>18.83 | 1.18 *** (0.44)<br>0.31 | 0.14 (0.17) |
| Threat | 0.45 (0.47)<br>1.57 | 0.60 (0.39)<br>1.82 | 0.20 (0.55)<br>1.22 | 0.80 (0.51)<br>2.23 | 0.09 (0.76)<br>1.09 | 0.66 (0.46)<br>1.94 | 0.24 ** (0.12) |
| Worry | 2.37 *** (0.72)<br>10.66 | 0.39 (0.50)<br>1.48 | 1.53 ** (0.65)<br>4.64 | 1.70 ** (0.73)<br>5.46 | 1.00 (1.44)<br>2.73 | 1.25 *** (0.42)<br>3.50 | 0.35 *** (0.10) |
| Control | −0.27 (0.39)<br>0.76 | −0.60 (0.38)<br>0.55 | 0.25 (0.45)<br>1.28 | 0.07 (0.48)<br>1.07 | −0.96 (0.77)<br>0.38 | −0.54 (0.35)<br>0.58 | −0.07 (0.92) |
| Sustainability | 0.68 (0.46)<br>1.98 | 1.17 *** (0.40)<br>3.22 | 0.89 ** (0.47)<br>2.43 | 0.49 (0.45)<br>1.01 | 0.56 (0.78)<br>1.75 | 1.88 *** (0.43)<br>6.58 | 0.29 *** (0.99) |
| Age | 0.04 ** (0.01)<br>1.04 | −0.02 (0.01)<br>1.00 | 0.01 (0.01)<br>1.01 | 0.01 (0.01)<br>1.01 | 0.10 (0.03)<br>1.01 | 0.02 ** (0.01)<br>1.02 | 0.01 ** (0.00) |
| Edu | 0.12 (0.12)<br>1.13 | 0.11 (0.12)<br>1.12 | 0.22 (0.16)<br>1.24 | 0.47 ** (0.21)<br>1.59 | 0.15 (0.35)<br>1.17 | 0.30 *** (0.11)<br>1.34 | 0.08 ** (0.32) |
| Gen | 0.03 (0.38)<br>1.03 | 0.09 (0.33)<br>1.10 | −0.28 (0.39)<br>0.75 | 0.10 (0.40)<br>1.11 | 0.63 (0.69)<br>1.88 | 0.04 (0.34)<br>1.05 | 0.03 (0.09) |
| HHsize | 0.35 * (0.19)<br>1.42 | 0.12 (0.14)<br>1.13 | −0.15 (0.22)<br>0.86 | 0.06 (0.22)<br>1.06 | 0.15 (0.36)<br>1.16 | 0.39 ** (0.19)<br>1.48 | 0.04 (0.05) |
| HHincome | 0.13 (0.50)<br>1.14 | −0.39 (0.40)<br>0.68 | 0.88 (0.55)<br>2.41 | 0.64 (0.57)<br>1.90 | 2.97 ** (1.51)<br>19.49 | 0.46 (0.37)<br>1.59 | 0.22 ** (0.10) |
| Ownership | 0.98 ** (0.40)<br>2.65 | 1.33 *** (0.47)<br>3.78 | 0.15 (0.55)<br>1.16 | −0.66 (0.55)<br>0.52 | 0.91 (1.71)<br>2.48 | 1.99 *** (0.46)<br>7.35 | 0.27 ** (0.11) |
| Odaw/Korle | 0.44 (0.44)<br>1.56 | 0.24 (0.46)<br>1.27 | −0.11(0.62)<br>0.89 | 0.78 * (0.42)<br>0.46 | 1.41 (0.90)<br>4.11 | 0.19 (0.43)<br>1.22 | 0.06 (0.13) |
| Information | 0.57 (0.36)<br>1.76 | 0.73 ** (0.34)<br>2.08 | 0.91 ** (0.37)<br>2.48 | 0.69 (0.40)<br>2.00 | −0.65 (0.81)<br>0.52 | 0.61 * (0.33)<br>1.83 | 0.26 ** (0.10) |
| Constant | −9.14 ***<br>(1.49) | −6.02 ***<br>(1.40) | −8.12 ***<br>(1.99) | −7.97 ***<br>(2.03) | −12.27 ***<br>(4.09) | −8.95 ***<br>(0.33) | −1.42 ***<br>(0.36) |
| Pro > $chi^2$ | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 |
| Pseudo $R^2$ | 0.52 | 0.16 | 0.18 | 0.16 | 0.24 | 0.47 | 0.12 |
| | Hosmer-Lemeshow Goodness of Fit | | | | | | |
| $chi^2(8)$ | 11.35 | 3.51 | 12.24 | 14.34 | 32.09 | 6.85 | |
| Pro > $chi^2$ | 0.18 | 0.89 | 0.09 | 0.06 | 0.00 | 0.55 | |

*, **, ***: Significant respectively at 10%, 5% and 1%. Robust standard errors of coefficients are in (). Odds ratios of coefficients presented below coefficients and standard errors.

The perception of households regarding the destructive effects of floods on a sustainable environment is presented by the Sustainability variable and how it affects FDP behaviour. Sustainability has positive coefficients with the "use of sandbags" and "Household learned about flood disaster" in models 2 and 3, respectively. Households that are aware and accept that flood disasters negatively impact sustainability are 3.22 and 2.44 times more likely to provide sandbags to block floodwaters and learn about flood disaster management, respectively, than households without an awareness of the harm floods can cause to their environment.

Household and individual characteristics also have significant effects on the adoption of FDP behaviour though the variables and their effects differ across the specific models. In the first model, age, household size, and house ownership have significant positive coefficients with "Household cleaned drainage, waterways and desilt gutters". In model 2, house ownership and information about rainfall and floods were significantly (positively) related to the use of sandbags; in model 3, households learning about flood disaster management was positively and significantly related to information about rainfall and floods; education and residence close to Odaw river/ Korle lagoon had positive coefficients with reinforcing buildings or raising elevations of the house as an FDP in model 4; and finally household income level had a positive effect on the purchasing of flood disaster insurance.

Based on model 6, the adoption of at least one FDP behaviour has a positive and significant relationship with Probability, Severity, Worry, Sustainability, Age, Education, Household size, House ownership, and Information. This indicates that the odds of adopting at least one FDP increases with a unit increase in disaster cognitive and risk perception factors (Probability, Severity, and Worry), perception about flood effects on the sustainable environment (Sustainability), and household and individual characteristics (Household Size, House Ownership, Age, Education, and Information), when holding every other factor unchanged.

The final model (Tobit regression) presents the factors influencing the total number of FDP behaviours adopted by households. Among the flood disaster risk perception factors, probability, a threat to lives, and a sense of worry were positively related to the total number of adopted FDP behaviors. Thus, households perceiving a high probability of flood occurrence, as a threat to their lives, and were worried about flood disasters, are more likely to adopt more FDP behaviours than households with low probability, no threat to lives, and no sense of worry perceptions. Households perceiving that flood destroys a sustainable environment have a higher odd of adopting more FDP behaviours than households who are not aware of the danger floods pose to a sustainable environment. This is shown by the significant (positive) coefficient of Sustainability with the total number of FDP behaviours adopted. Household and individual characteristics such as age, education, household income, ownership, and information all have positive coefficients and are significant. Thus, the odds of the total number of FDP behaviours adopted increases for every unit increase in age of household head, years of household head's formal education, household income, house ownership, and information, when other factors remain unchanged.

## 4. Discussion

This study analyzed five indicators of flood disaster risk perception, and a parameter measuring perception of floods impact on sustainability, based on data sourced from urban households residing in the flood-prone zones of the Odaw river/Korle lagoon flood plains. The logistic and Tobit regression models were used to examine the effects of Urban households' flood disaster risk perception, and sustainability risks due to floods, on the adoption of FDP behaviours (each of the five FDP behaviours, at least one FDP behaviour, and the total number of FDP behaviours). Consistent with empirical results from other disaster risk studies from most countries, only 40% of households adopted FDP behaviours and the rest (60%), constituting the majority, did not prepare for flood disasters.

Flood disaster risk perception and perception of floods impact on sustainability are important factors that influence the FDP behaviour adoption of households, but few studies have been made globally considering this relevant issue and none have yet been carried out in the case of Ghana. The findings of this research indicate flood that disaster risk perception and perception of floods impact on sustainability positively influence the adoption of FDP behaviours. Thus, households in flood-prone zones put measures in place to mitigate flood disasters depending on their level of flood disaster risk perception. If households perceive high probability, severity, worry, and threat to their lives, they are more likely to adopt more FDP behaviours for flood disaster resilience than households without these perceptions about flood disasters. Risk-averse households maximize satisfaction by adopting FDP behaviours to make them more secure and less exposed to flood disaster. The results are consistent with the disaster preparedness studies of Xu et al. [17], Miceli et al. [65], Hashim et al. [21], Han & Nigg [13], Ozdemir & Yilmaz [66] Han et al. [24] and Cui et al. [67] but inconsistent with other relevant studies [68–70].

The characteristics of individual household heads and their households in general also affect their adoption of FDP behaviours. In line with the majority of research on disaster preparedness, this study found that the socioeconomic characteristics of households had positive relationships with their adoption of FDP behaviours. The years of formal education a household head has obtained increases risk aversion level and hence increases the likelihood of adopting more FDPs. Education empowers people to realize the need for risk reduction and disaster management. Thus, with more years of education, respondents' knowledge about disaster management is increased and their sense of awareness to adopt pragmatic preventive measures is improved. In previous studies such as those of Xu et al. [17], Hoffmann & Muttarak [29], and Muttarak & Lutz [71], the same positive effect of education was found on disaster preparedness. A higher level of income also empowers households to invest in disaster preparations in the form of reinforcing houses, buying insurance against flood disasters, and adopting various forms of FDP. Many households who are risk-averse have the will to adopt more strategies but the limitation posed by some cost-effective strategies limits low-income households from resorting to the basic forms of FDP behaviour. This is explained by the significantly positive effect of income on adopting the purchase of insurance against floods. This finding is consistent with the study of Xu et al. [17], who found income influenced insurance against landslide disasters. Information, house ownership, and age of household heads also affect the adoption of FDP behaviour positively, and this result is supported by previous studies [13,17,24,66,67,72].

Measuring flood disaster risk and perceptions of effects on sustainability, using multiple dimensions and different econometric techniques, provides novel ideas in this study about flood disaster mitigation and pragmatic ideas with which to understand households' behaviour towards FDP compared to other disaster studies previously conducted. Despite these critical contributions, there are some limitations, as the sample for this research consisted of flood-prone residents in the urban households of the most flood occurrent Odaw river/Korle lagoon flood plains. Further studies could consider other disasters aside from floods such as bushfires, drought, and epidemics to explore how the conclusions of this research relate. Further studies can be done to cover rural households in other regions, especially the farming and fishing communities that face severe river and coastal floods in the countryside.

## 5. Conclusions

This study used survey data collected from urban households in the most flood-prone region in Ghana to analyze the effect of flood disaster risk and sustainability risk perception of floods on households' flood disaster preparedness. Logistic and Tobit regression models were established to study this relationship and the main findings are: First, the behaviour of households to elude flood disasters needs improvement, as flood disaster preparedness of the respondents was low, with the majority of the households (60.16%) unprepared for flood disasters. Second, the perception of flood disaster risk and sustainability risk posed by floods significantly affect the FDP behaviours of households. The total number of FDP behaviours adopted was significantly related to probability, the threat to lives, sense of worry, and sustainability risk perceptions. Finally, income, education, and house ownership, among other household and individual characteristics, had significant positive effects on preparations for flood disasters.

Based on these conclusions, the study suggests educational policies are implemented, creating awareness and imparting knowledge about flood disaster risks and mitigation. As the study results showed that educated households had higher level of preparedness, great attention must be paid to less educated and uneducated households to improve their knowledge and sense of awareness about flood risks and effective measures for preparations. This acquisition of critical knowledge about floods through education will raise the awareness of households and affect their risk perception and behaviour towards flood disaster preparations. Vital information about rainfall intensities and anticipation of floods by the government agencies such as the meteorological institution should be effectively communicated to residents in flood-prone areas ahead of time, to enable households to make adequate preparations in order to reduce flood disasters. Finally, as vital as providing infrastructures to mitigate flood disasters, the government should also involve residents and all stakeholders in the community in making effective communications to strategize flood disaster mitigation.

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