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Choice of household adaptation strategies to flood risk management in Accra, Ghana

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ABSTRACT

In this paper, we discuss the psychological and socio-economic factors as well as the constraints that inhibit private precautionary flood-risk mitigation measures among urban households in the Greater Accra Metropolitan Area of Ghana within the Protection Motivation framework. The results show that threat appraisal has mixed effects on the decisions by households to adopt a damage protection measure against flooding. With regards to coping appraisal, the study found that households who do not feel helpless about flooding in the neighbourhood resort to some structural measures such as reinforcing their house against flood damage. The study also finds that socio-economic factors have an overall positive effect on protective behaviour. Additionally, structural measures taken by the public sector to provide protection against damage from a flood are shown to complement the adoption of some specific private protective measures such as clearing drains and sandbagging by households. We, therefore, recommend policy choices to focus on the provision of the needed community-level flood protection infrastructure since it stimulates private flood precautionary measures.

1. Introduction

Climate change and variability have a significant impact on livelihoods and the broader environment mainly resulting from extreme weather events, rising sea levels, drought and flooding [1] which deprives many countries of much-needed resources for development [2]. The Greater Accra Metropolitan Area (GAMA) is the capital city and the economic hub of Ghana. It has a population of about 4.7 million in 2015 and rainfall is quite erratic Twerefou et al., [3]. This has resulted in flooding which has destroyed properties and claimed lives. Between 2001 and 2015, Ghana experienced about 13 major floods [4] which affected over 178,000 people with 250 fatalities. Munich Re [5] estimates that the economic cost of floods has been increasing exponentially in recent times.

Several factors determine flood damage and vulnerability, including exposure, sensitivity and adaptation [6]. Flood exposure relates to measurable indicators such as frequency and duration while flood sensitivity is associated with indicators such as population density, economic value, among others. While flood exposure and sensitivity influence potential damage, actual damage can be mitigated by adaptation defined as the ability to avoid potential damage through adjustments in ecological, social or economic systems in response to flood impacts [6].

Although some adaptation measures may require significant investment in infrastructure such as the construction of drains and embankments, among others, other simple mechanisms exist such as reorganisation of household equipment, sand-bagging or relocation [7–9]. Many of these simple adaptations can substantially mitigate household floods impact. For instance, Schmuck [10] showed that in Char lands, Bangladesh, simple adaptation strategies such as building platforms out of reeds for animals and fixing wooden beds below the roof were crucial to their survival. Also, Fink et al. [11] established that simple adaptations taken by residents in Cologne, Germany, were instrumental in reducing losses by more than half in 1995 from an estimated €65bn in 1993.

Adaptation can be classified into public and private and also into reactive and precautionary [1,12]. Private precautionary adaptation is driven by the self-interest of households or communities and involves measures taken before floods, such as reinforcement of houses, clearing of gutters and relocation, and these have a significant impact on flood damage [11]. Public precautionary measures include the building of levees to redirect floodwaters, among others. Where such efforts are deemed effective by households, they are less likely to undertake private precautionary measures [12]. The complex nature of decision-making on flood risk which revolves around technical, institutional, psychological and social complexities makes the identification of the determinants of precautionary measures quite imperative for every social planner.

The Greater Accra Metropolitan Area (GAMA) is a low-lying flood-prone and highly urbanized area. Three types of flood hazards can be identified in GAMA: flooding arising from inadequate drainage, flooding from

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the overflow of streams, rivers and lagoons and coastal flooding from the sea through storm surges and tidal waves [13] all of which are directly or indirectly related to climate change. Within the metropolis, over 90% of flood-prone communities are informal settlements where poor physical and socio-economic living conditions prevail (ibid).

Historical data on heavy rain (Number of days when rainfall is >20 mm) over GAMA from 1980 to2020 [14] is generally variable (Fig. 1) but shows an increasing trend. The dominating positive anomalies could imply a high probability of potential meteorological hazards triggered by heavy rainfall events in GAMA. Indeed rainfall projections by McSweeney et al. [15] from different models show a wide range of changes with majority projecting increases. The increasing intensity coupled with the poor adaptive capacity suggests that flooding will be a significant challenge for Ghana. Griggs and Noguer [1] report that flooding is one of the main impacts of increased rainfall intensities and is expected to impact on many communities globally.

Despite these forewarnings, it is not clear how households living in flood-prone GAMA can be motivated to cope better with future floods. Also, it is unclear what factors inhibit households from undertaking private precautionary measures against flooding which is central to mediating flood exposure and sensitivity and consequently, damage. Factors that potentially influence household's decision to undertake private precautionary adaptation may broadly be psychological, such as previous flood experience, flood risk perception, fear, or socio-economic, such as age, sex, educational level, nature of tenancy [16,17].

The overall objective of the study is to provide insights on the psychological and socio-economic factors that influence private precautionary flood-risk adaptation in the GAMA, as well as the barriers using the basic and extended versions of the Protection Motivation Theory (PMT). These are to serve as key inputs to flood risk management policy in flood-prone urban areas in Ghana. The paper aims at providing answers to the following questions: What are the factors that encourage or impede the adoption of any kind of private precautionary measure against flood damage? What kind of private precautionary measures against flood damage do households implement and what are the determinants? These questions are answered using the basic and extended versions of the PMT framework.

The study's focus on the Greater Accra Metropolitan Area arises from the fact that it remains the most urbanized locality in Ghana with the highest flood-related deaths, injury, damage to property that present a serious challenge to institutions and society (Codjoe and [18]). The flood risk in GAMA and many other urban areas is compounded by poor waste disposal practices and drainage systems, silting and choking of drains, land-use change and informal urbanization, all of which remain a key challenge for the local authorities and the government. Addressing these challenges requires a multi-pronged approach involving particularly private efforts at flood mitigation to complement public measures. Analysing the factors that determine private precautionary mitigation actions will enable government design policy choices on flood control in urban areas and in line with Sustainable Development Goals 9 and 11 of building resilient infrastructure and making cities and human settlements inclusive, safe, resilient and sustainable.

2. Theoretical framework and empirical review

2.1. Theoretical framework

Modelling the determinants of households' flood adaptation choices requires accounting for both psychological and socio-economic factors [12], which is made possible by the PMT developed by Rogers [19] following the works of Lazarus [20] and Leventhal [21]. The authors provide a conceptual understanding of how individuals evaluate threats and the factors that motivate their response. The PMT was developed initially for psychological research on health behaviour, but has in recent years remained a prominent framework for the assessment of adaptation strategies of households to natural disasters such as flood risk [12,22,23].

According to the PMT, individuals are inclined to take steps towards personal protection against a given hazard if they believe that the threat they face is high – threat appraisal – and the coping appraisal – their ability to effectively address the threat – is high. Threat appraisal thus describes how a household assesses a threat's probability of occurrence and damage potential to property, assuming no change in his or her behaviour and has two subcomponents: perceived probability and perceived consequences

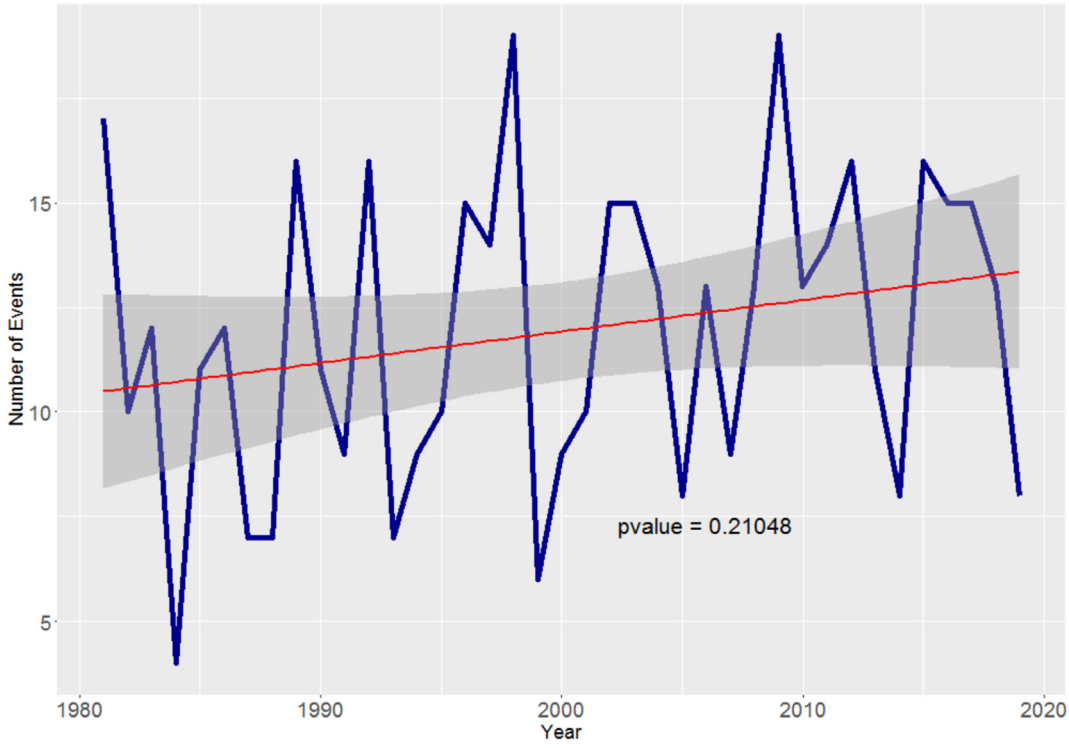

Fig. 1. Number of days when rainfall in greater that 20 mm in Accra, 1980–2020 Source: Calculated with data from the Ghana Meteorological Authority.

which leads to fear or worry. The coping appraisal evaluates a person's ability to cope with and avert being harmed by the threat, along with the cost of coping, and usually takes place after the threat appraisal process has passed a certain threshold [24]. Coping appraisal has three subcomponents: protective response efficacy, perceived self-efficacy and protective response costs [12].

The response of an individual to a given risk may be protective or non-protective. The adoption of a protective response by an individual will hinge on the conviction that the steps to be taken are sufficient to deal with the threat (high response efficacy), they are within the capability of the individual (high self-efficacy) and necessarily override the cost of taking action (low response cost) [25]. Protective responses are those that prevent monetary or physical damage if an event occurs and may be private or public. However, an individual may have a non-protective response despite a high threat appraisal if the perceived response costs are considered to be too high. In other words, low coping appraisal despite high threat appraisal is unlikely to yield protective response. The non-protective response includes denial, wishful thinking and fatalism.

Although the PMT basic sought to explain the processes by which fear, elicited through verbal communication can influence attitudinal change and thus behavioural change, the framework has been extended to capture other sources of information including personality, observational learning and prior experience that can also elicit protection motivation. Thus, within an extended framework, other components, such as flood experience, barriers and socio-economic characteristics may augment the analysis as shown in Fig. 2 [17]. Grothmann and Reusswig [12] note that protection motivation may not necessarily lead to actual protective behaviour due to barriers such as money, knowledge or social support that are not expected at the time of intention forming and can, therefore, be included in an estimation of a PMT model. This study uses the basic and extended versions of the PMT to analyse the links between households' flood risk perception and coping response in flood-prone areas of the GAMA.

2.2. Empirical literature

The literature on PMT generally shows that coping appraisal positively correlates with the adoption of response behaviour (see [26,27]). However, the explanatory power of threat appraisal is often not strong, evidenced by the mixed empirical results on the relationship between flood risk perceptions and private precautionary efforts [16].

While studies such as Reynaud et al. [23] and Terpstra [28] report that increased perception of floods vulnerability results in adaptation measures, others such as Wachinger et al. [29] and Bradford et al. [30] have cast doubts on the causal relationship using cross-sectional data on various European economies. Bubeck et al. [16] attributed the latter to two reasons: first that households' response to perceived risk may be non-protective arising from fatalism, wishful thinking and denial, and secondly, the inability to properly account for possible feedback from previously adopted precautionary measures on current risk perceptions. Richert et al. [26] confirm that feedback effects from previous flood mitigation measures affect current explanatory factors and that risk perceptions decline following the implementation of precautionary measures. This suggests that adaptations to flooding need to be considered as dynamic and not static.

Bubeck et al. [16], using data for the period 1980 to 2011, found that flood mitigating measures increased among households living near the Rhine river in Germany after severe floods even though Siegrist [41] and Takao et al. [31] argued that the severity of the negative flood impact may be more important than past floods. Kron and Thumerer [32] also found that areas with recent flooding experienced significantly lower damage than those that had not recently experienced flooding suggesting that the period that has elapsed between flood events also influences the adoption of private adaptation measures. The reason provided is that persons living in areas that had experienced recent floods are better prepared for floods than those in areas with a large interval between flood events.

Baldassarre1 et al. [33] developed a dynamic model to represent the interactions and feedback loops between hydrological and social processes to explore the dynamics of the human-flood system and the effect of changing individual characteristics, including external forcing such as technological development. The results showed that the conceptual model is able to reproduce reciprocal effects between floods and people as well as the emergence of typical patterns. For instance, they showed that when levees were built or raised to protect floodplain areas, their presence not only reduces the frequency of flooding but also exacerbates high water levels; then, because of this exacerbation, higher flood protection levels are required. They concluded that more and more flooding events are avoided, but rare and catastrophic events can take place.

Fuchs et al. [34] used data from Greece to examine private adaptation capacity and willingness with respect to flooding in two different catchments areas prone to multiple flood events during the last 20 years. Their results, based on a comparison of results from the different sites, have shown that both the levee effect and the adaptation effect have considerably different characteristics; as flood experience alone is not sufficient to encourage local adaptation strategies. They concluded that because of the different notion of risk, those who are responsible for developing and implementing flood risk management strategies need to understand and to include the individual risk construction of those affected people.

More recently, Eakin et al. [35] used data from Mexico City to argue that households' efforts to adapt in conditions of marginality can come at the expense of households' investment in other aspects of human welfare, reinforcing poverty traps. They showed how such cross-scale connectivity is failing as a result of lack of trust and transparency, the difficulty of collective action, and the devolution of some responsibilities for risk

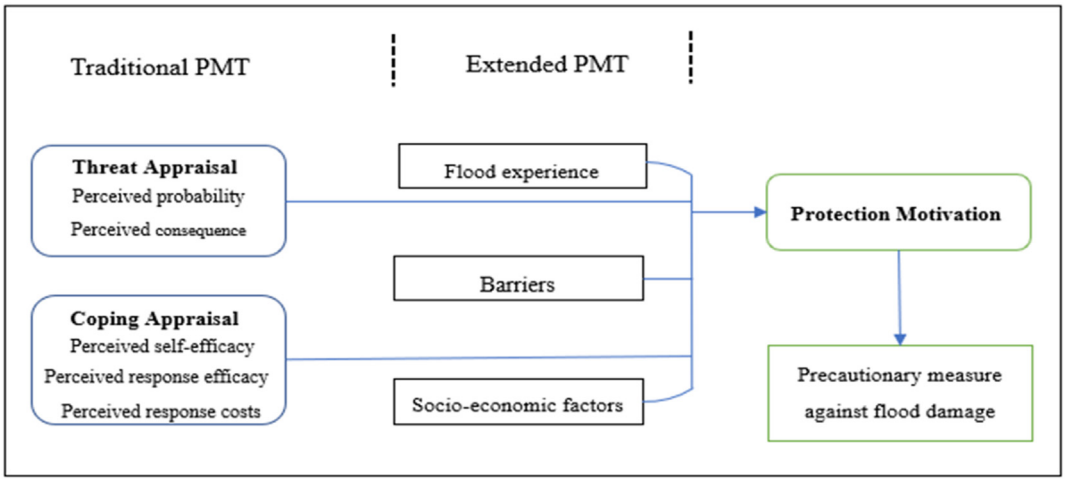

Fig. 2. Protection motivation framework Source: Adapted from Poussin et al. [17].

management from the public sector to households. They concluded that greater public attention should focus on ensuring that private adaptation does not come at the cost of more generic welfare loss among the most vulnerable populations.

The literature does not overtly support the view that flood knowledge is an important determining factor of flood mitigating measures. While studies such as Miceli et al. [36] and Thieken et al. [37] establish a weak positive relationship between flood information and private mitigation measures, Botzen et al. [38] found that flood information recipients are less likely to adopt mitigating measures. Also, Zaleskiewicz et al. [39] observed no significant difference between households that bought flood insurance and those which did not.

The role of socioeconomic factors such as age, sex, education, income, among others, in explaining private precautionary measures has been explored as part of efforts to extend the PMT and are found not to consistently explain flood mitigating behaviour [27]. Age and education have been found not to play a significant role in flood mitigation behaviour [27,40]. In terms of gender, women are perceived to have a relatively higher risk perception compared to men, but this does not reflect in a greater likelihood of flood mitigation measures [38] and tenants are less likely to adopt precautionary measures than homeowners [37] since they do not bear the cost of flood damage to building and require approval in implementing structural mitigation measures.

The PMT acknowledges the presence of barriers to the adoption of private precautionary measures. Some of these barriers include negative perceptions on government support after flooding [38], cost of mitigation [41], non-protective responses such as hopelessness and wishful thinking [12] even though studies such as Reynaud et al. [23] in Vietnam and Poussin et al. [17] in France established a positive relationship between public precautionary measures and private efforts.

3. Materials and methods

The study was undertaken in the Greater Accra Metropolitan Area which lies between longitude 0°1′W and 0°15′E and latitude 5°30′N and 0°15′E. The GAMA can be found within the dry climatic zone and experiences a two-fold rainy seasons: from May to the middle of July and from mid-August to the end of October [42]. It is the capital city and the economic hub of Ghana, covers an area of about 3245 sq. km and has a population of about 4.7 million in 2015. The survey was undertaken by the team in the GAMA under the Integrated Climate-smart Flood Risk Management project. The project sought to investigate how to manage socio-demographic changes and risks resulting from the impact of climate changes in the GAMA.

3.1. Sampling approach

A National Master Sampling Frame constructed from the 2010 Ghana Population and Housing Census by the Ghana Statistical Service (GSS) was used to select the required number of households. Based on information on flood-risk prone map developed by Kasei [14], two communities in each of the seven districts - Accra Metropolitan Assembly, La Dade-Kotopon Municipal Assembly, Ledzokuku Krowor Municipal Assembly, Adentan Municipal Assembly, Ashaiman Municipal Assembly, Tema Metropolitan Assembly (TMA) and Kpone-Katamanso Municipal Assembly that form the GAMA were purposively selected. Three Enumeration Areas (EA) were randomly selected from each of the fourteen communities selected in the GAMA. Subsequently, an extensive listing and map-spotting exercises were carried out in all eligible households within the selected EAs to update the list of households of usual residence.

The frame for selection of households was based on the names and addresses of households within the proposed EAs. Following the ordered sampling frame, thirty households were systematically selected from all the communities in the seven districts. Out of the total 1260 households that were selected, 1252 were identified for the interviews out of which 1204 representing 93.3% response were successfully completed with the aid of Computer Assisted Personal Interviews. Questionnaires that covered a broad range of issues, including household housing and neighbourhood characteristics, employment, assets, sanitation, flooding and its impact, adaptive capacity and resilience were administered between October and November 2017.

3.2. Empirical model

In line with the theoretical framework, we estimate two PMT models in which both psychological and socio-economic factors influence, first, the decision by households to undertake any kind of private precautionary measure in response to flooding as against doing nothing, and secondly, the decision to choose a particular private precautionary measure among other mutually exclusive measures as against doing nothing.

The first model is a probit estimator, which is expressed as:

$$Y_i = \alpha_i X_i + \varepsilon_i \quad (1)$$

where Y_i is a binary variable indicating the decision to implement any kind of private precautionary measure and X_i represents various psychological and socio-economic factors.

The second model explores factors that will influence a specific private precautionary (protective) response against doing nothing (non-protective). These protective response choices are actions related to sandbagging, clearing of drains, reinforcement of dwelling and relocation as against doing nothing (non-protective). Given the multivariate nature of these responses and the fact that they are mutually exclusive in the survey, relying on the probit model may not be desirable. We relied on a multivariate choice model. The multinomial logit estimator is one such model that has been frequently used for such purposes. We relied on this estimator and specify as follows:

$$p_{ij} = p(y_i = j) = \phi\left(x'_{ij}\beta\right) \quad (2)$$

where Y_i is the response variable (sandbagging, clearing of drains, reinforcement of dwelling and relocation) and doing nothing is the reference category. X_i is as earlier defined.

3.3. Dependent variables

Out of the 1204 households that provided valid responses, 608 representing 50% indicated they had experienced flooding currently or in the past and therefore formed the basis of our analysis. Table 1 provides descriptive statistics of the variables. The violin plots of the variables are presented in the Appendix 1. The dependent variable for the first model is based on responses to a question that asked households about how they prepare towards floods. About 67% reported undertaking some protective response while the remaining (33%) did not. The dependent variable for the second model is the list of mutually exclusive coping responses. About 33% indicated they reinforce their dwellings, 16% cleared drains, 14% used sandbags as a barricade, 3% indicate their desire to relocate. The remaining (34%) did not respond to this question.

3.4. Independent variables

We classify the independent variables into threat appraisal, coping appraisal, flood experience, barriers to private precautionary measures and socio-economic factors. While the threat and coping appraisals are within the basic PMT framework, flood experience, barriers and socio-economic factors feature within an extended PMT framework.

3.5. Threat appraisal

Threat appraisal involves the perceived probability and consequence of future floods. We use two variables to capture the perceived probability of flooding - flood frequency and flood prediction. We rely on responses to a

Table 1
Variable description and summary statistics.

Variable	Values	Mean	Min	Max
Dependent variables				
Protective response	Dummy: 1 if protective response, 0 otherwise	0.666	0	1
Sandbag	Dummy: 1 use of sandbag, 0 otherwise	0.140	0	1
Reinforce house	Dummy: 1 if reinforce house, 0 otherwise	0.334	0	1
Clear drains	Dummy: 1 if cleared drains, 0 otherwise	0.164	0	1
Relocate	Dummy:1 if relocate, 0 otherwise	0.030	0	1
Independent variables				
Threat appraisal				
Increased risk	Dummy: 1 if flood risk increased, 0 otherwise	0.176	0	1
Same risk	Dummy: 1 if flood risk same, 0 otherwise	0.163	0	1
Decreased risk	Dummy: 1 if flood risk decreased, 0 otherwise	0.452	0	1
Predict flood	Dummy:1 household can predict flooding, 0 otherwise	0.339	0	1
Coping appraisal				
Helpless	Dummy: 1 if household feels helpless, 0 otherwise.	0.069	0	1
Info prep meeting	Dummy: 1 if the household has attended a meeting on coping with flooding, 0 otherwise	0.109	0	1
Flood experience				
Flood exposure	Continuous: Minimum number of times of flood in 5 years	5.789	0	10
Flood damage	Dummy:1 if experienced flood damage, 0 otherwise	0.829	0	1
Flood intensity	Continuous: last flood water level on the wall	22.420	0	350
Barriers				
Community drains	Dummy: 1 if drains have been constructed in the past 5 years in the community, 0 otherwise	0.189	0	1
Community sea defence	Dummy: 1 if sea defence wall has been put up in the past 5 years, 0 otherwise	0.054	0	1
Community desilt	Dummy: 1 if drains have been desilted in past 5 years, 0 otherwise	0.303	0	1
Community demolish building	Dummy: 1 if buildings on waterways have been demolished in the past 5 years, 0 otherwise	0.020	0	1
Community waste disposal	Dummy: 1 if there have been changes in community waste disposal in the past 5 years, 0 otherwise	0.188	0	1
Household after flood support	Dummy: 1 if the household received support after a flood, 0 otherwise.	0.549	0	1
Log monthly income	Continuous: Log of the monthly income of the household head	863.268	0	20000
Modified building	Dummy: 1 if household modified building in the past 5 years, 0 otherwise	0.472	0	1
Erect barrier	Dummy: 1 if household erected flood barrier in past 5, 0 otherwise.	0.433	0	1
Flood info	Dummy: 1 if the household received information about floods from government intuitions, 0 otherwise	0.215	0	1
Socio-economic factors				
No education dummy	Dummy: 1 if the head has no education, 0 otherwise	0.087	0	1
Primary school dummy	Dummy: 1 if the head has completed primary education, 0 otherwise	0.109	0	1
Basic education dummy	Dummy: 1 if the head has completed basic education, 0 otherwise	0.464	0	1
Secondary school dummy	Dummy: 1 if the head has completed secondary education, 0 otherwise	0.155	0	1
Post-secondary and above dummy	Dummy: 1 if the head has completed tertiary education, 0 otherwise	0.186	0	1
Female	Dummy: 1 if head is female, 0 otherwise	0.306	0	1
Age	Continuous: Age of household head	43.776	19	99
Married	Dummy: 1 if head is married, 0 otherwise	0.584	0	1
Indigene	Dummy: 1 if the household head was born in the locality, 0 otherwise	0.197	0	1
Homeowner	Dummy; 1 if head is the homeowner, 0 otherwise	0.441	0	1
Household size	Continuous: Number of persons in the household.	3.768	1	17
Observations				608

Source: RIPS's Survey, 2017.

question that asked respondents about their thoughts on the frequency of current floods compared to the past five years – whether it has increased, decreased or remained the same. These responses were used because we expect households to base their perceptions about future flood risks on patterns of the past few years. About 18% of the respondents felt the risk of flooding had increased as the frequency of recent floods were higher compared to the last five years, 16% felt it was the same, and 45% felt it has decreased. The rest (21%) did not respond to the question. To capture flood prediction, we used responses to a question that inquired if any member of the household can predict when it is going to rain and by implication flooding in the neighbourhood. While this variable is not a perfect measure of the perceived probability of future floods, it provides some insight into the mindset of households living in flood-prone areas towards an assessment of the threat of flooding. About 34% of households had members that can predict floods (see Table 1).

3.6. Coping appraisal

We follow Reynaud et al. [23] and adopt indirect coping appraisal measures such as information, preparedness and helplessness to capture the cognitive processes involved in coping appraisal. Availing oneself to information about flooding is essential because an individual develops a better appreciation of the threat which influences preparedness. To measure this variable, we rely on responses to a question that inquired if respondents have attended a community meeting where emergency or disaster preparedness was discussed and if they have received information from any governmental institutions on flooding and storms. About 11 and 22% of respondents reported attending such meetings and receiving such information respectively. Also, we created a variable for self-perceived helplessness based on responses to a question that inquired if respondents think that flooding in the community could be minimised. About 93% thought flooding could be minimised suggesting that 7% felt helpless about the situation.

3.7. Flood experience

The study also captures variables related to prior flood experience which include flood exposure, flood damage and flood intensity. To measure flood exposure, respondents were asked to indicate the frequency of flood occurrence in the past five years. On average, households reported experiencing flooding about 5.8 times in the past five years (see Table 1). To measure flood damage, responses from a question that asked respondents if they had been affected by flood now or in the past, including the destruction of home, asset or livestock, pollution of drinking water, loss of income or human life, and affected by diseases. About 83% of respondents indicated they had suffered some damage from flooding. Flood intensity

was based on responses to a question on the flood water level on the wall from the last rainy season which was physically measured. The average elevation as measured by enumerators was about 22 cm (see Table 1).

3.8. Barriers to flood protection

Factors such as past private and public flood mitigating actions or the availability of external support during flooding may be obstacles to the adoption of private flood mitigating measures. For instance, the provision of drains in communities or prior reinforcement of dwelling may minimise or eliminate the need to undertake private mitigating actions if there is confidence in their efficacy. To account for this phenomenon, we introduce a first set of variables which capture the following public flood mitigation measures provided in the community in the past five years: drain construction, sea defence, desilting of drains, demolition of buildings on waterways and proper waste management as dummies and a second set of variables that capture households' implementation of the following private mitigation measures in the past five years: modification of house structure such as walls, roof or floor in anticipation of floods and erection of physical barriers as dummies. Another dummy variable was also introduced to capture if a household has received any support in the form of financial, social, or material after flooding.

3.9. Socio-economic factors

These included personal and socio-economic characteristics of the household or head. Personal characteristics include sex, marital status, age and education of the household head, homeowner, income and whether or not the household head/respondent was born in the locality in which the interview was conducted (indigene).

Based on the tenets of the PMT and empirical evidence from the literature, we expect threat appraisal, coping appraisals and flood experience be associated with the likelihood of taking private precautionary measures against flooding, and mixed results from barriers and the socio-economic factors.

3.10. Correlation results

An assessment of the correlation between the independent variables is undertaken using the Pearlman correlation coefficients to test for multicollinearity. Results from the Pearlman correlation estimation (Appendix 2) indicates that the correlation between all the variables in all the models is <0.80, suggesting that the variables do not suffer from high correlation as argued by Bryman and Cramer [43].

4. Results

4.1. Factors influencing private protective response to flood damage

Table 2 shows the results for two expressions of Eq. (1): column 1 has estimates of a basic PMT; in column 2 is the extended PMT model in which the effect of flood experience, socio-economic variables and barriers are also estimated.

4.2. The role of risk

The results from the basic PMT model (column 1) shows that households who feel that there is still some flood risk, albeit decreased compared to five years ago, are more likely to take protective action against flood damage. In the extended PMT framework (column 2), a feeling of decreased risk of flood damage among households is still associated with a likelihood of the household implementing some protective action against flood, given flood experience, various barriers and socioeconomic factors.

Table 2
Logistic regression of determinants of a protective response.

	Variables	Basic	Extended
Threat appraisal	Increased risk	0.010 (0.301)	0.428 (0.509)
	Same risk	0.077 (0.298)	0.410 (0.507)
	Decreased risk	0.544** (0.246)	0.929** (0.474)
	Predict flood	0.174 (0.216)	0.124 (0.244)
Coping appraisal	Helpless	−0.404 (0.342)	−0.322 (0.399)
	Info prep meeting	−0.022 (0.284)	−0.082 (0.310)
Flood experience	Flood exposure		−0.007 (0.029)
	Flood damage		−0.983* (0.508)
	Flood intensity		0.000 (0.004)
Barriers	Community drain construction		0.854*** (0.287)
	Community sea defence		0.323 (0.513)
	Community desilt		0.043 (0.231)
	Community demolish buildings		−1.123* (0.624)
	Community waste disposal		0.028 (0.285)
	Household after flood support		0.265 (0.218)
	Log monthly income		−0.036 (0.056)
	Modified building		0.659*** (0.223)
	Erect barrier		0.620***(0.227)
	Flood info		−0.667***(0.246)
Socio-economic	Primary		0.879**(0.436)
	Basic		0.831**(0.346)
	Secondary		0.728*(0.408)
	Tertiary		0.745*(0.387)
	Female		0.038(0.253)
	Age		0.001(0.008)
	Married		0.081(0.237)
	Indigene		0.683**(0.285)
	Homeowner		−0.003(0.211)
	Household size		−0.016(0.049)
	Constant	0.135(0.305)	−0.498(0.708)
	Districts	Yes	Yes
	Observations	608	608

Source: RIPS's Survey, 2017.
Notes: Robust standard errors in parentheses.
□□□ $p < 0.01$.
□□ $p < 0.05$.
□ $p < 0.1$.

4.3. Previous experience of damage from flooding

No significant relationship is found between protective response and flood exposure in terms of the number of times the household had experienced flooding in the last 5 years, on the one hand, protective response and flood intensity in terms of the level of floodwater on the wall from the last flood. However, households that had experienced some damage, personal harm or loss from flood seemed more likely to do nothing by way protective response against further flood damage.

4.4. Barriers to private protective response

Different structural flood protection interventions by the local or national government aimed at mitigating flood damage appear to have different effects on the likelihood of households adopting any kind of action to minimise damage from flooding. On the one hand, the availability of community drains increases the likelihood of households adopting some protective measure against flooding. On the other hand, households living in communities in which houses built on waterways had been demolished appear less likely to adopt some protective action against flood damage.

The results further indicate that previous private structural protective actions against flood damage increase the likelihood of households adopting some kind of protective response to flooding. In particular, households that had previously modified their buildings or erected a flood barrier

within their premises in the last five years were more likely to adopt some protective measure against flood damage than those who had not.

One would generally have expected that information about flooding and storms from government institutions will positively influence the likelihood of households adopting some form of protective action to prevent flood damage. The results, however, show that households that received information about floods and storms were less likely to take some action to limit flood damage. This results is puzzling. Income, measured as the natural log of the household head's income, was not found to have a statistically significant effect on the likelihood of adopting any kind of protective response to flooding.

4.5. Socio-economic factors

Compared to household heads without education, all household heads with education from primary school level up to the tertiary level were more likely to adopt a protective response to flood damage. Again, household heads who indicated they were born in the locality (indigene) appeared to be more likely to adopt one form of a protective response to flooding compared to those who were not born in the locality.

4.6. Determinants of specific adaptation strategies

Various protective response strategies against flood damage are available to households. However, these strategies vary by way of input required, such as effort and materials needed, the investment required and potential efficacy in dealing with the risk of flood damage. The main strategies outlined by respondents in the study include the clearing of drains to facilitate the free flow of floodwaters, use of sandbags as a barricade against floodwaters, reinforcement of building structure and relocation. To examine factors that influence the decision of households to undertake a particular protective response as against doing nothing, we estimate a multinomial logit model for the mutually exclusive options with the base category being a non-protective response. Results of the basic and extended PMT models are presented as Tables 3 and 4 respectively.

4.7. Perceived probability of floods

From the basic PMT model in Table 3, the perceived probability of flooding either through some basic risk assessment or through the ability to predict floods is found to have varying effects on the different protective actions against flooding. Households who were of the view that the current frequency of floods had increased compared to five years ago, and therefore, the current risk of flooding had increased were more likely to do nothing than clear drains. Households that regarded the current frequency of flooding to be unchanged and therefore posed the same risk were more likely to adopt the use of sandbags rather than do nothing, and less likely to clear drains. Those who were of the view that the current frequency of flooding had declined and therefore faced a declining risk were nonetheless more likely to adopt sandbagging or reinforce their houses against potential flood damage. Also, households that indicated that they could predict the onset of floods were less likely to use sandbags, but more likely to reinforce their houses than doing nothing.

In the extended PMT model (Table 4), the perceived probability of flood damage by households appears to have an effect only on protective actions involving the use of sandbags and reinforcing houses. Households with the view that there was some risk of flooding, albeit decreased, were more likely to reinforce their houses rather than do nothing. However, those who could predict the onset of flooding were more likely to do nothing than adopt the use of sandbags.

4.8. Perceived response- and self-efficacy in flood-damage mitigation

The survey asked respondents whether they felt that flooding in their neighbourhood could be minimised as a way of measuring how helpless they felt about their situation. The results of the basic model (Table 3) shows that households that felt helpless about their situation were less likely to reinforce their houses against flood damage. In the extended model, this finding persists, suggesting that the feeling of helplessness is associated with doing nothing to prevent flood damage.

4.9. Flood experience

Typically, one would expect that any prior experience of damage, personal harm or loss as a result of flooding in the past will motivate a household to adopt some mitigating action. We, however, observe (Table 4) that households who reported to have been affected by floods in the form of destruction of home, asset, livestock, pollution of drinking water, loss of income or human life were less likely to reinforce their house and would rather do nothing.

4.10. Barriers to flood mitigation measures

Barriers have mixed effects on the private precautionary response (Table 4). Both private and public flood mitigation measures in the past influence current private protective response as the construction of drains are associated with the likelihood of sandbagging as against doing nothing and clearing drains rather than doing nothing. Also, the construction of sea defence is associated with the likelihood of using sandbags rather than doing nothing. Households that have undertaken precautionary actions in the past five years were found to take further steps to attenuate the impact of floods as those that have modified their house structure and erected barriers in the past five years are more likely to reinforce their houses as against doing nothing. Furthermore, households that had in the past

Table 3
Multinomial logit estimates of basic PMT Model.

Variables	Sandbag	Reinforce	Clear drains	Relocate
Threat appraisal				
Increased risk	0.437(0.494)	0.386(0.354)	−0.819*(0.446)	−1.126(1.232)
Same risk	0.858*(0.468)	0.395(0.361)	−1.118**(0.477)	0.132(0.948)
Decreased risk	1.015***(0.394)	0.831***(0.306)	−0.208(0.333)	0.453(0.748)
Predict flood	−0.612*(0.332)	0.470** (0.238)	0.203(0.328)	−0.073(0.585)
Coping appraisal				
Helpless	0.446(0.459)	−1.080**(0.506)	−0.457(0.505)	0.155(1.153)
Info prep meeting	0.047(0.437)	−0.276(0.341)	0.288(0.400)	0.266(0.834)
Constant	−2.136***(0.535)	−0.725*(0.372)	−0.825*(0.454)	−2.331***(0.862)
Observations	608	608	608	608

Source: RIPS's Survey, 2017.
Note: Robust standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

Table 4
Multinomial logit results of extended model

Variables	Sandbag	Reinforce	Clear drains	Relocate
Threat appraisal				
Increased risk	0.972(0.909)	1.192(0.765)	−0.360(0.761)	−2.378(1.624)
Same risk	1.244(0.899)	1.105(0.765)	−0.791(0.780)	−1.485(1.435)
Decreased risk	1.422(0.864)	1.573**(0.742)	0.166(0.704)	−0.712(1.264)
Predict flood	−0.715**(0.364)	0.350(0.268)	0.243(0.362)	0.266(0.659)
Coping appraisal				
Helpless	0.357(0.503)	−1.064*(0.553)	−0.452(0.577)	1.058(1.453)
Info prep meeting	−0.144(0.480)	−0.437(0.376)	0.331(0.439)	0.356(1.009)
Flood experience				
Flood exposure	0.027(0.042)	0.002(0.033)	−0.025(0.040)	−0.075(0.084)
Flood damage	−0.868(0.934)	−1.465*(0.784)	−0.989(0.740)	2.093(1.620)
Flood intensity	−0.007(0.006)	−0.003(0.004)	0.005(0.005)	0.004(0.007)
Barriers				
Community drain construction	1.061**(0.415)	0.385(0.356)	1.473***(0.368)	0.379(1.242)
Community sea defence	1.450**(0.707)	0.310(0.577)	−0.218(0.752)	−13.574 (1,024.508)
Community desilt	−0.379(0.362)	0.142(0.270)	0.350(0.323)	0.295(0.769)
Community demolish buildings	−0.606(0.981)	−1.295(0.965)	−1.012(0.883)	−13.423 (1,237.457)
Community waste disposal	−0.328(0.438)	0.181(0.322)	−0.033(0.378)	−1.095(1.281)
Household after flood support	0.417(0.321)	0.475*(0.260)	−0.074(0.319)	0.868(0.690)
Log monthly income	−0.169**(0.083)	0.029(0.068)	−0.013(0.081)	−0.117(0.185)
Modified building	0.451(0.349)	1.218***(0.271)	−0.011(0.348)	−0.623(0.838)
Erect barrier	0.358(0.355)	0.809***(0.270)	0.519(0.352)	0.410(0.825)
Flood info	−0.964**(0.408)	−0.910***(0.298)	−0.299(0.340)	0.057(0.691)
Socio-economic				
Primary	0.692(0.686)	0.586(0.529)	1.441**(0.621)	1.317(1.476)
Basic	0.769(0.580)	0.754*(0.422)	0.834(0.542)	1.797(1.284)
Secondary	1.048(0.657)	0.514(0.496)	0.602(0.633)	1.648(1.498)
Tertiary	0.860(0.658)	0.895*(0.476)	0.039(0.642)	2.287(1.453)
Female	0.005(0.395)	0.033(0.296)	−0.161(0.362)	0.937(0.867)
Age	0.003(0.012)	0.003(0.010)	−0.004(0.012)	−0.004(0.027)
Married	0.636*(0.370)	−0.008(0.282)	−0.253(0.343)	0.470(0.867)
Indigene	0.698*(0.409)	0.549*(0.323)	1.118***(0.387)	−0.858(1.168)
Homeowner	−0.051(0.310)	0.163(0.247)	0.084(0.305)	−1.970**(0.865)
Household size	0.024(0.073)	−0.029(0.060)	−0.022(0.076)	0.012(0.160)
Constant	−3.000**(1.179)	−1.881**(0.894)	−0.878(1.063)	−4.704*(2.714)
Districts		Yes		Yes
Observations	608	608	608	608

Source: RIPS's Survey, 2017.
Note: Robust standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

received some form of support after flooding were more likely to reinforce their dwellings as against doing nothing, suggesting that the provision of support after flooding does not promote non–protective responses.

Rising income among households is found to be associated with the likelihood of non-protection as against sandbag use in flood mitigation. Interestingly, receipt of flood information is associated with the likelihood of non-protection as against sandbag use and reinforcing premises.

Under socio-economic factors, various levels of education are associated with protective as against non-protective behaviour. Particularly, household heads with primary education are more likely to resort to the clearing of drains than do nothing. Also, household heads with basic and tertiary education are more likely to reinforce their houses. Being married and being an indigene are also associated with undertaking a protective response against non-protective behaviour while homeowners are less likely to relocate than do nothing. This is consistent with Poussin et al. [17].

5. Discussion

5.1. Threat appraisal

The PMT framework posits that high perceived risk of flood damage drives individuals towards protective action [12]. Studies such as Richert et al. [26] have found risk perceptions to influence protective responses positively however empirical evidence may be weak or negative [16]. The results of this study indicate that threat appraisal has a mixed effect on damage protection decisions by households, especially when the PMT is extended and specific protection actions are considered (see Table 4). Poussin et al. [17] also show that perceptions about the probability of damage may not automatically lead to flood preparedness by individuals. Risk perception may not always elicit fear leading to protection, but could lead to fatalism or wishful thinking and therefore non-protection.

5.2. Coping appraisal

Empirical evidence exists on the effect of self-efficacy on the adoption of protective actions against flood damage [12,44,45]. Consistent with the literature, households who do not feel helpless about their situation are likely to resort to structural measures such as reinforce their house against flood damage (Table 4). Poussin et al., [17] notes that perceived self-efficacy may not necessarily lead to actual steps although it does influence the decision to act but in the adoption of non-structural measures in the case of their study. What these results show is that persons with low coping appraisal are less likely to undertake flood mitigation actions compared to those with relatively high coping appraisal [26]. It is, however, possible for persons with high coping appraisal to undertake protective responses especially if they have taken sufficient actions in the past.

5.3. Flood experience

Damage and losses associated with flooding in the past have been observed to encourage the adoption of protective actions [17,46,47]. Our results, however, show that households that had suffered from flood damage in the past would rather do nothing than adopt a measure such as reinforcing their houses (Tables 2 and 4). The results are consistent with findings by Richert et al. [26] and Osberghaus [48]. Bubeck et al. [16] note that risk perceptions may mediate experience with flooding in such a way that it reduces the likelihood of taking precautionary actions against flooding. The influence of flood experience on current decisions to take protective actions can also wane with time. According to Siegrist and Gutscher [41], a sense of hopelessness, as well as significant costs in implementing protection against flood damage, may explain why flood experience may not result in the adoption of protective measure.

5.4. Barriers to protective measures against flood damage

Flood risk management policies implemented by local or national authorities play an important role in influencing the adoption of protective measures by households. Evidence on this in the literature is however mixed. While studies such as Botzen and Van den Bergh [40], Grothmann and Resswig [12] find that public measures have a negative effect on the adoption of private protective measures, others such as Poussin et al. [17] and Reynaud et al. [23] find contrary evidence. Our results reflect the general literature in which public efforts are shown to complement the adoption of some specific private protective measures such as clearing drains and sandbagging (Table 4) but also has a negative effect on protective response (Table 2).

Also, the adoption of private protective measures in the past appears to encourage protective response (Table 2) specifically, the reinforcement of houses (Table 4). Rising income among households is found to be associated with the likelihood of non-protection as against sandbag use in flood mitigation. One possible reason could be that high-income earners have already undertaken some flood mitigation measures. For instance, Tema Metropolitan Area is the industrial and harbour city of Ghana with the highest average income. Despite the susceptibility of most parts to flooding, many areas are well laid out which means floodwaters recede quite quickly. The likelihood for residents to, therefore, resort to private flood mitigation is quite low.

The negative effect of the availability of flood information on the use of sandbags is puzzling but reinforces premises largely attributable to the cynicism with which weather forecast information is typically received. More work needs to be done to better explain this. This finding is consistent with Botzen et al. [38] although studies such as Miceli et al. [36] and Thieken et al. [37] establish a positive but weak relationship between flood information and the adoption of precautionary responses.

5.5. Socio-economic factors

The positive effect of various levels of education on protective behaviour (Table 4) is consistent with Richert et al. [26], Poussin et al. [17]. In other words, education remains a key determinant of private protective measures against flooding. Being married and being an indigene are also associated with undertaking a protective response as against nonprotective behaviour while homeowners are less likely to relocate than do nothing. This is consistent with Poussin et al. [17].

6. Conclusion

The objective of the study is to determine the psychological and socio-economic factors, as well as the constraints that determine private precautionary flood-risk adaptation among urban households in the Greater Accra Metropolitan Area using the PMT framework. We find that threat appraisal has mixed effects on the decisions by households to adopt a damage protection measure against flooding. While the perceived probability of flood damage has an effect on some protective actions, household heads who could predict the onset of a flood appeared to be less likely to adopt some protective measure against flood damage such as sandbagging. In regard to the coping appraisal, the study establishes that households who do not feel helpless about flooding in the neighbourhood resort to some structural measures such as reinforcing their house against flood damage.

Households who had experienced some damage, personal harm or loss as a result of flooding in the past would rather do nothing than adopt a measure such as reinforcing their houses against flood damage. The overall effect of flood risk management measures by local or national authorities is found to have mixed effects on private protection against flood damage. Also, private protective measures in the past are found to encourage protective response against flood damage. Rising income among household heads was found to be associated with the likelihood of non-protection against flooding as against the use of sandbags.

Finally, socio-economic factors have been shown to have an overall, positive effect on protective behaviour. Education, being married, being a female household head, homeownership, being an indigene, being older are all found to have a positive and significant effect on the likelihood of adopting a protective response against flood damage.

Extending the basic PMT model has been useful and provided some insights with possible policy implications. The positive impact of public measures on private protection suggests that providing the needed community-level flood protection infrastructure will encourage private flood precautionary measures. It also appears the there is no evidence to support the use of information to encourage the adoption of precautionary measures against floods. Further investigation into why information is associated with non-protective response will be useful in identifying possible policy variables that can move households from non-protective to protective responses.

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Appendix A. Supplementary data

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