

Assessment of Preventive Flood Protection Measures Implemented by Urban Households in Ouagadougou, Burkina Faso

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Abstract

This study analyses household adaptation strategies to recurrent urban flooding in Ouagadougou, Burkina Faso, in a context of increasing hydrometeorological hazards linked to climate change. Based on a survey conducted between July and September 2022 among 1026 households in flood-prone neighborhoods, this study highlights the range of preventive structural measures adopted and examines their socio-economic determinants. Results show that households consistently use at least one means of protection, most often protective belts, solid or permanent construction, perforation of fences, and raising of door thresholds. However, the adoption, accumulation and quality of these measures vary markedly depending on education level, housing tenure and household income. Households that are more educated, wealthier and homeowners invest more frequently in sustainable and costly measures such as solid construction and elevation of housing, while poorer households and tenants use the low-cost or temporary strategies. Perceived effectiveness also reflects these inequalities: nearly 60% of respondents judge their measures “not effective”, with negative evaluations concentrated among low-income and less-educated groups. Conversely, the highest income categories report strong satisfaction with the performance of the implemented measures. Overall, the findings reveal significant socio-economic disparities in preventive investments and perceptions of protection measures, highlighting differentiated vulnerabil-

ity to flooding and the need for targeted interventions to strengthen household resilience.

Keywords

Flood, Households, Preventive Protection Measures, Ouagadougou, Burkina Faso

1. Introduction

Climate change and its effects are now central themes in global scientific debates and on political and economic agendas (Nassor & Makame, 2021). Over the past few decades, the frequency and intensity of climate change-related disasters have increased (Šakić Trogrlić et al., 2018). In general, hydrometeorological disasters are among the most devastating natural phenomena (Dalu et al., 2018). Floods are the most widespread type of hydrological disaster worldwide, causing significant consequences, including economic losses and infrastructure destruction (Bell, 2011; Kundzewicz et al., 2014).

Floods are defined as hydrological phenomena characterized by the partial or total submersion of an area that is normally free of water (Jerome Glago, 2021). Urban areas appear to be particularly exposed to the flood risk due to their high population density, concentration of infrastructure, and increased intensity of economic activities (Dumedah et al., 2021; Rentschler et al., 2022). Globally, it is estimated that more than 17 million people are displaced each year as a result of flooding, with nearly 80% living in urban or peri-urban areas (IDMC, 2019).

In developing countries, particularly in Asia and Africa, urban areas are vulnerable to flooding compared to those in developed countries (Leta & Adugna, 2023). This situation is evident in Ouagadougou, the capital city of Burkina Faso, where the generally flat topography, combined with high climate variability, increases the city's exposure to hydrological hazards (Nouaceur, 2020). Since the end of the 20th century, Burkina Faso has seen an increase in flooding, with socio-economic and environmental repercussions that are particularly damaging to the population. The average number of annual flood events rose from one between 1986 and 2005 to five between 2006 and 2016, with nearly a third of them occurring in Ouagadougou (Tazen et al., 2019). More recently, in September 2020, torrential rains led to further flooding, causing 41 deaths, 112 injuries, and more than 100,000 people affected nationwide, including approximately 2300 households directly affected in Ouagadougou (Da & Bonnet, 2021).

Faced with increasingly severe flooding in Ouagadougou, improving prevention and management measures has become a strategic priority for the Burkinabe authorities (Hangnon et al., 2018). Despite the implementation of multiple public interventions, households remain on the front line and are developing a set of adaptation strategies aimed at mitigating their exposure and reducing their vul-

nerability to flood risks. However, the effectiveness, relevance, and long-term sustainability of these strategies remain insufficiently documented, while the socio-economic factors shaping their adoption are still poorly understood. This gap raises a critical research question: to what extent do household level adaptation strategies implemented in flood-prone urban areas of Ouagadougou effectively reduce their vulnerability to flood risks, and which factors influence their selection and performance? This study addresses this gap by evaluating household adaptation strategies through a questionnaire-based survey conducted among residents of the main flood-prone areas of the city of Ouagadougou.

Adaptation to flood risk encompasses a wide range of strategies that can be broadly classified into structural, non-structural, and reactive measures (Mureithi, 2015; Yoga Putra et al., 2019). Structural strategies involve physical and engineered interventions designed to modify flood dynamics or reduce potential damages, while non-structural strategies include regulatory, institutional, and behavioral actions such as land-use planning, early warning systems, or awareness-raising initiatives. Reactive strategies, in contrast, are typically implemented during or after flood events and aim primarily at emergency response and recovery. In this paper, non-structural, and reactive measures are not considered, allowing the analysis to focus specifically on household adaptation strategies in flood-prone urban areas.

The next section describes the study area and the methodological approach adopted in this research. Section 3 outlines the main results obtained, while Section 4 provides a comprehensive discussion that situates these findings within the context of previous studies. Section 5 outlines the study's strengths and limitations. Finally, Section 6 offers concluding remarks and key implications derived from the overall analysis.

2. Materials and Methods

2.1. Study Area

The research was conducted in Ouagadougou, the capital of Burkina Faso (Figure 1). As the country's main urban center, it concentrates major economic and cultural activities and hosts the largest population estimated at 2,684,052 inhabitants in 2019, representing about 11.78% of the national total (INSD, 2022). The city of Ouagadougou is characterized by an overall flat landscape that gently decreases in elevation from south to north, with no major geomorphological constraints limiting urban development. Local soils are generally shallow and highly susceptible to erosion, and are mainly composed of sandy, sandy-clay, or clayey textures (Kédowidé et al., 2010). Ouagadougou is located within a dry tropical climate regime, marked by a single rainy season extending from June to October (typically peaking in August) and a dry season from November to May. Mean annual rainfall ranged from approximately 511 to 1003 mm between 1980 and 2020 (Traoré et al., 2024). Temperatures fluctuate considerably throughout the year, with the coolest daily averages reaching around 16°C in December, and the highest tem-

peratures often reaching 40°C in March and April (Tazen et al., 2019). From the hydrological perspective, Ouagadougou lies within the Massili catchment, which drains northward into the Nakanbé River through a moderately developed network of waterways. The presence of several streams and artificial reservoirs increases the city's susceptibility to flooding, especially during episodes of intense precipitation.

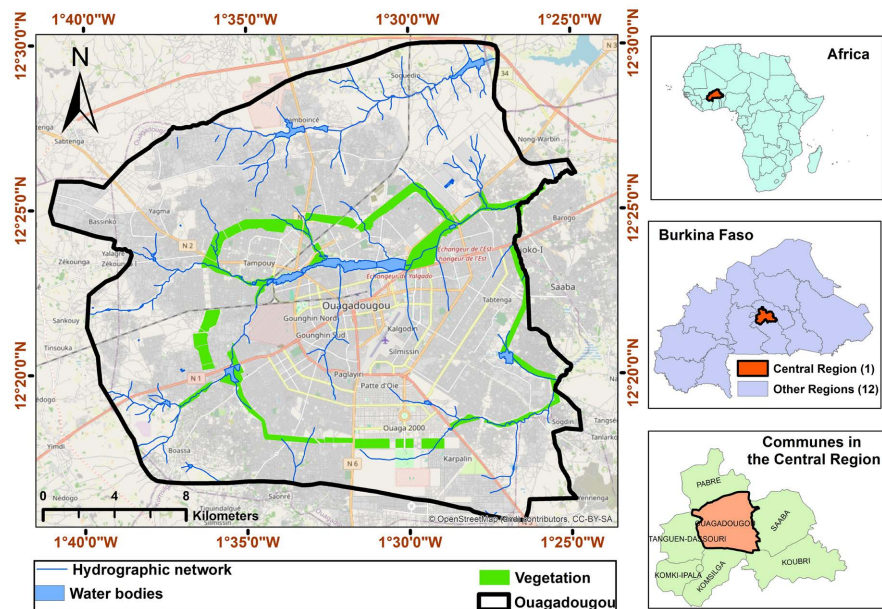


Figure 1. The location of the study area.

2.2. Survey Design and Data Collection

The data used in this study were collected through a face-to-face household survey conducted between 4 July and 10 September 2022. Fifteen surveyors, selected for their prior field experience and basic training in natural disaster management, participated in the data collection process. To ensure consistency in data-gathering practices, they received a four-day intensive training covering the objectives of the research, ethical requirements, and methodological guidelines for administering structured interviews.

Before each interview, surveyors informed respondents of the purpose of the study, reiterated the confidentiality safeguards, and obtained their verbal informed consent. Participation was entirely voluntary, and respondents could withdraw at any point. Surveyors were instructed to clarify any ambiguous questions to improve the reliability of the information provided. Only one respondent per household was selected, and eligibility required being at least 18 years old, having lived in the household for a minimum of one year, and exhibiting no apparent cognitive impairments. The questionnaire underwent two rounds of pre-testing with 37 residents, which helped identify unclear or redundant items and refine the overall structure of the instrument.

Data collection was carried out using *KoboToolbox*, deployed through the

KoboCollect mobile application (version 2022.4.4). The digital format facilitated administration on Android smartphones, ensured compliance with the predefined question sequence, and prevented item omissions. Real-time monitoring was enabled through the *KoboToolbox* dashboard, supplemented by regular phone communication with field teams, which supported immediate troubleshooting and continuous quality control. Each interview lasted an average of 45 to 60 minutes.

No formal administrative authorization was required for this survey, as it did not involve the collection of sensitive personal information or pose any risk to participants' rights. Respondents were briefed on the purpose of the study prior to inclusion. The final questionnaire comprised sections addressing sociodemographic characteristics and the preventive measures implemented by households to protect themselves from flooding.

2.3. Sample Selection and Data Analysis

To reduce the exposure of populations to the risk of flooding, the government of Burkina Faso adopted a decree locating and demarcating flood zones in the city of Ouagadougou after the major flood of September 1, 2009. Through Decree No. 2009-793/PRES/PM/MHU/MATD/MEF/MID/MAHRH/MECV of November 19, 2009, governing easements for primary storm water drainage channels, non-buildable flood zones, and submersible zones in the city of Ouagadougou, the administrative boundaries of flood zones are defined as a distance of 300 m on either side of the boundaries of watercourses and dams in the city. In this study, the entire flood-prone urban area of Ouagadougou was investigated to provide a comprehensive understanding of the preventive measures adopted by households to mitigate flood risks and strengthen community resilience. A total sample of 1026 respondents were randomly selected from households located in flood-prone areas of the city of Ouagadougou. Primary data were processed and analyzed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics, including frequencies and percentages, were used to summarize the main variables. In addition, the Chi-square test of independence was applied to examine the associations between flood-prevention measures and a set of selected sociodemographic characteristics (Mabuku et al., 2019; McHugh, 2013; Nihan, 2020). The χ^2 test is commonly used to explore relationships between categorical variables, for example, to determine whether a particular characteristic is associated with another and to verify whether the observed differences are significant. The null hypothesis (H_0) of the test states that the two variables are independent (i.e., there is no association). For a contingency table with r rows and c columns, the χ^2 test statistic follows a chi-square distribution (Equation (1)):

$$\chi^2 = \sum_{i=1}^r \sum_{j=1}^c \frac{(O_{ij} - E_{ij})^2}{E_{ij}}, E_{ij} = \frac{R_i - C_j}{N} \quad (1)$$

where O_{ij} is the observed frequency or count in the cell at the i^{th} row and j^{th} column, E_{ij} is the expected frequency under the assumption of independence, R_i is

the sum of the observed frequencies in the j^{th} row, C_j is the sum of the observed frequencies in the j^{th} column, and N is the total number of observations.

3. Results

3.1. Preventive Flood Protection Measures

Households in the city of Ouagadougou implement a wide range of preventive structural measures to reduce their exposure to flooding (Figure 2). These strategies, which are primarily based on individual initiatives, include strengthening housing construction, installing protective belts, constructing drain-age trenches or ditches, raising door thresholds, partially or fully elevating buildings, perforating fences to facilitate water drainage, and using sandbags.

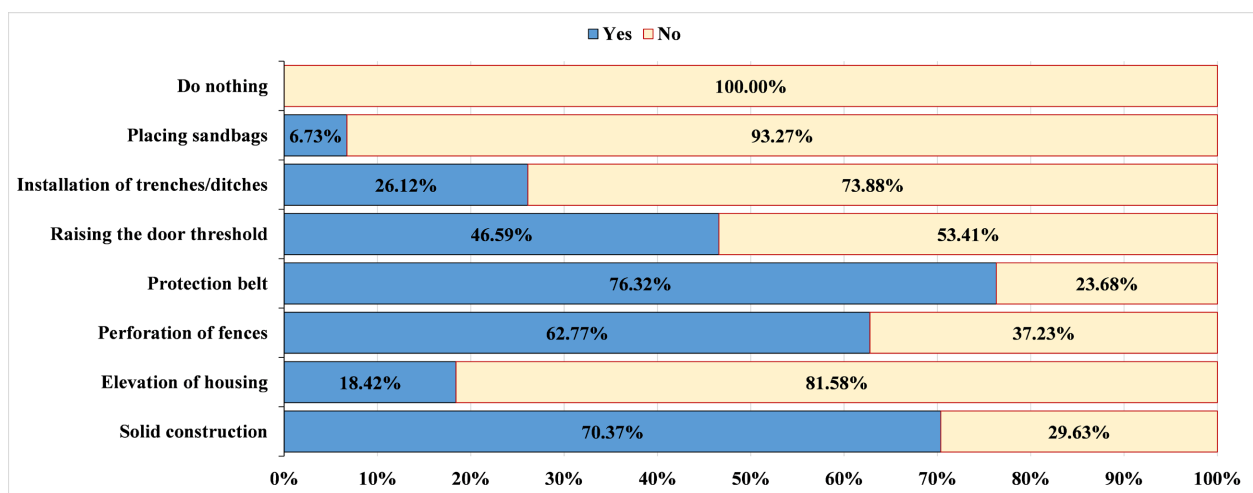


Figure 2. Preventive flood protection measures implemented by individual households.

Figure 3 presents a series of illustrations highlighting the diversity of preventive measures implemented by households to reduce their exposure to flooding. Protective barriers appear to be the most widely used measure, employed by 76.32% of households. Similarly, 70.37% of households have opted for solid construction, reflecting a significant structural effort to strengthen the resistance of buildings to hydrometeorological shocks. This measure reflects a higher level of investment and a desire to reduce physical vulnerability in the long term.



(a)



(b)



Figure 3. Illustrations of preventive flood protection measures implemented by different households: (a) Solid construction; (b) and (c) Protection belt; (d) Installation of trenches/ditches; (e) Raising the door threshold; (f) Elevation of housing; (g) Perforation of fences; (h) Placing sandbags.

The perforation of fences (62.77%) also plays a central role among preventive mechanisms. This practice aims to facilitate water flow (or runoff) in order to prevent its accumulation within concessions, reflecting a pragmatic and gradual adaptation by households to the failure or inadequacy of urban drainage systems. Raising the door threshold (46.59%) is another commonly adopted strategy to prevent water from directly entering homes, reflecting the frequency of low-level flooding episodes.

However, certain measures remain less widely used. The installation of trenches or drainage channels (26.12%) reflects a more limited capacity to develop outdoor spaces, often constrained by the narrowness of urban plots or the lack of land ownership. Similarly, the use of sandbags upstream of flooding remains marginal

(6.73%), highlighting either the limited availability of these materials or a preference for other forms of protection deemed more effective.

Finally, it is noteworthy that no households reported taking no action, indicating widespread awareness of the risk and almost universal engagement in at least one form of protection. This trend confirms that urban populations are developing preventive strategies tailored to their economic capacities and living conditions, in a context marked by recurrent flooding and inadequate drainage infrastructure.

3.2. Socio-Economic Determinants of Preventive Flood Protection Measures

The results of the chi-square test highlight statistically significant relationships between several selected socioeconomic characteristics of households and their use of preventive flood protection measures in the city of Ouagadougou (Table 1).

Table 1. Statistical relationships between the socio-economic profile of households and the coping strategies employed by households affected by flooding in the city of Ouagadougou.

Socio-economic profile of households	Preventive flood protection measures						
	Solid construction	Elevation of housing	Perforation of fences	Protection belt	Raising the door threshold	Installation of trenches/ditches	Placing sandbags in front of the house
Education level of the household head							
No schooling	235 (62.83%)	58 (15.51%)	228 (60.96%)	374 (100.00%)	161 (43.05%)	89 (23.80%)	29 (7.75%)
Primary	189 (65.63%)	30 (10.42%)	192 (66.67%)	287 (99.65%)	142 (49.31%)	81 (28.13%)	28 (9.72%)
Secondary (1st cycle)	142 (78.02%)	45 (24.73%)	111 (60.99%)	177 (97.25%)	78 (42.86%)	54 (29.67%)	8 (4.40%)
Secondary (2nd cycle)	100 (81.97%)	28 (22.95%)	77 (63.11%)	122 (100.00%)	61 (50.00%)	30 (24.59%)	2 (1.64%)
University	56 (93.33%)	28 (46.67%)	36 (60.00%)	60 (100.00%)	36 (60.00%)	14 (23.33%)	2 (3.33%)
χ^2	41.451	52.724	2.844	18.189	8.664	3.224	12.461
<i>p</i> -value	0.000	0.000	0.584	0.001	0.070	0.521	0.014
Housing Tenure							
Owner	538 (68.80%)	150 (19.18%)	506 (64.71%)	780 (99.74%)	405 (51.79%)	232 (29.67%)	62 (7.93%)
Tenant	150 (81.52%)	32 (17.39%)	107 (58.15%)	180 (97.83%)	58 (31.52%)	30 (16.30%)	2 (1.09%)
Free occupancy	34 (56.67%)	7 (11.67%)	31 (51.67%)	60 (100.00%)	15 (25.00%)	6 (10.00%)	5 (8.33%)
χ^2	17.305	2.252	6.098	9.802	36.527	22.365	11.377
<i>p</i> -value	0.000	0.324	0.047	0.007	0.000	0.000	0.003

Continued

Household Income (USD per month)							
<80.12	130 (48.69%)	1 (0.37%)	186 (69.66%)	267 (100.00%)	105 (39.33%)	61 (22.85%)	21 (7.87%)
80.12 - 160.24	103 (58.19%)	1 (0.56%)	102 (57.63%)	177 (100.00%)	75 (42.37%)	52 (29.38%)	15 (8.47%)
160.24 - 320.49	194 (67.60%)	2 (0.70%)	162 (56.45%)	281 (97.91%)	119 (41.46%)	61 (21.25%)	14 (4.88%)
320.49 - 480.73	208 (100.00%)	98 (47.12%)	126 (60.58%)	208 (100.00%)	106 (50.96%)	61 (29.33%)	19 (9.13%)
>480.73	87 (100.00%)	87 (100.00%)	68 (78.16%)	87 (100.00%)	73 (83.91%)	33 (37.93%)	0 (0%)
χ^2	198.056	654.662	21.590	15.540	60.246	13.375	11.176
<i>p</i> -value	0.000	0.000	0.000	0.004	0.000	0.010	0.025

The level of education has a significant influence on certain structural strategies, although the intensity of the relationships varies depending on the measures considered. The quality of the protective barriers installed by households varies considerably depending on the investments made (Figure 3(b) and Figure 3(c)). However, despite these disparities, they generally constitute the minimum measure that each household seeks to implement to protect itself from the effects of flooding. In this context, households headed by illiterate people already show a particularly marked use of protective measures, with systematic use of protective barriers observed among all respondents and a high rate of fence perforation, reached by nearly two-thirds of them (60.96%). On the other hand, housing construction using sustainable materials and raising the height of the dwelling show statistically very significant associations, as evidenced by the chi-square values ($\chi^2 = 41.451$ and $\chi^2 = 52.724$; $p < 0.001$). These results indicate that these measures are more widely adopted by households whose heads have a secondary or university education. For example, 93.33% of heads of households with a university education live in housing built with sustainable material, compared to 62.83% of those without schooling, and 46.67% of university graduates have raised their homes, compared to 15.51% of households with no education. In contrast, certain less technical strategies, such as perforating fences ($p = 0.584$) or installing trenches/ditches ($p = 0.521$), do not vary significantly according to level of education, suggesting that they are an adaptation that is accessible regardless of educational capital. Raising door thresholds showed a marginal relationship ($p = 0.070$). Finally, the use of sandbags showed a significant association ($p = 0.014$), with little education households using them more, revealing an emergency adaptation favored in contexts of limited resources.

The residential status is also an important determinant of the adoption of adaptation measures. Homeowners are significantly more likely to use almost all

strategies, particularly permanent construction (68.80%), raising thresholds (51.79%), installing trenches (29.67%), and placing sandbags (7.93%), compared to tenants and households living in free occupancy. The relationships are statistically significant for five of the seven strategies: permanent construction ($p < 0.001$), fence perforation ($p = 0.047$), protective belt ($p = 0.007$), raising the threshold ($p < 0.001$), and installing trenches ($p < 0.001$). These results reflect the tendency of homeowners to invest more in sustainable and structural measures, while tenants favor low-commitment strategies or remain inactive. Conversely, raising the height of the dwelling ($p = 0.324$) and using sandbags ($p = 0.109$) did not show significant variations according to residential status, illustrating measures adopted in a relatively uniform manner.

Income level emerges as one of the most significant factors of the adoption of preventive flood protection measures, as indicated by the highest χ^2 values and consistently highly significant p -values. There is a clear increase in structural investment as income rises. The lowest income households (<80.12 USD per month) report limited use of permanent construction (48.69%) and raising the height of their homes (0.37%), while these measures are adopted by all households in the two highest income categories (>320.49 USD per month), underscoring pronounced socioeconomic disparities in adaptive capacity ($p < 0.001$).

Similar income related patterns are observed for other adaptation strategies. Raising door thresholds is significantly more prevalent among wealthier households (83.91%) than the poorest households (39.33%) ($p < 0.001$). Households with high incomes are also more likely to install trenches measures (37.93% in the highest income bracket). Notably, even low-cost and low-technology strategies, such as placing sandbags, vary significantly according to income ($p = 0.025$), highlighting that even inexpensive measures still require a minimum level of financial or material resources. Although the association between income and the construction of protective barriers is comparatively less pronounced, it remains statistically significant ($p = 0.004$).

3.3. Inequalities in Preventive Investment against Flooding

The analysis of **Table 2** highlights significant heterogeneity in the accumulation of protective measures, reflecting differing investment capacities depending on the socioeconomic characteristics of households. Three determinants stand out clearly: the level of education of the head of household, the occupancy status of the dwelling, and monthly income.

Table 2. Variations in the number of protective measures according to the socioeconomic profile of households.

Socio-economic profile of households	Number of various protective measures							Overall
	1	2	3	4	5	6	7	
Education level of the household head								
Without schooling	33	118	82	70	51	16	4	374

Continued

Primary	16	72	81	61	46	12	0	288
Secondary (1st cycle)	15	41	53	23	33	17	0	182
Secondary (2nd cycle)	5	32	27	29	20	9	0	122
University	0	11	15	13	13	8	0	60
Housing Tenure								
Owner	46	189	197	156	134	56	4	782
Tenant	15	63	43	31	27	5	0	184
Free occupancy	8	22	18	9	2	1	0	60
Household Income (USD per month)								
<80.12	30	80	75	55	26	1	0	267
80.12 - 160.24	12	63	47	31	23	0	1	177
160.24 - 320.49	27	92	88	44	34	2	0	287
320.49 - 480.73	0	39	41	50	46	29	3	208
>480.73	0	0	7	16	34	30	0	87
Overall	69	274	258	196	163	62	4	1026

Firstly, the education level of the head of household reveals a very marked gradient in the accumulation of flood protection measures. Households headed by people without schooling are predominantly concentrated in the categories adopting only one to two measures, reflecting a preference for basic and low-cost strategies, while very few of these households reach higher levels of measure accumulation. In contrast, households headed by individuals who have completed secondary or university education are more prevalent in the four to six measure categories, reflecting a greater capacity for anticipation and investment. Thus, the level of education appears to be a determining factor in the adoption of diversified and cumulative flood protection strategies.

Secondly, the distribution of flood protection measures according to property status clearly highlights the structural advantage enjoyed by homeowners. They account for almost all households that have adopted five to seven protective measures, reflecting their greater autonomy in decision-making and their ability to undertake structural interventions such as adding extra floors or building permanent structures. In contrast, tenant households remain largely confined to the lower accumulation categories (one to three measures), illustrating their limited room for maneuver due to their lack of rights over the building. Households occupying their homes free of charge have the lowest levels of accumulation, characterized by a virtual absence of structural measures. Overall, these patterns indicate that land tenure security is therefore a decisive factor of the depth of protective investments in flood risk mitigation.

Third, monthly income has a major influence on the intensity of the measures adopted. Low-income households (80.12 USD per month) remain concentrated at the lower levels (one to three measures), while more costly measures remain very marginal. This distribution highlights the predominant role of financial constraints in the ability to implement more elaborate protection strategies.

Overall, the results confirm that the effectiveness and diversity of adaptation measures implemented by households are closely linked to their socioeconomic resources, thereby reinforcing the idea of differentiated vulnerability to flooding. Households with greater economic, educational, and tenure security capacities are better positioned to implement a wider and more effective range of protective strategies, while resource-constrained households remain limited to fewer and often less durable measures.

3.4. Effectiveness of Different Flood Adaptation Strategies

The analysis in **Table 3** highlights statistically significant associations between several dimensions of households' socioeconomic profiles and their assessment of the effectiveness of flood protection measures. The results reveal a clear pattern in perceptions of effectiveness according to educational level, while the effect of residential status remains more muted. Monthly income appears to be the most strongly discriminating factor.

Table 3. Association between the socioeconomic profile of households and the perceived effectiveness of flood protection measures.

Socio-economic profile of households	Effectiveness of flood protection measures			
	Not effective	Moderately effective	Quite effective	Very effective
Education level of the household head				
No schooling	230 (61.50%)	67 (17.91%)	67 (17.91%)	10 (2.67%)
Primary	184 (63.89%)	62 (21.53%)	37 (12.85%)	5 (1.74%)
Secondary (1st cycle)	108 (59.34%)	24 (13.19%)	46 (25.27%)	4 (2.20%)
Secondary (2nd cycle)	70 (57.38%)	20(16.39%)	26 (21.31%)	6 (4.92%)
University	21 (35.00%)	12 (20.00%)	20 (33.33%)	7 (11.67%)
χ^2	49.458			
<i>p</i> -value	0.000			
Housing Tenure				
Owner	448 (57.29%)	149 (19.05%)	158 (20.20%)	27 (3.45%)
Tenant	119 (64.67%)	30 (6.30%)	30 (16.30%)	5 (2.72%)
Free occupancy	46 (76.67%)	6 (10.00%)	8 (13.33%)	0
χ^2	14.12			
<i>p</i> -value	0.079			

Continued

Household Income (USD)				
<80.12	224 (83.90%)	42 (15.73%)	1 (0.37%)	0
80.12 - 160.24	142 (80.23%)	29 (16.38%)	4 (2.26%)	0
160.24 - 320.49	224 (78.05%)	52 (18.12%)	10 (3.48%)	1 (0.35%)
320.49 - 480.73	23 (11.06%)	58 (27.88%)	116 (55.77%)	11 (5.29%)
>480.73	0	4 (4.60%)	65 (74.71%)	18 (20.69%)
χ^2	768.111			
<i>p</i> -value	0.000			
Overall	613 (59.75%)	185 (18.03%)	196 (19.10%)	32 (3.12%)

The first structuring factor is the level of education of the head of household. The chi-square value ($\chi^2 = 49.458$; $p < 0.001$) confirms a highly significant association between this factor and the assessment of protective measures. Households without schooling have a generally negative perception, with more than 61% of them considering the measures to be “not effective”. Conversely, households whose head has attained a university level of education express significantly more favorable assessments: 33.33% consider the measures “fairly effective” and 11.67% “very effective”, proportions that are significantly higher than those observed in lower levels of education. This gradient highlights the importance of educational capital in understanding, appropriating, and evaluating adaptation strategies.

The second determinant, occupancy status, shows a more moderate link, without reaching statistical significance ($\chi^2 = 14.12$; $p = 0.079$). Nevertheless, trends are emerging: homeowners report higher levels of perceived effectiveness (23.65% rated them as “fairly” or “very effective”) than tenants (19.02%), while households living rent-free give the lowest ratings, with 76.67% considering the measures to be “not very effective”, a situation likely linked to a low capacity or motivation to make sustainable investments.

The third determinant, monthly income, is by far the most decisive factor. The association observed is statistically very significant ($\chi^2 = 768.111$; $p < 0.001$). The poorest households (<80.12 USD per month) stand out with an extremely negative assessment: 83.90% consider the measures to be “not very effective” and less than 1% consider them to be “quite effective”. As income increases, the assessment improves significantly. Households with incomes between 320.49 and 480.73 USD per month give 61.06% positive assessments, and the wealthiest segment (>480.73 USD per month) gives 95.40% favorable opinions. This marked gradient confirms that financial capacity directly influences the quality, sustainability, and, consequently, the perceived effectiveness of developments.

Overall, nearly 60% of households consider the measures they implement to be “not effective”, reflecting widespread dissatisfaction despite the widespread adoption of protective measures. These results indicate that, despite households’ tan-

gible commitment to addressing risk, the perceived effectiveness of the strategies implemented remains closely linked to the volume and nature of the resources available to them, whether educational, land-based, or financial.

4. Discussion

The results reveal widespread adoption of flood protection measures by households in Ouagadougou, despite the inadequate urban drainage infrastructure. Almost all households adopt at least one preventive strategy, confirming that, as in several West African cities, adaptation to flooding relies heavily on individual “self-protection” initiatives in response to the structural limitations of drainage and urban development systems (Abass, 2023). The most commonly used measures, such as protective belts, solid construction, and fence perforation, reflect both the need to consolidate housing structures and the search for pragmatic adaptations to improve water drainage at the household level. This dynamic is consistent with observations made in other African urban contexts, where households develop localized technical responses to compensate for public infrastructure deficits (Mureithi, 2015; Nassor & Makame, 2021).

This diversity of measures, often combined, reflects a form of incremental adaptation, according to Intergovernmental Panel On Climate Change (IPCC) terminology, whereby gradual improvements are introduced without fundamentally changing the urban system (IPCC, 2023). While such adaptation demonstrates a degree of foresight at the household level, it remains limited by its predominantly individual nature and the lack of collective coordination. The relatively limited use of measures such as trenches and sandbags also highlights the material and land constraints faced by households, particularly in densely populated neighborhoods where available outdoor space is scarce. These trends are consistent with findings observed in Accra (Ghana), where land insecurity limits the implementation of more costly or spatially demanding flood protection measures (Owusu Twum & Abubakari, 2019; Twerefou et al., 2019).

Analysis of socioeconomic determinants highlights clear inequalities in access to protective strategies. Education level appears to be a major factor, influencing in particular the adoption of structural measures requiring investment or technical skills, such as solid construction and building elevation. Household heads with a university education are significantly more likely to implement these flood protection measures. These results are consistent with studies showing that education improves understanding of risk, the ability to evaluate different adaptation options, and the willingness to make long-term investments (Baytiyeh, 2018; Kitagawa, 2021).

Residential status also plays a significant role in shaping household investment in flood adaptation. Homeowners invest more in sustainable protection measures, benefiting from land security that reduces uncertainty about building use. Conversely, tenants and informal occupants continue to focus on less costly and less binding measures, reproducing a pattern of land inequality that has already been

well-documented as a key factor in urban vulnerability (Randrianantenaina & Émile, 2024).

However, monthly income appears to be the most decisive factor. Low-income households almost exclusively employ basic strategies, while wealthier households accumulate several measures, including the costliest ones. This economic stratification of adaptive capacities has also been documented in various African contexts, highlighting that poor households remain trapped in a cycle of vulnerability characterized by high exposure to hazards, insufficient protection, and limited resources to improve their living conditions (Abass, 2023; Houston et al., 2021).

The analysis of the cumulative number of adaptation measures confirms these socioeconomic inequalities. Educated, home-owning, and affluent households are disproportionately represented in the categories adopting four to six measures, indicating their ability to build a multi-layered protective framework against flooding. In contrast, vulnerable households can accumulate only a limited number of measures, which amplifies the effects of differential exposure and sensitivity to flood risks. These findings are consistent with the concept of “urban climate justice”, whereby the most vulnerable populations to climate related risks are often those with the fewest resources to protect themselves, even though they are the most exposed (IPCC, 2023).

Finally, the perceived effectiveness of the measures remains low overall: nearly 60% of households consider them to be “not effective. This gap between individual investment and satisfaction reveals the limitations of incremental adaptation, particularly in a context of intensifying hydrometeorological extremes in West Africa (Diop et al., 2025). Poor households, limited to basic measures, express the most negative perceptions, while wealthy households, with access to more robust solutions, report higher levels of effectiveness. These findings are consistent with the analyses of Owusu Twum & Abubakari (2019) and Abass (2023), which show that individual measures can partially reduce damage but remain insufficient to prevent events of increasing magnitude.

5. Study Strengths and Limitations

The study is the first attempt to assess preventive flood protection measures implemented by urban households in Ouagadougou, Burkina Faso. Its main strength lies in its focus on household-level structural adaptation strategies and in the analytical approach that distinguishes and compares different groups of determinants shaping the adoption of these measures. This framework provides valuable insights into the socio-economic mechanisms underlying differentiated adaptation capacities in a flood-prone urban context.

However, several limitations should be acknowledged. First, part of the analysis relies on self-reported data, particularly regarding the perceived effectiveness of protection measures, which may be affected by perception and reporting biases. Second, the cross-sectional design of the survey captures adaptation strategies at a single point in time and does not allow assessment of their evolution or long-

term effectiveness under repeated flood events. In addition, the findings are context-specific and cannot be directly generalized to other cities where flood dynamics, urbanization patterns, and institutional settings may differ. Finally, the study focuses exclusively on preventive structural measures at the household level, thereby excluding non-structural strategies and post-disaster responses that also contribute to flood-risk management.

Despite these limitations, the study provides robust empirical evidence on socio-economic inequalities in household flood adaptation and offers a useful basis for future research adopting longitudinal and more integrated analytical approaches.

6. Conclusion

This study demonstrates that, in a context marked by the increasing intensity and frequency of climate-related flood hazards, households in Ouagadougou do not adopt a passive stance. On the contrary, they implement a diversified range of predominantly preventive structural measures aimed at limiting flood-related damages. These measures include the use of solid construction materials, the installation of protection belts, the perforation of fences to facilitate water flow, the elevation of door thresholds, the digging of trenches, and the deployment of sandbags. However, the analysis reveals marked socio-economic inequalities in both the accumulation and quality of these measures, as well as in how their effectiveness is perceived. Education level, housing tenure, and above all household income strongly condition the ability to invest in robust and sustainable protections and shape positive assessments of their performance. Conversely, the poorest, least educated, and tenure-insecure households remain largely confined to low-cost, short-term solutions that they themselves consider insufficient.

These findings underline that vulnerability to flooding is deeply embedded in socio-economic inequalities and that household-level initiatives, while widespread, cannot offset structural deficits in drainage infrastructure, urban planning, and social protection. From a policy perspective, this calls for flood-risk management strategies that move beyond uniform approaches and instead rely on targeted interventions tailored to household capacities. Concrete measures may include material subsidies or voucher schemes to support low-income homeowners in upgrading flood-resilient building components (e.g., elevated thresholds, reinforced walls), micro-credit or revolving funds with adapted repayment conditions for incremental housing improvements, and public workshops providing technical guidance on affordable flood-resilient construction practices. At the neighborhood level, these household-focused actions should be complemented by investments in collective drainage infrastructure and participatory upgrading programs in flood-prone areas.

Overall, strengthening the effectiveness of household adaptation requires closer articulation between individual strategies and public interventions, supported by differentiated financing mechanisms and technical assistance. Future research

should adopt longitudinal approaches to better assess the durability of household adaptations over time and explore how integrated policy frameworks can reduce social inequalities while enhancing the sustainability of urban flood-risk governance.

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Author Contributions

All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by K. T., T. F. and M. O. The first draft of the manuscript was written by K. T. All authors commented on previous versions of the manuscript. H. K. helped for the funding acquisition. All authors read and approved the final manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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