Living with Floods: Protective Behaviours and Risk Perception of Vietnamese Households

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We empirically investigate the determinants of household flood protective strategies and risk perception using data from a household-level survey conducted in spring 2012 in Vietnam. Our empirical analysis shows that some flood protective behaviours of Vietnamese households are driven by the perception of flood risks, a result consistent with the Protection Motivation Theory (PMT). Our results also suggest that both perceived probabilities and perceived consequences of floods are related to some cognitive processes included in the PMT. Lastly, we document the important role played by public flood management policies in shaping individual flood risk perception and protective behaviours. *The Geneva Papers* (2013) 38, 547–579. doi:10.1057/gpp.2013.16

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Introduction

With 89.4 per cent of its GDP generated in areas at risk, Vietnam is the world's seventh most exposed country to natural disasters.¹ Over the past 20 years, natural disasters have resulted, on average each year, in 650 deaths, in damage to 340,000 ha of paddy (rice) and in total destruction of 36,000 houses.² A very conservative estimate of the average annual cost of natural disasters (including damage to residential housing and public-sector properties, agriculture and infrastructure) is 1 per cent of Vietnamese GDP.³ Within natural disasters, floods are the single most important cause of loss, accounting for 49 per cent of total economic losses.² Moreover, floods are expected to generate higher social losses in the future due to climate change. Vietnam has indeed been identified as one of the five countries expected to suffer the most from climate change.¹

Measures to deal with this high flood risk can be taken at different levels. Both structural (dikes, sea dikes, channelisation) and non-structural strategies (warning systems, education and preparedness programmes) have been implemented by

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¹ WorldBank (2005).

² WorldBank (2010).

³ This number is provided by the Vietnamese Central Committee for Flood and Storm Control, but should be viewed as a very low lower bound on real flood costs (WorldBank, 2010).

Vietnamese authorities for a long time.⁴ Non-structural strategies remain underdeveloped, despite a noticeable and recent change in flood management policies. At the level of households, a number of mitigation strategies exist, including self-protection (preparing sand bags, owning a water pump, etc.), risk transfer to formal institutions, and informal risk sharing. The role played by household mitigation behaviours to reduce flood damage has been underlined in a number of previous works.⁵ Self-protection measures have been shown to reduce flood damage, for instance in Germany.⁶ Flood risk management includes transferring risk to formal organisations. Yet, although catastrophe insurance schemes have been promoted for Vietnam by international organisations such as the World Bank² or the Asian Development Bank,⁷ the Vietnamese flood insurance market remains extremely limited.⁸ Vietnamese households often have to rely on informal mutual aid schemes.

Our paper addresses two important issues related to flood risk management. Our first objective is to understand the variance in households' actions taken to avoid flood damage in a flood-prone area like Vietnam. Since risk perception has dominated the literature on flood mitigation behaviour, and because raising risk awareness is an important element of potential future flood management policies in Vietnam, our second objective is to provide an assessment of the determinants of flood risk perception for Vietnamese households. To address these two issues, we rely on a household-level survey conducted in spring 2012 in Vietnam. The survey uses an extended questionnaire, which includes measures relating to behaviour, past experience, expectations and social involvement as well as incentivised tasks (used to elicit risk preferences).

We use the framework provided by an extended version of the Protection Motivation Theory (PMT)⁹ to assess the determinants of household flood protective behaviours. This framework has indeed been used for health risks and natural hazards and appears particularly suited to poor households in a developing country, whose behaviour and motivation are unlikely to depend only on market prices. It also allows us to assess the relative importance of risk perception, of experience and coping appraisal, and of external actions, including public policies as perceived by respondents. Our analysis will also include informal risk-sharing strategies.

We contribute to the economic literature on flood management in several different ways. We first document that an extended version of the PMT, initially proposed by Rogers,⁹ offers a valid approach for understanding and predicting the flood protective behaviour of Vietnamese households. In particular, some of our measures of flood risk

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⁴ Pilarczyk and Nuoi (2005).

⁵ Grothmann and Reusswig (2006); Bubeck *et al.* (2012a); Cameron and Shah, (2012).

⁶ Kreibich *et al.* (2005); Thieken *et al.* (2007); Kreibich *et al.* (2011).

⁷ Lin *et al.* (2007).

⁸ The limited role played by flood insurance in developing countries has already been documented, for instance in Bangladesh (Brouwer and Akter, 2010). In Vietnam, several explanations of the very low penetration rate of catastrophe insurance have been proposed. They include problems of adverse selection, lack of awareness and understanding by households of the role and operation of a flood risk insurance, high administrative costs and high financial exposure due to highly correlated risks.

⁹ Rogers (1975).

perception are significant for explaining protective behaviour. This result contrasts with the previous literature which has found, at best, a weak relationship between flood risk perception and private mitigation measures.¹⁰ Second, we will use a very detailed and precise measure of flood experience at the household level. Previous works have relied either on aggregate measures of flood experience¹¹ or household-level counting of flood events.¹² We will argue that since the impact of floods on a household is by nature highly multi-dimensional, a valid assessment of households' exposure to floods requires considering the impacts of floods on housing, on agricultural production and on health separately. Indeed, our empirical analysis reveals that perceived flood consequences are quite different in these three dimensions. Third, we will also demonstrate the need to consider a precise measure of the intensity of the flood experience, and we will propose several ways to measure this flood intensity at the household level, including the maximal elevation of water inside houses or the average duration of floods. We will in particular show that individual perceived flood probabilities are impacted by flood intensity.

From a policy perspective, our results show that information programmes might be useful in specific domains. We find almost no impact of threat experience appraisal on perceived flood probabilities. If flood events are correlated, this could reflect an irrational, or mistaken, belief. In that case, education and informational campaigns could be quite valuable. Low-education households could also benefit from targeted information.¹³ We also find that the perceived flood consequences for housing, agricultural production and health do not have the same determinants. This militates for targeted flood management policies for each of these three dimensions. These results could be of value in the context of Vietnam's current efforts to develop non-structural risk management (as exemplified by a three-year pilot agricultural flood insurance programme launched in June 2012).

The remainder of the paper is organised as follows. In the next section, we describe the theoretical models we rely on. The subsequent section presents our survey and the way it has been administered in Vietnam. It presents how the different constructs and obstacles, relevant to flood risk perception and protective behaviour, are measured. The results of the econometric models are presented in the latter section, for protective behaviour, and the penultimate section, for risk perception. Finally, the last section concludes.

Relevant literature

In this section, we discuss briefly the theoretical frameworks we rely on, and some previous results from the existing empirical literature.

¹⁰ Bubeck *et al.* (2012a); Bubeck *et al.* (2012c).

¹¹ Cameron and Shah (2012).

¹² Kreibich *et al.* (2005).

¹³ We show that low-educated households are less likely to own a pumping set, despite its usefulness in case of a flood.

Factors influencing flood mitigation behaviours

The existing literature has demonstrated that private flood mitigation measures can significantly reduce flood damage and, thereby, contribute to risk reduction.¹⁴ This explains why considerable efforts have been undertaken in order to understand the determinants of private flood protective behaviours; see Bubeck *et al.*¹⁵ for a recent survey of this literature.

The *Protection Motivation Theory (PMT)*, proposed by Rogers,⁹ provides a widely adopted psychological model to describe decision-making in relation to threats.^{15,16} Figure 1 provides a schematic representation of the extended PMT adapted to the flood context by Grothmann and Reusswig.¹⁷

Protection motivation stems from two mediating processes that individuals use in evaluating threats (threat appraisal process) and in selecting among protective strategies, along with costs of coping (coping appraisal process).

The *threat appraisal process* relies on the perceived probability and perceived consequences of floods—fear plays an indirect role by affecting the estimate of the severity of floods.

The *coping appraisal process* is the cognitive process used by a person for evaluating his or her ability to cope with, and avert being harmed by, a flood, along with the costs of coping. As discussed in Grothmann and Reusswig,¹⁷ this process only starts if a specific threshold of threat appraisal is reached. It encompasses the person's perceived protective response efficacy (belief that protective actions will be effective), perceived self-efficacy (a person's perceived ability to perform or carry out the protective responses), and perceived protective response costs (including monetary costs, the cost of time and effort). In PMT, threat and coping appraisal processes combine to result in motivations to protect from a given risk, such as floods.

Following Grothmann and Reusswig,¹⁷ we assume that protection motivation relies on two additional groups of factors, namely *threat experience appraisal* and *reliance on non-individual flood protection*. *Threat experience appraisal* is an assessment by a household of the severity of floods in the past. There are different reasons why past flood experience matters to understand households flood protective motivations. First, flood occurrence is a shock that may contain new information about flood probabilities. Households may update their beliefs on background risk, with a subsequent impact on protective motivations.^{11,18} Second, disaster exposure brings more experience, and this, together with the fact that a person has survived and coped with a disaster before, may make her more likely to better cope in the future. This is in line with the “inoculation hypothesis”, which states that individuals who have experienced a similar type of natural disaster in their past are less likely to suffer from

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¹⁴ Takao *et al.* (2004); Kreibich *et al.* (2011).

¹⁵ Bubeck *et al.* (2012a).

¹⁶ Historically, the first application of the PMT was for health risks (Floyd *et al.*, 2000), but its use has been extended to other domains such as natural hazards (Mulilis and Lippa, 1990; Grothmann and Reusswig, 2006).

¹⁷ Grothmann and Reusswig (2006).

¹⁸ See also the hedonic price literature that assesses the changes in property prices after a flood occurrence. Kousky (2010) is a recent example, for St. Louis County, Missouri.

Figure 1. Schema of the extended PMT (adapted from Grothmann and Reusswig⁵).

long-term psychological distress after subsequent disasters.¹⁹ Third, having experienced a disaster before may on the contrary result in more fear and anxiety when the threat of disaster strikes again—see Hussain *et al.*²⁰ on psychiatric disorders following a natural disaster. The psychological literature is thus not conclusive, but it convincingly suggests the existence of a relationship between past flood experience and flood protective motivations. Motivation for protective behaviours is also related to households' *reliance on non-individual flood protection*. Households may indeed be less inclined to undertake precautionary actions if public authorities are successfully implementing flood prevention programmes or flood management policies—a common crowding-out effect of public policies.

Finally, protection motivations may not lead to actual protective behaviours (coping responses) due to actual barriers (lack of money, of knowledge or of social support, for instance), not forecasted at the time of intention forming.

Empirical findings of studies using the PMT to investigate the precautionary behaviour of households living in flood-prone areas are as follows.

¹⁹ Norris and Murrell (1988).

²⁰ Hussain *et al.* (2011).

First, the coping appraisal component is usually found to be a significant determinant of protective behaviour.²¹ In contrast, the threat appraisal component is usually found to have a lower explanatory power.¹⁵

Second, mixed evidence is found concerning the relationship between flood risk perceptions and the adoption of private mitigation measures. In the Netherlands, Botzen and van den Bergh²² observe a positive statistically significant relationship between flood risk perceptions and the intention of home owners to invest in sandbags. Similarly, Terpstra²³ and Zaalberg *et al.*,²⁴ still in the Netherlands, report that increasing perceptions of vulnerability to flood risk lead to greater intentions to perform risk reduction behaviours. This positive relationship has recently been challenged by Wachinger *et al.*,²⁵ Bradford *et al.*²⁶ and Siegrist²⁷ who stress the difficulties in establishing a causal relationship between flood risk perception and precautionary behaviours from cross-sectional data.

A third result that emerges is that experience of a flood is almost always significantly and positively related to the adoption of private mitigation measures.²⁸ Such a result has been also recently found by Bubeck *et al.*²⁹ who have worked on precautionary measures adopted between 1980 and 2011 by German households living in flood-prone areas along the German part of the Rhine. Bubeck *et al.*²⁹ report that a significantly increased rate of implementation can be consistently observed in the aftermath of severe flood disasters.

Factors influencing the construct of flood risk perceptions

The main theories of individual risk perception (including hazard perception) have been largely promoted within different disciplines³⁰: the psychometric paradigm in psychology and in decision sciences,³¹ in which cognitive factors have a major influence on individuals' perception of risk, and the cultural theory of Douglas and Wildavsky³² developed by anthropologists and sociologists, in which risk perception is the result of social and cultural influences.

The psychometric paradigm assumes risk to be subjectively defined by individuals who may be influenced by a wide array of psychological and cognitive factors. It provides an understanding of why people perceive or react to risks differently. The cultural theory relies on the idea that individuals belong to different social structures

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²¹ Grothmann and Reusswig (2006); Zaalberg *et al.* (2009).

²² Botzen and van den Bergh (2012).

²³ Terpstra (2011).

²⁴ Zaalberg *et al.* (2009).

²⁵ Wachinger *et al.* (2012).

²⁶ Bradford *et al.* (2012).

²⁷ Siegrist (2013).

²⁸ Grothmann and Reusswig (2006); Siegrist and Gutscher (2008); Hung (2009).

²⁹ Bubeck *et al.* (2012b).

³⁰ Some works have addressed the scope for more integration of these approaches (Marris *et al.*, 1998; Slovic, 1999).

³¹ Slovic (1987).

³² Douglas and Wildavsky (1982).

and that social context shapes individuals' values or attitudes. Socialised cognitive patterns work like filters in the evaluation of information about risks. According to this perspective, the most important predictors for risk perception are not individual cognitive processes (as according to the psychometric paradigm), but socially shared worldviews in relation to the "culture" individuals belong to.

In line with recent theoretical models proposed in cognitive and emotional psychology, risk perception may also depend on individual affective aspects: when people evaluate the likelihood of a risky event occurring, they rely on prior affective experiences, current feelings and images associated with the event.³³ Learning from experience also leads to a different perception of probabilities. Recent evidence in psychology and neurosciences indeed highlights the "description-experience gap": when individuals learn about a risk from personal experience, they tend to undervalue small probability events, contrary to the usual overweighing that occurs when they learn from description.^{34,35}

The empirical literature on flood risk perception has been recently summarised by Kellens *et al.*³⁶ In flood-prone areas, flood risk perception is influenced by several factors, including socio-demographic characteristics, knowledge about hazards, trust in institutions, earlier disaster experiences, feelings and emotions. However, Botzen *et al.*³⁷ have shown that, in general, perceptions of flood risk are low. Regarding household socio-demographic characteristics, they provide some evidence that older and more highly educated individuals have a lower flood risk perception. Individuals living in areas unprotected by dikes tend to underestimate the risk of being flooded, as do individuals with little knowledge about the causes of floods. According to many authors, flooding experience is an important determinant of risk perception. Moreover, knowledge about floods and about how to respond to them relates positively to repeated experiences of flooding.³⁸ As indicated in Kreibich *et al.*,¹² detailed knowledge about floods may inform individuals about possible precautionary measures—such as elevated configuration and fortification of cellars for buildings in flood-prone areas. In contrast, for the specific case of flash floods in the U.S. (Southwest Virginia), Knocke and Kolivras³⁹ indicate that the essential knowledge of the climate phenomenon does exist, but is not accurate enough for proper awareness.

Risk perception can also be influenced by trust in the public authorities responsible for managing flood risk. In a recent work in South Africa, Fatti and Patel⁴⁰ show that flood risk perceptions are highly influenced by historical distrust of the local government. Lastly, emotions play a role in probability judgements. In line with the

³³ Slovic *et al.* (2004).

³⁴ Hertwig *et al.* (2004); Hertwig and Erev (2009); Camilleri and Newell (2013).

³⁵ This effect may exist even for Vietnam, where destructive floods are less rare than in other areas. Hau *et al.* (2008) indeed show that the description-experience gap is reduced, but persists for events that are experienced from large samples.

³⁶ Kellens *et al.* (2013).

³⁷ Botzen *et al.* (2009a).

³⁸ Hansson *et al.* (1982).

³⁹ Knocke and Kolivras (2007).

⁴⁰ Fatti and Patel (2012).

existing literature on this topic, Miceli *et al.*⁴¹ highlight the role played by emotions (particularly fear, that performs an adaptive function) for flood risks in northern Italy. Keller *et al.*⁴² provide another application in the context of flood risk.

Data

Questionnaire development

Our household survey was conducted in Nghe An Province. The design phase of the questionnaire started in June 2011. From June 2011 to December 2011, several meetings involving research team members, water experts or local representatives (farmers, politicians and households) were organised in Nghe An Province. After a pilot study in December 2011 on 30 households, the questionnaire was reshaped and the final survey took place from 4 April to 10 June 2012, a period during which no flood or natural disaster was recorded in Nghe An Province.

Sampling strategy

Nghe An Province is located in the central part of Vietnam. Flood risks are different depending on the location. In the mountains (the eastern part of the province), households face flash flood risks with associated risks of landslides. In coastal areas, people are directly affected by typhoons and tropical storms. Finally, people located along rivers or living in delta river areas are affected by floods resulting from river overflows.

Our sampling strategy was the following. First, 14 districts (out of 17 in Nghe An Province) were selected according to geographical location (coastal area, plain area, mountain area). Then, based on discussions with local representatives of the Ministry of Agriculture and Rural Development, two representative villages/communes were targeted within each district (there are 417 villages/communes in Nghe An Province). Finally, within each village/commune, 16 households were randomly selected from the village/commune listing of registered citizens. This sampling stratification allows us to have in our data all types of floods which may impact the population in Nghe An Province. Household random selection guarantees that our sample is representative of the Nghe An population. Our sample is made up of 448 households, observed in 28 villages/communes from 14 districts of Nghe An Province.

The survey was implemented in spring 2012 using face-to-face interviews.⁴³ The survey is structured into seven sections. The questionnaire starts with the usual socio-demographic questions (household's income, housing characteristics, family structure). Specific questions for households involved in farming activities are included. A section then refers to the respondent's experience with flooding, flood damage and

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⁴¹ Miceli *et al.* (2008).

⁴² Keller *et al.* (2006).

⁴³ Fewer than 10 per cent of the households contacted refused to participate.

evacuation due to flood threats. In the final section, we elicit the risk preferences of respondents through lottery games with monetary incentives.

Data and sample characteristics

According to the extended version of the PMT presented in Figure 1, protection motivations and responses are driven by threat experience appraisal, threat appraisal, coping appraisal, reliance on non-individual flood protection and actual barriers.

Measuring threat experience appraisal

Threat experience appraisal is measured through three groups of variables collected at household-level: past flood exposure, past flood experience and past flood intensity (see Table 1).

Flood exposure is defined as the number of times a household has been exposed to a flood in the last 5 years, possibly without being negatively impacted. Our flood exposure measure reflects a household's subjective assessment of its background flood risk. In our sample, respondents report that they have faced on average 1.5 floods per year in the last 5 years (see Table 1).

Since a household may have faced a flood without being directly negatively impacted, additional information is required to really capture household *flood experience*. As discussed previously, floods in Vietnam may result in significant losses, but these losses vary a lot according to household property type. To address the multi-dimensional nature of flood experience, we use three different variables. We first asked each household if their house had been flooded at least once in the past 5 years. In our sample, this is the case for 40.4 per cent of households (among these, 76.5 per cent report that they had been flooded for the last time in year 2011). Second, flood experience may be considered as a traumatic event, especially in the case of an evacuation. We thus asked each household if they had been *evacuated* from their home due to a flood at least once in the past 5 years. This is the case for 20.3 per cent of households. A third important dimension of flood experience is the fact that the flood can directly affect health.⁴⁴ To capture this dimension, we asked each respondent if a member of the household had been *injured* due to a flood at least once in the last 5 years. This is the case for 4.9 per cent of the respondents.

It has been suggested in the recent literature on flood management that it is not the experience of flooding, as such, that may drive private mitigation behaviour, as much as the intensity or the severity of the experienced negative consequences.⁴⁵ In our case, *flood intensity* is captured by two variables. The first is the average number of days in the 5 last years during which a respondent's house had been flooded. The average in our sample is 2.4 days per year—and 6.5 days per year when the sample is restricted to

⁴⁴ In a household survey carried out in Cao Lanh (Dong Thap Province, Vietnam), 75 per cent of respondents identified an impact of flooding on their health (USSH, 2002). The most direct health impacts of flooding were deaths and injuries caused by the existence of floodwater in or around people's homes as stressed in Few *et al.* (2004).

⁴⁵ Grothmann and Reusswig (2006); Bubeck *et al.* (2012a).

Table 1 Data summary

<i>Variable name</i>	<i>Variable definition</i>	<i>Mean</i>	<i>Std dev.</i>
<i>Threat experience appraisal (based on the last 5 years)</i>			
Flood Exposure	Number of times per year the respondent has faced a flood	1.499	1.106
Flooded	House flooded at least once (0,1)	0.404	0.491
Evacuated	Respondent evacuated at least once (0,1)	0.203	0.403
Injured	One household member injured at least once (0,1)	0.049	0.216
Day Flooded	Number of days with house flooded (days per year)	2.439	5.061
Water Elevation	Maximal elevation of water in house (in meters)	0.501	2.131
Flood Significant	Flood has represented some significant expenditures (0,1)	0.761	0.427
<i>Threat appraisal</i>			
More Flood	Household expects more floods in the next 10 years (0,1)	0.181	0.385
Damage Flood	Intensity of damage due to flood for the next 10 years, on a scale going from 1 (no losses and no damage) to 10 (critical damage and losses)	7.504	1.856
House Impact	A hypothetical flood has a negative impact on respondent's house (0,1)	0.768	0.423
Health Impact	A hypothetical flood has a negative impact on household's health (0,1)	0.797	0.403
Agri Impact	A hypothetical flood has a negative impact on agri. production (0,1)	0.883	0.320
Time Recover	Number of days to recover from an hypothetical flood	9.093	24.297
<i>Coping appraisal</i>			
Preparedness	Dummy equal to 1 if population education and preparedness is included in the two preferred flood management policies of the household	0.228	0.420
Less Vulnerable	Dummy equal to 1 if respondent considers that he/she is less vulnerable to climate disasters than other households living in the same village (0,1)	0.252	0.435
<i>Reliance on non-individual flood protection</i>			
State Confidence	Respondent's confidence level in State to efficiently manage flood risks (scale 1 to 10, with 1 for not at all confident and 10 for very confident)	8.393	1.579
Prov Confidence	Similar to State Confidence but for Province	7.828	1.631
City Confidence	Similar to State Confidence but for City or Village	7.462	2.148
Protect River Dike	Respondent's house protected by a river dike (0,1)	0.442	0.497
Protect Sea Dike	Respondent's house protected by a sea dike (0,1)	0.179	0.383
Protect Dam	Respondent's house protected by a dam (0,1)	0.393	0.489
Fin Aid Pub	Respondent has received financial aid from public authorities after a flood (0,1)	0.279	0.449
Mat Aid Pub	Respondent has received material aid from public authorities after a flood (0,1)	0.670	0.471
Health Insurance	Respondent has a health insurance (0,1)	0.440	0.497
Life Insurance	Respondent has a life insurance (0,1)	0.049	0.216
<i>Actual barriers</i>			
Low Education	Maximum level of education is primary school (0,1)	0.208	0.406
Low Income	Household belongs to the first income decile (0,1)	0.092	0.289

households that have been flooded. The second variable describing flood intensity is the maximum elevation of water inside the house during a flood in the last 5 years.⁴⁶ This maximal elevation averages 0.50 meters, varying from zero to 3m.

Another way to evaluate flood experience is through a measure of the economic impact of past floods. In our sample, 76.1 per cent of households consider that flooding had represented a significant expenditure over the past 5 years (see Table 1). Respondents were asked to provide an estimate of the average annual cost of flooding for their household in the past 5 years, distinguishing damage to their house and house contents, damage to agricultural production and damage to health (all medical expenses due to flooding for any member of the household). The average annual cost of flood damage caused to agricultural (and fishery) production is VND 3.5 million, representing 14.8 per cent of household income on average.⁴⁷ The average annual cost for flood damage caused to houses and house contents is slightly lower: VND 2.6 million per year or 9.3 per cent of the annual household income. Health expenses only represent 1.2 per cent of the annual household income. Combining these damages, we get an average annual cost of flooding damage of VND 6.4 million per year, or 25.26 per cent of the average annual household income. This is in line with Navrud *et al.*⁴⁸ who found, in a sample of Vietnamese households located in Quang Nam Province, that the average flood damage represented approximately 20 per cent of their annual income.

Measuring threat appraisal

Following Bubeck *et al.*,¹⁵ we propose to define *flood risk perception* as the combination of “perceived probability” (or likelihood) and “perceived consequences” (or severity) of a flood event.

Perceived flood probabilities are measured in our survey by asking each respondent about his/her beliefs as to the future frequency of floods in the area where he/she lives. The specific question used is: “Now, I would like to get your opinion about floods in the future for you and your household. Compared to the last 10 years, do you expect in your area for the next 10 years: More floods; fewer floods; the same number of floods; I don’t know if there will be more or fewer floods”. While 18.1 per cent of respondents expect more frequent floods, 71.0 per cent of respondents expect fewer floods and 7.2 per cent believe the frequency will remain the same (only 3.8 per cent of respondents do not know how to answer this question).

Perceived consequences of floods are measured through five variables capturing different dimensions of potential damage (see Table 1).

The first variable captures global perceived consequences of floods in the future: Respondents were asked to rank flood damage for their household in the next 10 years, on a scale going from 1 (no loss and no damage) to 10 (critical damage and

⁴⁶ Working on housing flood resilience in Central Vietnam, Kobayashi *et al.* (2012) have shown that water elevation inside a house is a key indicator of flood damage.

⁴⁷ These statistics are provided on a subsample of 407 households (out of 448) having reported financial information.

⁴⁸ Navrud *et al.* (2012).

losses). The second, third and fourth variables are dummy variables equal to 1 if the respondent expects that a hypothetical flood would have a negative impact on, respectively, his/her house⁴⁹ (as for 76.8 per cent of respondents), the health of the members of his/her household⁵⁰ (as for 79.7 per cent of respondents), and his/her agricultural production (as for 88.3 per cent of respondents). The last variable is the number of days needed by the household to recover from a hypothetical flood (on average, a little more than 9 days).

It is a priori surprising that households expect fewer floods in the future, but high damage (as a percentage of their budget, as seen in the previous section). One possible explanation is that they expect to be less often impacted (perhaps assessing recent frequency as unusually high); but also expect floods to be more severe, possibly because of climate change. This explanation is supported by the fact that 94.1 per cent of the respondents report that the climate has changed in the area where they live, compared with 10 years ago. Households may also simultaneously expect fewer floods in the future but high damage because of the existence of sea or river dikes. When such structures are built, floods are likely to occur less often but, when they occur, they tend to have more severe impacts.

Measuring coping appraisal

Coping appraisal defines a person's cognitive process in evaluating his/her ability to cope with, and avert being harmed by, a threat, along with the costs of coping. Since we do not have in our data any direct evaluation of the costs of coping, we will rely on two indirect measures of *self-efficacy*, which is closely related to one's belief about one's ability to cope with flood threats. The psychologist Albert Bandura has pioneered detailed study of self-efficacy, viewed as a major construct in his "social cognitive theory". Bandura⁵¹ (p. 391) defines self-efficacy "as people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances".

First, we will use whether "population education and preparedness" is one of the two preferred flood management policies of the household. Population education and preparedness is defined as information campaigns to educate people in correctly assessing flood risks and to teach them methods they can apply at the private level to alleviate flood impact. We argue that this variable should be positively correlated with the household's perceived ability to cope with flood risk. This is in line with Bandura⁵²: "People with high assurance in their capabilities approach difficult tasks as challenges to be mastered rather than as threats to be avoided". In our context, respondents choosing education and preparedness as one of their preferred policies

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⁴⁹ The exact question used is: "Do you think that, in case of a flood, your house (including house equipment) will be: positively affected; negatively affected; not affected; I am not sure how floods may affect my properties".

⁵⁰ The exact question used is: "Do you think that in case of a flood, the health of the members of your household will be: positively affected; negatively affected; not affected; I am not sure how floods may affect health".

⁵¹ Bandura (1986).

⁵² Bandura (1994).

demonstrate a belief in their ability to cope with floods. A household with a low self-efficacy should prefer the other types of flood management policies (dikes, dams, early warning systems), that do not rely on the household's participation and capabilities.

Second, we use a variable based on reported self-perception of vulnerability to natural hazards (that is typically associated with self-efficacy, compared with questions based on objective characteristics). We indeed know if a respondent considers that he/she is less vulnerable to climate disasters (including floods) than other households living in the same village. We argue that this variable should also be positively correlated with individual self-efficacy. We however recognise that feeling less vulnerable is not *necessarily* related to self-efficacy. Indeed, it may simply be caused by the fact that the respondent is objectively less exposed to flood risk because of a safer location of the household. Alternatively, it may result from an individual *optimistic bias*.^{53,54}

To conclude, since we do not consider here perceived protective response efficacy and perceived protective response costs and, since we use two proxies for self-efficacy, our results related to the coping appraisal cognitive process should then be taken with caution.

Measuring reliance on non-individual flood protection and actual barriers

Since household mitigation decisions might be complementary or a substitute to non-individual protection (such as public policies), we include variables characterising public flood management policies and households' perception of them:

- ProtectRiverDike, ProtectSeaDike, ProtectDam are dummy variables equal to 1 if the respondent's house is protected respectively by a river dike, a sea dike or a dam.
- StateConfidence, ProvConfidence and CityConfidence measure the respondent's confidence level in the State, the province and the city to efficiently manage flood risks (scale from 1: not at all confident, to 10: very confident).
- FinAidPub and MatAidPub are dummy variables equal to 1 if the respondent has received either financial or material aid from national or local public authorities after a flood.

Considering that being covered by a health insurance or holding a life insurance is a form of risk transfer towards a third party, we also include the following two variables:

- HealthInsurance and LifeInsurance are dummy variables equal to 1 if the respondent has a health or a life insurance respectively (as for 44.0 and 4.9 per cent of respondents, respectively).⁵⁵

⁵³ Weinstein (1980).

⁵⁴ We thank an anonymous referee for having suggested these two alternative explanations.

⁵⁵ In Vietnam, health insurance is compulsory, but only for contracted labour. Poor farmers in rural or in mountainous areas typically do not subscribe to health insurances.

Lastly, protection motivations may not lead to actual coping responses because of actual barriers. We hypothesise that, for Vietnamese households, the main barriers are related to low income and low education levels.

- LowEducation is a dummy variable equal to 1 if the highest education level of the household's head is primary school (as for 20.8 per cent of respondents).
- LowIncome is a dummy variable equal to 1 if a household belongs to the first decile of the income distribution.

Measuring household flood protective behaviours

Flood protective decisions at the household level include actions to reduce the likelihood of adverse events, actions to lessen their negative consequences, and risk mitigation actions (taken *ex ante* to ensure *ex post* compensation).⁵⁶ This last category includes in particular social contracts, holding of savings, purchase of insurance, etc. Some of these actions are informal.⁵⁷

We focus on households' actions taken to reduce flood exposure (self-protection behaviours), on risk-sharing and risk diversification strategies, and on the use of social and informal networks.

Self-protection behaviour is captured by four different variables (see Table 2). A first mitigation strategy relates to housing floor elevation. According to Kobayashi *et al.*,⁵⁸ floor elevation is crucial for reducing flood exposure.⁵⁹ We collected for each household the elevation of the highest floor (with respect to ground level), this floor being used for storage in the event of a flood. Elevation is on average 1.24m, varying from an average of 0.98m in mountainous districts to 1.44m in plains, where the risk of river overflow is the highest. A second mitigation strategy is owning a water pump (pumping set). This helps limit flood damage. In our sample, 45.7 per cent of households report having a water pump. A third possible strategy is moving to an area where the flood risk is lower. In our sample, 8.9 per cent of households plan to move to another area due to floods where they live. Last, specific mitigation strategies exist when a household member is involved in agricultural activities. In that case, we have asked each household which flood mitigation strategies they have adopted within a list of 12 possible strategies.⁶⁰ Our fourth (farmer-specific) variable is the number of flood mitigation strategies adopted (on average 3.9). The flood mitigation strategy the most often adopted (76.9 per cent of farmer respondents) is storage of paddy in bags so that they can easily be evacuated in case of a flood.

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⁵⁶ Heitzmann *et al.* (2002).

⁵⁷ Schilderman (2004).

⁵⁸ Kobayashi *et al.* (2012).

⁵⁹ In their case study on housing resilience to floods in Central Vietnam, Kobayashi *et al.* (2012) have pointed out that floor elevation is typically adjusted to the height of the annual floodwater elevation in each location. Increasing the house floor elevation may be then interpreted as a self-protection behaviour.

⁶⁰ The proposed mitigation strategies include for instance storing food during the flood season, constructing secondary floors in the house to store agricultural production or modifying the timing of crop planting.

Table 2 Flood protective behaviour variables

<i>Variable name</i>	<i>Variable definition</i>	<i>Mean</i>	<i>Std dev.</i>
<i>Self-protection decisions</i>			
Floor Elevation	House highest floor elevation (in meters)	1.235	1.408
Pumping Set	Household possesses a pumping set (0,1)	0.457	0.498
Plan To Move	Household plan to move to another location due to floods (0,1)	0.089	0.285
Farmer Mitigation	Number of flood mitigation strategies taken by farmers	3.881	2.127
<i>Risk-sharing and risk diversification</i>			
Income Agriculture	Share of household income coming from agriculture	0.443	0.380
Work Abroad	One household member works abroad (0,1)	0.062	0.242
Remittances	Household has received remittances in the last 2 years (0,1)	0.046	0.211
<i>Social networks</i>			
Membership	Number of household memberships in an organisation	2.690	2.368
Exchange Information	Household has regularly exchanged information about floods with neighbours (0,1)	0.149	0.357

Risk-sharing and risk diversification strategies also constitute potential flood protective behaviours. The literature in development economics has shown that households in low-income countries employ a variety of channels to diversify their risk exposure, including purchases/sales of durable production assets, diversifying the marriage location of their daughters, and borrowing from family networks.⁶¹ Since farmers are usually highly affected by floods, a first strategy is having household members engaged in non-agricultural activities. We have collected the household's total income in 2010 and the share coming from agricultural activities. While 79 per cent of households' heads declare agriculture as their main professional activity, agriculture accounts for only 44.3 per cent of average income. Another way of securing income in case of a flood is to have a household member working abroad (as for 6.2 per cent of our sample) or to benefit from remittances (4.6 per cent of our sample). In one third of cases, remittances received do not come from household members living abroad. Hence, those two variables do not measure exactly the same risk management strategy.

Last, *informal and social networks* play an important role in many developing countries for households facing risks.⁶² We rely on two measures of social network participation. Each household indicated to which organisation they belonged, within a list of 20 (including the Communist Party, religious groups, labour unions, professional associations, veteran associations).⁶³ The intensity of social connections can be captured by the number of institutions/organisations each household belongs to. In our sample, a household belongs on average to 2.7 different organisations. While 14.51 per cent of

⁶¹ Rosenzweig (1988).

⁶² In a seminal paper on Indian farmers, Townsend (1994) shows that community-based informal insurance arrangements are very effective for smoothing poor household consumption levels over idiosyncratic income shocks.

⁶³ Respondents could also add an organisation not included in the list.

households report that they do not belong to any organisation, 15.85 per cent report a high level of social interactions (they belong to at least five different organisations). Since we wanted to capture social interactions in the flood management context, we also asked each household if it has exchanged experiences and/or ideas related to floods with neighbours: 14.51 per cent of households never, 17.63 per cent rarely, 52.90 per cent occasionally and 14.96 per cent regularly have done so.

An analysis of household flood protective behaviours

Additional explanatory variables

We estimate some econometric models (discrete choice models and OLS) explaining flood protective behaviours by potential determinants derived from the extended PMT (see Table 1). We also include a set of variables reflecting each household's socio-economic level and preferences, which are expected to play a role in the adoption of protective behaviours⁶⁴:

- Income represents total household income in 2010, in millions of VND (on average, VND 32.5 million, representing a little more than US\$1,500).⁶⁵
- HighEducation is a dummy variable equal to 1 if the household's head has attended high school (as for 30.6 per cent of our sample).
- Age is the age of the respondent, in years (on average 48.8 years).
- Size is the number of household members (on average 4.1).
- Child3 is a dummy variable equal to 1 if the household includes a child younger than three (as for 19.0 per cent of our sample).
- RiskPref is the constant relative risk aversion coefficient (CRRA) of the respondent elicited through an incentivised lottery task.⁶⁶ Vietnamese households appear to be quite risk-averse since the average CRRA is 2.5.
- TimePref is the respondent's individual psychological interest rate elicited from hypothetical questions using a double referendum format.⁶⁷ The average discount rate is 53 per cent, a figure which is not unusual in developing countries.

Those variables have been added based on the previous literature on the adoption of flood protective behaviours. Inclusion of the Age variable reflects for instance the "maturation hypothesis" in psychology, which states that older people tend to develop coping strategies and are generally less emotionally responsive to stress—this results in less distress when experiencing a natural disaster.⁶⁸

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⁶⁴ The protective behaviours we mention in the remainder of the paper always refer to floods.

⁶⁵ The 2010 VND–US\$ exchange rate was around 21,000 to 1.

⁶⁶ Individual CRRA coefficients are estimated by maximum likelihood following Harrison and Rutström (2008) using data obtained in the last section of the questionnaire from a set of lottery tasks adapted from Eckel and Grossman (2002, 2008).

⁶⁷ Households were asked if they preferred to receive VND 1 million today or VND 1.4 million one year from now. Depending on their answer, they had to answer a second similar question.

⁶⁸ Shenk *et al.* (2009).

Determinants of flood protective behaviours

Table 3 reports the estimations for self-protection decisions. Since the decision to have a pumping set or to move to another area is by nature discrete, we use a logistic regression (logit model). For the two other self-protection variables, the model is estimated by ordinary least squares (OLS).⁶⁹

The explanatory power of the models presented in Table 3 is good with R^2 or pseudo- R^2 varying from 0.25 to 0.32. For all models presented, we reject the null hypothesis of all estimated coefficients not being significantly different from zero ($p < 0.001$). A first message is thus that the extended PMT provides a valid understanding of household flood self-protection decisions.

Let us now consider the role of each component of the extended PMT.

We find some mixed evidence concerning the impact of *threat experience appraisal* on protective behaviour. Having one's house flooded at least once in the past 5 years is significant for none of the self-protection strategies; the intensity of flood exposure is significant (with a negative sign) only for floor elevation, possibly due to reverse causality. However, having a household member injured by a flood in the past 5 years results in a higher probability of owning a pumping set. Being evacuated increases both floor elevation and the likelihood of intending to move to another area. This suggests that being evacuated or injured due to a flood might be considered as a traumatic event even in a flood-prone country like Vietnam. This traumatic experience has an impact on some long-term household decisions such as the one to migrate. Our finding thus lends additional support to the psychological literature that argues that the experience of a disaster may result in more fear and anxiety with respect to future occurrences. These significant relationships are in line with the existing economic literature. In their survey, Bubeck *et al.*⁷⁰ indicate that, except for Takao *et al.*⁷¹ and Thieken *et al.*,⁷² all existing works have found that previous experience of a hazard is statistically significantly related to the adoption of private mitigation measures.

Threat appraisal appears to be significant for explaining some self-protection decisions. Expecting more frequent floods in the future is significant (positive) for explaining floor elevation and the intent to move to another location. It is however not significant when considering the two other flood protective behaviours (pumping set and farmer's strategies). Perceived consequences of a flood also matter, although some mixed evidence is found. Households expecting high flood damage in the next 10 years are more likely to own a pumping set and, for farmers, to implement a large number of self-protection strategies. The negative sign between expecting high flood damage and floor elevation is surprising. One explanation could be some omitted variables. Indeed, floor elevation is likely to have some determinants not related to floods. Some of them may have been omitted in our setting. Similar effects are found for people who expect that

⁶⁹ For the number of flood protective behaviours implemented by farmers, other models have been estimated including Poisson and negative binomial regressions. The results are available from the authors upon request.

⁷⁰ Bubeck *et al.* (2012a).

⁷¹ Takao *et al.* (2004).

⁷² Thieken *et al.* (2007).

Table 3 Determinants of self-protection decisions

<i>Variable</i>	<i>Floor Elevation</i>		<i>Pumping Set</i>		<i>Plan to Move</i>		<i>Farmer's Strategies</i>	
	<i>Coef.</i>	<i>(SE)</i>	<i>Coef.</i>	<i>(SE)</i>	<i>Coef.</i>	<i>(SE)</i>	<i>Coef.</i>	<i>(SE)</i>
<i>Threat experience appraisal</i>								
Flood Exposure	−0.10*	(0.06)	−0.17	(0.13)	0.03	(0.18)	−0.02	(0.10)
Flooded	0.12	(0.17)	0.57	(0.35)	0.98	(0.62)	0.15	(0.32)
Injured	−0.27	(0.28)	1.00*	(0.60)	−0.60	(0.92)	−0.51	(0.48)
Evacuated	0.44**	(0.18)	−0.80**	(0.39)	1.84***	(0.58)	−0.21	(0.34)
Water Elevation	−0.00	(0.00)	−0.00**	(0.00)	−0.00	(0.00)	−0.00	(0.00)
Days Flooded	0.03*	(0.01)	−0.01	(0.03)	0.02	(0.03)	0.05	(0.03)
Flood Significant	0.01	(0.16)	−0.85***	(0.32)	0.47	(0.68)	0.13	(0.28)
<i>Threat appraisal</i>								
More Flood	0.87***	(0.16)	0.53	(0.33)	0.95*	(0.51)	−0.23	(0.31)
Damage Flood	−0.11***	(0.03)	0.27***	(0.08)	−0.05	(0.11)	0.13*	(0.07)
House Impact	0.03	(0.18)	0.30	(0.37)	−0.02	(0.73)	0.23	(0.33)
Health Impact	0.13	(0.19)	0.80**	(0.39)	−0.10	(0.73)	0.66**	(0.33)
Agri Impact	−1.13***	(0.21)	−1.45***	(0.47)	1.10	(0.70)	0.63	(0.53)
Time Recover	0.00	(0.00)	0.00	(0.00)	−0.01	(0.02)	0.00	(0.00)
<i>Coping appraisal</i>								
Preparedness	0.15	(0.15)	−0.18	(0.31)	−0.07	(0.48)	−0.03	(0.27)
Less Vulnerable	−0.01	(0.14)	−0.61**	(0.31)	−0.73	(0.66)	0.19	(0.27)
<i>Reliance on non-individual flood protection</i>								
State Confidence	0.02	(0.05)	0.16	(0.11)	0.19	(0.17)	−0.03	(0.10)
Prov Confidence	−0.02	(0.05)	−0.05	(0.11)	−0.42**	(0.18)	0.03	(0.10)
City Confidence	−0.03	(0.03)	0.13*	(0.07)	−0.18*	(0.11)	−0.08	(0.06)
Protect River Dike	−0.14	(0.13)	0.43	(0.26)	−0.43	(0.52)	−0.17	(0.23)
Protect Sea Dike	0.10	(0.17)	0.66*	(0.34)	−0.07	(0.59)	−0.98***	(0.31)
Protect Dam	0.16	(0.13)	0.03	(0.27)	−0.44	(0.47)	1.00***	(0.22)
Fin Aid Pub	−0.06	(0.15)	1.11***	(0.30)	0.08	(0.53)	0.22	(0.25)
Mat Aid Pub	0.19	(0.14)	−0.21	(0.30)	−0.58	(0.52)	0.14	(0.25)
Health Insurance	−0.38***	(0.12)	0.73***	(0.25)	−0.29	(0.46)	1.13***	(0.22)
Life Insurance	−0.10	(0.27)	0.45	(0.58)	−0.20	(1.22)	1.62***	(0.48)
<i>Actual barriers</i>								
Low Education	−0.09	(0.15)	−1.14***	(0.34)	1.08**	(0.50)	−0.09	(0.27)
Low Income	0.03	(0.22)	0.14	(0.50)	1.55**	(0.74)	−0.12	(0.39)
<i>Household characteristics</i>								
Income	0.00	(0.00)	0.03***	(0.01)	0.03	(0.03)	0.02**	(0.01)
Income × Income	−0.00	(0.00)	−0.00***	(0.00)	−0.00	(0.00)	−0.00*	(0.00)
High Education	0.16	(0.13)	0.13	(0.27)	−0.54	(0.55)	0.06	(0.25)
Age	0.01*	(0.01)	0.03*	(0.02)	0.02	(0.03)	−0.02	(0.02)
Risk Pref	−1.32*	(0.69)	−2.27	(1.42)	−2.60	(2.41)	2.19	(1.61)
Time Pref	0.33	(0.42)	0.33	(0.91)	−0.51	(1.33)	−1.70**	(0.76)
Size	0.11***	(0.04)	0.13	(0.08)	−0.16	(0.15)	−0.03	(0.07)
Child3	0.16	(0.16)	−0.38	(0.33)	0.89	(0.56)	−0.05	(0.29)
Intercept	4.78***	(1.48)	−0.76	(3.11)	4.45	(5.02)	−3.06	(3.35)
Model	OLS		Logit		Logit		OLS	
<i>N</i>	448		448		448		355	
<i>R</i> ²	0.303		0.253		0.252		0.320	

Significance levels: *10 per cent; **5 per cent; ***1 per cent.

floods will result in significant injury costs in the next 10 years. The negative relationship between the agricultural cost of floods and floor elevation or the probability of owning a pumping set can be understood: Households who expect a high agricultural cost of floods are typically (low-income) farmers. They are less likely to live in multi-level houses than the rest of the population. Moreover, they tend to adopt other flood protective behaviours such as storing food or paddy in bags during the flood season. Our findings depart from the previous literature that has mainly found, at best, a weak relationship between flood risk perceptions and already-adopted private flood protective measures.¹⁵ One explanation could be that our detailed database allows us to control for some potential determinants (public policies, risk-sharing mechanisms) which were not always accounted for in previous studies.⁷³ Moreover, we work on a sample of households located in a developing country, whereas all studies reported in Bubeck *et al.*¹⁵ deal with developed countries. And since flood risks are much larger in a country like Vietnam, the PMT cognitive processes may be more easily observable.⁷⁴

Coping appraisal has a limited impact on protective behaviours. Attaching a high value to individual flood preparedness (that is, to all methods which can be applied at the private level to alleviate floods impacts) is never significant. Feeling oneself to be less vulnerable to floods than other households in the same village has a significant negative impact on the probability of having a water pump. This limited impact of coping appraisal could come from the fact that we only have some indirect measures of the respondent's perceived self-efficacy, and no measure of protective response efficacy or cost of coping.

Reliance on *non-individual flood protection* also matters for understanding protective behaviours. Being protected by a sea dike increases the probability of owning a pumping set. Interestingly, the presence of a dam increases the number of self-protection strategies implemented by farmers. This may be due to the fear of a dam collapse in case of a large flood or hurricane. Dam collapses are indeed a real safety issue in Vietnam, as indicated by the recently launched project of the Ministry of Agriculture and Rural Development that concerns Nghe An Province where our respondents live.⁷⁵ Confidence in institutions in charge of flood management is a key explanatory factor of flood protective behaviours. High levels of confidence in the ability of public authorities to efficiently implement flood management policies reduce the likelihood of a household implementing protective behaviours. Households confident in the ability of the province or the village to efficiently manage flood risks have a significantly lower probability of intending to relocate. This reflects the substitution between *efficient* flood policies and private protective behaviours. Our result is in line with Fatti and Patel⁴⁰ who have shown that flood risk perceptions, in South Africa, are highly influenced by historical distrust of local

⁷³ Some differences with the way flood risk perceptions have been measured in the existing studies might also explain this result.

⁷⁴ In their study in the Elbe river area (Germany), Kreibich *et al.* (2005) report that only 15 per cent of households in their sample have experienced a flood. In our case, 94.6 per cent of the households declare having experienced a flood at least once in the last 5 years.

⁷⁵ The Ministry of Agriculture and Rural Development (MARD) has approved in March 2013 a project to study dam safety in Vietnam, with extensive funding from New Zealand (the project costs US\$1.769 million). The project is to be implemented in Hanoi and Nghe An until April 2015. It follows recent deadly dam collapses.

governments. Finally, receiving either monetary or financial aid from public authorities after a flood has only a limited effect on the adoption of protective behaviours. We do not find evidence of crowding out—contrary to Botzen *et al.* (2009b) who find that the availability of government compensation for flood damage relates negatively to the willingness of homeowners to buy sandbags in the Netherlands.

Actual barriers mainly matter for the intention to move to another village. Low-income households or households with a low education level have a higher probability of intending to move to another city or village due to flood risk than households with a higher level of income or education. It is likely that wealthier households were able to locate their house in safer areas, and that they have more opportunities for mitigating, and insuring against, the risk of floods. A low education level also reduces the probability of having a pumping set, indicating possible scope for a public programme informing households about the use and usefulness of pumping sets.

Lastly, we should stress that socio-economic variables play only a limited role in protective behaviours. The relationship between a household's income and the probability of having a pumping set, or the number of flood protective strategies implemented by farmers, is significant and non-monotonic. Older respondents are more likely to have a pumping set and to live in a house with a high floor elevation. Respondents' risk and time preferences appear to play only a minor role.

Table 4 reports the estimates for risk-sharing and risk diversification decisions, and for decisions related to social networks. Since some decisions are discrete, whereas others are continuous, we use logistic regressions (logit model) and OLS. The explanatory power of models presented in Table 4 is similar to that of models in Table 3, with R^2 or pseudo- R^2 varying from 0.220 to 0.378. For all models we reject the null hypothesis of all estimated coefficients not significantly different from zero ($p < 0.001$).

Threat experience appraisal has a limited impact on social network decisions since no variable appears to be significant for explaining the number of household memberships. The probability of exchanging information about floods with neighbours is affected only (positively) by having one's house flooded. The impact of threat experience appraisal is slightly higher for risk-sharing and risk diversification decisions. Having been evacuated or flooded increases the likelihood of having a household member working abroad or receiving remittances. Conversely, households who consider that floods in the last 5 years represented significant expenditures are less likely to have a member working abroad and to receive remittances (perhaps due to the impact of wealth). Mixed evidence is found for threat appraisal. Strategies related to social network participation are more likely to occur if the respondent expects more floods in the future (for membership), if he/she believes that flood damage will be high in the future (for information exchange), especially housing damage (for membership). Risk sharing and risk diversification are affected by threat appraisal to a limited extent—being more patient increases the likelihood of exchanging information with neighbours.⁷⁶ Similar to estimations presented in Table 3, our measures of coping appraisal appear to have a quite limited impact. Households who view themselves as less

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⁷⁶ Dohmen *et al.* (2010) show that patience is associated with higher IQs, which may be associated with better perceptions of the value of information exchange.

Table 4 Determinants of risk-sharing, risk diversification and social network decisions

<i>Variable</i>	<i>Income Agri</i>		<i>Work Abroad</i>		<i>Remittances</i>		<i>Membership</i>		<i>Exchange Info</i>	
	<i>Coef.</i>	<i>(SE)</i>	<i>Coef.</i>	<i>(SE)</i>	<i>Coef.</i>	<i>(SE)</i>	<i>Coef.</i>	<i>(SE)</i>	<i>Coef.</i>	<i>(SE)</i>
<i>Threat experience appraisal</i>										
Flood Exposure	0.01	(0.02)	-0.40	(0.30)	-0.78*	(0.45)	-0.11	(0.11)	0.25	(0.19)
Flooded	0.01	(0.05)	0.73	(0.70)	2.17**	(1.05)	0.22	(0.32)	1.29**	(0.56)
Injured	-0.07	(0.07)	0.73	(1.01)	1.53	(1.67)	-0.39	(0.52)	0.83	(0.73)
Evacuated	-0.08	(0.05)	1.16*	(0.66)	-0.11	(1.00)	0.07	(0.34)	0.23	(0.52)
Water Elevation	-0.00	(0.00)	-0.00	(0.00)	-0.00	(0.00)	-0.00	(0.00)	-0.01	(0.01)
Days Flooded	-0.00	(0.00)	-0.02	(0.05)	-0.55**	(0.28)	0.00	(0.03)	0.04	(0.03)
Flood Significant	0.16***	(0.04)	-1.18**	(0.60)	-1.19*	(0.71)	-0.37	(0.29)	-0.16	(0.46)
<i>Threat appraisal</i>										
More Flood	-0.07	(0.04)	0.55	(0.55)	-0.07	(0.87)	0.86***	(0.31)	-0.46	(0.54)
Damage Flood	0.00	(0.01)	-0.17	(0.12)	-0.06	(0.17)	-0.07	(0.07)	0.35***	(0.11)
House Impact	-0.00	(0.05)	0.46	(0.75)	0.56	(0.97)	0.57*	(0.34)	0.23	(0.59)
Health Impact	-0.13***	(0.05)	-0.54	(0.74)	0.72	(1.07)	0.02	(0.35)	-0.73	(0.58)
Agri Impact	0.23***	(0.06)	0.07	(0.71)	0.10	(1.00)	-0.22	(0.40)	-1.87***	(0.63)
Time Recover	-0.00	(0.00)	0.00	(0.01)	-0.08	(0.07)	0.00	(0.00)	-0.03	(0.02)
<i>Coping appraisal</i>										
Preparedness	-0.01	(0.04)	0.10	(0.53)	1.08	(0.71)	0.02	(0.28)	0.07	(0.42)
Less Vulnerable	0.01	(0.04)	-0.46	(0.63)	-1.53*	(0.86)	-0.24	(0.27)	1.02**	(0.45)
<i>Reliance on non-individual flood protection</i>										
State Confidence	-0.01	(0.01)	-0.14	(0.16)	-0.39**	(0.18)	0.33***	(0.09)	0.59***	(0.22)
Prov Confidence	-0.02	(0.01)	0.31*	(0.19)	0.10	(0.23)	-0.07	(0.10)	0.02	(0.18)
City Confidence	0.00	(0.01)	-0.27**	(0.12)	-0.02	(0.17)	0.02	(0.06)	0.33***	(0.12)
Protect River Dike	0.04	(0.03)	-0.11	(0.54)	-0.19	(0.73)	-0.25	(0.24)	1.10***	(0.42)
Protect Sea Dike	-0.02	(0.04)	-0.39	(0.65)	-1.01	(0.83)	0.06	(0.32)	0.87*	(0.47)
Protect Dam	0.09***	(0.03)	-0.11	(0.52)	0.30	(0.71)	0.25	(0.24)	1.03**	(0.40)
Fin Aid Pub	-0.05	(0.04)	-0.25	(0.63)	-1.41	(0.93)	-0.01	(0.27)	-0.60	(0.47)
Mat Aid Pub	0.10**	(0.04)	-0.41	(0.58)	0.27	(0.68)	0.15	(0.27)	-0.10	(0.43)
Health Insurance	0.01	(0.03)	0.07	(0.50)	0.31	(0.66)	0.69***	(0.23)	0.17	(0.40)
Life Insurance	0.05	(0.07)	0.00	(0.20)	0.00	(0.10)	0.81	(0.51)	-0.84	(0.86)
<i>Actual barriers</i>										
Low Education	0.04	(0.04)	-1.17	(0.77)	-0.06	(0.77)	-0.30	(0.29)	-0.17	(0.48)
Low Income	-0.02	(0.06)	0.97	(1.02)	0.45	(1.70)	-0.56	(0.42)	-1.61	(1.15)
<i>Household characteristics</i>										
Income	-0.01***	(0.00)	0.04	(0.03)	0.06**	(0.03)	0.01*	(0.01)	0.03*	(0.02)
Income × Income	0.00***	(0.00)	-0.00	(0.00)	-0.00	(0.00)	-0.00	(0.00)	-0.00	(0.00)
High Education	-0.07**	(0.04)	-0.12	(0.50)	-0.40	(0.69)	0.04	(0.25)	-0.05	(0.42)
Age	-0.01***	(0.00)	0.00	(0.03)	0.05	(0.03)	0.02	(0.01)	-0.01	(0.02)
Risk Pref	0.51***	(0.18)	3.23	(2.65)	-3.29	(3.21)	-0.23	(1.29)	1.32	(2.11)
Time Pref	-0.06	(0.11)	0.00	(1.57)	1.15	(2.33)	1.29	(0.79)	6.40**	(2.58)
Size	-0.01	(0.01)	-0.03	(0.17)	0.24	(0.21)	0.27***	(0.08)	0.06	(0.13)
Child3	-0.07	(0.04)	0.23	(0.57)	-0.46	(0.81)	-0.20	(0.29)	-0.07	(0.52)
Intercept	-0.27	(0.39)	-8.84	(5.63)	3.10	(6.65)	-2.07	(2.77)	-20.21***	(5.18)
Model	OLS		Logit		Logit		OLS		Logit	
<i>N</i>	448		448		448		448		448	
<i>R</i> ²	0.326		0.228		0.378		0.302		0.363	

Significance levels: *10 per cent; **5 per cent; ***1 per cent.

vulnerable to flood risk than other households located in the same village invest more in information exchange, but tend to receive remittances less often.

To summarise, our measures of the three cognitive processes of the extended PMT (threat experience appraisal, threat appraisal and coping appraisal) appear to only have a limited explanatory power for explaining households risk-sharing and risk diversification strategies.

Social network involvement appears to be (weakly) complementary to private risk-sharing and risk diversification strategies. For instance, being protected by a river dike, a sea dike or a dam significantly increases the likelihood of exchanging information about floods with neighbours. Here again, confidence in institutions matters. Finally, we note a limited impact of socio-economic variables. A higher income is however associated with a higher likelihood of receiving remittances, a higher number of institution memberships and a higher probability of information exchange with neighbours.

An analysis of flood risk perception

The central question we explore in this section is the identification of the determinants of flood risk perception in Vietnam, with particular attention paid to flood experience.

Flood experience and perceived probabilities

Let us consider the first component of (flood) risk perception, that is, the perceived probabilities of floods. We will in particular try to determine if a significant relationship exists between past household experience (being flooded, evacuated or injured) and perceived probabilities.

As a starting point, we analyse the relationship between having one's housing flooded at least once in the last 5 years and perceived probabilities (see Table 5).

Being flooded results in both significantly higher beliefs in more floods in the future ($p < 0.001$) and significantly lower beliefs in less floods ($p < 0.05$). Flood intensity plays a crucial role here. Consider the households for which the highest level of water in their house was 2cm in the last 5 years (236 households): only 13.91 per cent of them expect an increase in flood frequency in the next 10 years; this compares with 31.34 per cent for households having experienced water elevation levels above 50cm (67 households). Similarly, whereas the percentage of households expecting more floods in the future is 18.40 per cent for households who have not been flooded in the last 5 years, it increases respectively to 20.59 per cent and 54.17 per cent for households who have been flooded on average each year between 1 and 10 days, and more than 10 days.⁷⁷ Important results from our study are thus that perceived flood probabilities:

- differ depending on being flooded or not;
- differ depending on intensity of the flood experience.⁷⁸

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⁷⁷ We cannot assess if the belief updating process is affected by the time elapsed since the last flood experience, since almost all households in our sample have been impacted in 2011.

⁷⁸ Intensity of flood was not accounted for in most previous studies, such as the one by Cameron and Shah (2012).

Table 5 Distribution of respondent's perceived flood probabilities per flood experience

	<i>Flood experience</i>								
	<i>Flooded</i>			<i>Evacuated</i>			<i>Injured</i>		
	<i>No</i>	<i>Yes</i>	<i>P-value</i>	<i>No</i>	<i>Yes</i>	<i>P-value</i>	<i>No</i>	<i>Yes</i>	<i>P-value</i>
Expect more floods (%)	12.21	27.53	0.000	14.49	34.09	0.000	17.94	27.27	0.251
Expect less floods (%)	76.34	66.29	0.026	75.85	57.95	0.000	72.49	68.18	0.767
Expect same number of floods (%)	9.54	3.93	0.027	7.67	5.68	0.495	7.42	4.55	0.629
Don't know (%)	1.91	2.25	0.947	1.99	2.27	0.343	2.15	0.00	0.341
Total (%)	100	100	–	100	100	–	100	100	–

P-value is for a *t*-test comparing means across samples.

Let us now analyse the relationship between being evacuated due to a flood, and beliefs about flood occurrence in the future. Since being evacuated is arguably a more traumatic event, compared with having one's house flooded, we expect a more significant relationship. Indeed 34.09 per cent of evacuated households believe that there will be more floods in the future compared with only 14.49 per cent for non-evacuated households. The proportion difference is significant ($p < 0.001$). Similarly only 57.95 per cent of evacuated households believe that there will be fewer floods in the future compared with 75.85 per cent for non-evacuated households ($p < 0.001$). Here again, flood experience significantly shapes beliefs about the occurrence of floods in the future. Lastly, 27.27 per cent of injured households believe that there will be more floods in the future, compared with only 17.94 per cent in the case of non-injured households. The proportion difference is however not significant (only 22 households have reported injuries due to floods in the last 5 years).

Let us now consider the multinomial logit model we have used to explain the probability of belonging to one of the three flood risk perception classes (expecting a lower risk in the future, the same risk, a higher risk).⁷⁹ Explanatory variables are threat experience appraisal, threat appraisal (excluding perceived flood probability), coping appraisal, reliance on non-individual flood protection, actual barriers, household characteristics and household protective behaviours. The value of the coefficients in the multinomial logit cannot be directly interpreted; we therefore provide in Table 6 the marginal effects (for a mean value of the explanatory variables). The adjustment of the multinomial model to the data is good with a pseudo- R^2 equal to 0.416.

Interestingly, we reject the null hypothesis of all coefficients being the same in the lower flood risk and the higher flood risk categories ($p < 0.0001$). This means that expecting low or high flood frequency in the future is *not* determined in the same way by the explanatory variables. For example, being protected by a sea dike or a dam increases the expectation of low flood frequency in the future. It has an opposite effect on the expectation of high flood frequency.

⁷⁹ The reference category in the multinomial logit is expecting the same flood risk in the future.

Table 6 Determinants of perceived flood probabilities (marginal effects from multinomial logit)

<i>Variable</i>	<i>Lower flood risk</i>		<i>Same flood risk</i>		<i>Higher flood risk</i>	
	<i>Coef.</i>	<i>(SE)</i>	<i>Coef.</i>	<i>(SE)</i>	<i>Coef.</i>	<i>(SE)</i>
<i>Threat experience appraisal</i>						
Flood Exposure	0.00	(0.02)	−0.02	(0.02)	0.02	(0.02)
Flooded	0.00	(0.06)	−0.06	(0.05)	0.06	(0.05)
Injured	−0.03	(0.08)	0.02	(0.07)	0.01	(0.07)
Evacuated	−0.12**	(0.05)	0.06	(0.04)	0.05	(0.05)
Water Elevation	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Days Flooded	0.00	(0.00)	0.00	(0.01)	0.00	(0.00)
Flood Significant	0.06	(0.05)	−0.05	(0.03)	−0.02	(0.04)
<i>Threat appraisal (except perceived probabilities of floods)</i>						
Damage Flood	−0.01	(0.01)	−0.01	(0.01)	0.02**	(0.01)
House Impact	0.01	(0.05)	0.04	(0.04)	−0.05	(0.05)
Health Impact	−0.12**	(0.06)	0.00	(0.04)	0.12**	(0.05)
Agri Impact	0.24***	(0.07)	−0.16***	(0.04)	−0.08	(0.06)
Time Recover	0.00	(0.00)	0.00*	(0.00)	0.00**	(0.00)
<i>Coping appraisal</i>						
Preparedness	0.10**	(0.05)	−0.03	(0.03)	−0.07*	(0.04)
Less Vulnerable	0.12**	(0.05)	−0.13***	(0.04)	0.01	(0.04)
<i>Reliance on non-individual flood protection</i>						
State Confidence	0.04***	(0.02)	−0.04***	(0.01)	0.00	(0.01)
Prov Confidence	−0.04***	(0.02)	0.01	(0.01)	0.03**	(0.01)
City Confidence	0.00	(0.01)	0.01	(0.01)	−0.01	(0.01)
Protect River Dike	0.04	(0.04)	−0.02	(0.03)	−0.02	(0.04)
Protect Sea Dike	0.17***	(0.05)	−0.05	(0.03)	−0.12**	(0.05)
Protect Dam	0.25***	(0.04)	−0.16***	(0.03)	−0.09**	(0.04)
Fin Aid Pub	−0.11**	(0.04)	0.08**	(0.03)	0.03	(0.04)
Mat Aid Pub	0.08*	(0.05)	−0.01	(0.04)	−0.06	(0.04)
Health Insurance	−0.04	(0.04)	−0.03	(0.03)	0.06*	(0.04)
Life Insurance	0.06	(0.09)	−0.01	(0.06)	−0.05	(0.08)
<i>Actual barriers</i>						
Low Education	−0.02	(0.05)	−0.03	(0.03)	0.05	(0.05)
Low Income	0.06	(0.08)	−0.15**	(0.07)	0.09	(0.06)
<i>Household flood protective behaviours</i>						
Floor Elevation	−0.04***	(0.02)	0.00	(0.01)	0.04***	(0.01)
Pumping Set	−0.05	(0.04)	−0.01	(0.03)	0.05	(0.04)
Plan To Move	0.05	(0.08)	−0.10	(0.08)	0.05	(0.06)
Income Agri	−0.12**	(0.06)	0.16***	(0.04)	−0.04	(0.05)
Work Abroad	−0.05	(0.10)	0.00	(0.08)	0.06	(0.07)
Remittances	0.05	(0.11)	−0.04	(0.09)	−0.01	(0.09)
Memberships	−0.04***	(0.01)	0.02***	(0.01)	0.01**	(0.01)
Exchange Info	0.11*	(0.07)	−0.01	(0.05)	−0.10*	(0.06)
<i>Household characteristics</i>						
Income	0.00	(0.00)	0.00	(0.00)	0.00*	(0.00)
Income × Income	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)

Table 6 (*continued*)

High Education	0.02	(0.04)	−0.05*	(0.03)	0.04	(0.04)
Age	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Risk Pref	0.45**	(0.22)	−0.42***	(0.16)	−0.03	(0.19)
Time Pref	0.33***	(0.11)	−0.06	(0.09)	−0.26***	(0.10)
Size	−0.01	(0.01)	0.00	(0.01)	0.01	(0.01)
Child3	−0.01	(0.05)	0.00	(0.04)	0.01	(0.04)
<i>N</i>	448					
Pseudo- <i>R</i> ²	0.416					

Significance levels: *10 per cent; **5 per cent; ***1 per cent.

We find almost no impact of threat experience appraisal on perceived flood probabilities. We only find that households evacuated from their home have a lower likelihood of expecting less frequent floods in the future. This finding may have important policy implications. If floods are actually independent events, a possibility discussed in Cameron and Shah,¹¹ the absence of a significant relationship between flood experience and perceived probabilities of floods is fully rational. If flood events are correlated however, then it should be interpreted as some form of irrational, or mistaken, belief. In that case, education and informational campaigns about flood risks could be quite valuable, especially in areas that have been impacted by floods.

Threat appraisal and perceived flood probabilities are significantly related. Households that expect high flood damage in the future (especially damage due to injuries) and that need more time to recover from a flood have a higher probability of expecting more floods in the future. This result reveals that perceived probabilities and perceived consequences of floods are intricately related.

Very interestingly, we find that our measure of coping appraisal, although imperfect, matters for explaining perceived probabilities. Attaching a high value to individual flood preparedness and believing oneself to be less vulnerable to floods than other households in the same village both increase the probability of expecting less frequent floods in the future.

Concerning the reliance on non-individual flood protection, we find that being protected by a sea dike or by a dam increases the probability of believing that there will be fewer floods in the future. Similarly the probability of expecting more floods in the future is reduced for households protected by a sea dike and/or dam. This reflects again a relationship between public flood management policies and private decisions or expectations. Socio-economic characteristics of households appear to play a limited role.⁸⁰

⁸⁰ Some variables measuring protective behaviour seem to play a role in beliefs. A high floor elevation increases the belief in higher future flood frequency, and reduces the belief in lower flood frequency. This could appear counter-intuitive if one ignored the endogeneity of protective behaviour. Similarly, belonging to a high number of institutions increases the probability of expecting more floods in the future and decreases the probability of expecting fewer floods. These results should be interpreted with caution due to obvious possible endogeneity.

Flood experience and perceived consequences

Finally, we analyse how flood experience may shape perceived consequences. Table 7 provides descriptive statistics on the perception of flood consequences, depending on household experience.

Expectations of flood damage are modified by experience. The global average damage score increases by 6 per cent, raising from 7.32 if the household has not been flooded to 7.76 if he has been, a difference significant at 5 per cent. Similar increasing patterns are found for households that have been evacuated or injured. The highest average score for flood damage is found for injured households.

Having one's dwelling flooded results in a higher expectation of flood impact on houses: 92.3 per cent of flooded households consider that a flood will have significant impact on their houses, compared with 66.3 per cent for those who have not been flooded ($p < 0.0001$). Similar patterns are observed for injured or evacuated households. As expected, households where people have been injured have the highest expectations in terms of future health impact of floods: 90.9 per cent of them consider that floods will result in a significant health impact, compared with 79.1 per cent for households that have not experienced any injury due to a flood ($p < 0.0001$).

Lastly, we document a relationship between flood experience and expectations about the time required for recovering. Households that have been flooded, evacuated or injured report needing a significantly higher number of days for recovering.

The general finding from Table 7 is that, having experienced a flood has a significant impact on perceived flood consequences. This result is confirmed by the econometric analysis presented in Table 8. We have used three logit models for explaining if a household considers that a flood has a negative impact on their house, on the health of their members or on their agricultural production. For the perceived impact of floods in general and for the number of days for recovering, we have used simple OLS. The explanatory power of the estimated models is relatively low, with a R^2 or a pseudo- R^2 varying from 0.107 to 0.500.

Our explanatory variables are the ones derived from the extended PMT and they also include household protective behaviours. The latter category of variables is included to capture the fact that households that have implemented flood

Table 7 Respondent's perceived flood consequences according to flood experience

	<i>Flood experience</i>								
	<i>Flooded</i>			<i>Evacuated</i>			<i>Injured</i>		
	<i>No</i>	<i>Yes</i>	<i>P-value</i>	<i>No</i>	<i>Yes</i>	<i>P-value</i>	<i>No</i>	<i>Yes</i>	<i>P-value</i>
Damage Flood (av. score)	7.32	7.76	0.132	7.43	7.79	0.098	7.47	8.04	0.161
House Impact (% yes)	66.29	92.27	0.000	77.31	89.01	0.000	76.29	86.36	0.276
Health Impact (% yes)	76.40	84.53	0.036	75.85	57.95	0.013	79.11	90.91	0.181
Agri Impact (% yes)	89.89	86.19	0.231	91.04	78.02	0.001	89.97	77.27	0.048
Time Recover (av. number of days)	8.10	12.43	0.295	8.97	9.56	0.837	9.07	9.59	0.922

P-value is for a *t*-test comparing means across samples.

Table 8 Determinants of respondent's perceived flood consequences

Variable	Damage Flood		House Impact		Health Impact		Agri Impact		Time Recover	
	Coef.	(SE)	Coef.	(SE)	Coef.	(SE)	Coef.	(SE)	Coef.	(SE)
<i>Threat experience appraisal</i>										
Flood Exposure	0.08	(0.08)	-0.00	(0.12)	-0.21*	(0.13)	0.45*	(0.27)	0.53	(1.19)
Flooded	0.27	(0.24)	0.71	(0.56)	0.13	(0.42)	0.17	(0.83)	-1.07	(3.48)
Injured	0.01	(0.39)	-0.29	(0.80)	0.92	(0.95)	-1.65	(1.02)	-1.32	(5.72)
Evacuated	0.26	(0.26)	0.72	(0.65)	0.62	(0.53)	-1.64**	(0.76)	-1.61	(3.84)
Water Elevation	-0.00	(0.00)	0.01	(0.01)	0.00	(0.00)	0.01	(0.01)	0.00	(0.01)
Days Flooded	-0.01	(0.02)	0.08	(0.09)	-0.07**	(0.03)	-0.05	(0.05)	0.10	(0.30)
Flood Significant	1.12***	(0.21)	0.86***	(0.32)	0.22	(0.38)	1.94***	(0.58)	5.78*	(3.13)
<i>Threat appraisal (except perceived consequences of floods)</i>										
More Flood	0.60**	(0.24)	0.16	(0.42)	0.75	(0.46)	-0.31	(0.60)	3.54	(3.45)
<i>Coping appraisal</i>										
Preparedness	-0.21	(0.21)	-0.45	(0.36)	-0.17	(0.37)	0.01	(0.53)	-1.80	(3.01)
Less Vulnerable	0.11	(0.21)	0.09	(0.32)	0.39	(0.35)	-0.59	(0.54)	-4.48	(3.01)
<i>Reliance on non-individual flood protection</i>										
State Confidence	0.05	(0.07)	-0.18	(0.12)	-0.08	(0.13)	-0.25	(0.20)	-0.64	(1.04)
Prov Confidence	0.15**	(0.07)	0.09	(0.13)	-0.09	(0.14)	0.42**	(0.20)	-0.26	(1.09)
City Confidence	-0.02	(0.05)	-0.18**	(0.09)	-0.23***	(0.09)	0.11	(0.13)	0.57	(0.67)
Protect River Dike	-0.18	(0.18)	0.46	(0.30)	0.97***	(0.34)	1.80***	(0.60)	4.71*	(2.63)
Protect Sea Dike	-0.42*	(0.23)	0.76*	(0.43)	2.51***	(0.79)	-0.63	(0.61)	-3.90	(3.42)
Protect Dam	0.31*	(0.18)	0.57*	(0.30)	-0.58*	(0.32)	-0.19	(0.51)	1.51	(2.62)
Fin Aid Pub	0.09	(0.21)	0.85**	(0.39)	0.36	(0.38)	0.64	(0.69)	-4.39	(3.02)
Mat Aid Pub	0.09	(0.20)	0.02	(0.32)	0.03	(0.36)	0.08	(0.55)	4.13	(2.94)
Health Insurance	-0.12	(0.17)	-0.25	(0.29)	-0.54*	(0.31)	0.37	(0.56)	4.77*	(2.56)
Life Insurance	-0.12	(0.38)	0.06	(0.62)	-0.23	(0.63)	-1.73*	(1.00)	-1.09	(5.61)
<i>Actual barriers</i>										
Low Education	-0.27	(0.22)	-0.61*	(0.36)	-0.16	(0.38)	-0.51	(0.60)	2.22	(3.21)
Low Income	-0.15	(0.32)	-0.57	(0.53)	-0.08	(0.57)	0.41	(0.97)	8.31*	(4.63)
<i>Household flood protective behaviours</i>										
Floor Elevation	-0.30***	(0.07)	-0.19	(0.11)	-0.02	(0.13)	-0.78***	(0.17)	1.05	(1.00)
Pumping Set	0.56***	(0.19)	0.50	(0.31)	0.75**	(0.34)	0.21	(0.55)	-1.70	(2.76)
Plan To Move	0.00	(0.30)	0.15	(0.62)	0.40	(0.64)	0.44	(0.79)	-3.77	(4.46)
Income Agri	0.14	(0.26)	-0.31	(0.43)	-1.28***	(0.48)	2.28***	(0.84)	-1.75	(3.77)
Work Abroad	-0.43	(0.41)	-0.65	(0.71)	-1.52**	(0.77)	0.65	(0.95)	2.16	(5.97)
Remittances	0.20	(0.48)	0.89	(0.81)	2.31**	(1.14)	-0.25	(1.08)	-6.39	(6.95)
Memberships	-0.02	(0.04)	0.12*	(0.07)	0.08	(0.07)	0.19*	(0.11)	0.34	(0.56)
Exchange Info	0.50**	(0.25)	-0.35	(0.44)	-0.78*	(0.44)	-1.60**	(0.71)	-1.84	(3.68)
<i>Household characteristics</i>										
Income	-0.01	(0.01)	-0.02	(0.01)	-0.03**	(0.01)	0.03	(0.02)	-0.01	(0.10)
Income × Income	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	-0.00	(0.00)	-0.00	(0.00)
High Education	0.22	(0.19)	-0.50	(0.32)	-0.44	(0.33)	0.44	(0.52)	1.98	(2.74)
Age	0.00	(0.01)	-0.02	(0.02)	0.02	(0.02)	0.05*	(0.03)	-0.25	(0.17)
Risk Pref	0.05	(0.98)	0.48	(1.58)	-0.83	(1.90)	-4.37*	(2.29)	15.15	(14.39)
Time Pref	0.97*	(0.59)	-0.46	(0.99)	-0.90	(1.13)	1.85	(1.53)	-5.85	(8.63)

Table 8 (*continued*)

Size	0.08	(0.06)	−0.01	(0.10)	−0.08	(0.10)	0.58***	(0.17)	−0.19	(0.83)
Child3	0.07	(0.22)	0.06	(0.36)	0.72*	(0.42)	0.19	(0.65)	−2.94	(3.22)
Intercept	4.21**	(2.10)	2.19	(3.44)	7.35*	(4.26)	3.61	(4.77)	−20.86	(30.76)
Model	OLS		Logit		Logit		Logit		OLS	
<i>N</i>	448		448		448		344			
<i>R</i> ²	0.212		0.234		0.246		0.500		0.107	

Significance levels: *10 per cent; **5 per cent; ***1 per cent.

protective behaviours may expect lower flood damage in the future, if they are confident enough in their own ability to reduce flood consequences on their household.

A first result in Table 8 is that the perceived flood consequences for housing, agricultural production and health do not have the same determinants (see columns 2–4). This stresses the need to jointly consider these three dimensions when assessing flood consequences. It also calls for designing and implementing flood management policies targeted at each of these dimensions (protection of housing, of agricultural production and of health).

Some variables belonging to the threat experience appraisal category have a significant impact on perceived consequences. The most important driver within this category is the fact that a household reports having experienced significant flood damage in the last five years. The coefficient for this variable is significant and positive in all cases except for explaining significant health impacts. We also document a significant relationship with threat appraisal. Households expecting more frequent floods in the future expect greater damage, a result *a priori* intuitive. Contrary to what has been found for perceived probabilities, our two variables capturing coping appraisal are here not significant.

Reliance on non-individual flood protection also matters. We find in particular that being protected by a river dike, a sea dike or a dam tends to increase the perception of high flood consequences in the future. It is likely that dikes and dams have been built in areas with a high probability of flood occurrence. We have also already mentioned the risks associated to dam collapses. When such structures are built, floods are likely to occur less often, but when they occur, they tend to have more severe impacts. This may explain the positive relationship we find between being protected by a dike or a dam and perceived flood consequences. Our measures of actual barriers (low income and low education) do not appear to be significant.

Mixed evidence concerning the impact of household flood protective behaviours are found. We find however that a higher floor elevation is associated with a lower belief in high flood damage, in particular for damage on agricultural production. Having a high floor elevation could then be viewed as a form of self-insurance allowing households to reduce losses in case of flood occurrence. For farmers, a higher floor elevation makes it easier to store agricultural production in a safe place. Lastly, only few household characteristics appear to be significant.

Conclusion

Flood private protective behaviours and flood risk perceptions are two important notions that should be embodied into any efficient flood policy, especially in a flood-prone country like Vietnam. In this paper, we have provided a detailed analysis of the determinants of protective behaviours and flood risk perceptions, using data from a household-level survey conducted in the Vietnamese province of Nghe An.

We have first documented that the extended protective motivation theory of Grothmann and Reusswig¹⁷ offers a valid approach for understanding and predicting the flood protective behaviours of Vietnamese households. Indeed, “threat appraisal”, “reliance on non-individual flood protection” and, to a much lesser extent, “threat experience appraisal” processes have been found to be significant determinants of flood protective behaviours as predicted by the PMT. In particular, some variables measuring threat appraisal (perception of flood probabilities and flood damage) are significant to explain flood protective behaviours. This contradicts the previous literature which has found, at best, a weak relationship between flood risk perceptions and private protective measures.¹⁵ We argue that one possible explanation for this discrepancy could be that our detailed household-level data allow us to control for some potential determinants (such as public policies and risk-sharing mechanisms) which were not always accounted for in previous studies. Almost all previous studies have dealt with developed countries. Since flood risks are comparatively much larger in a country like Vietnam, the PMT cognitive processes may be more easily identifiable. Nevertheless, one must recognise that some cognitive processes expected to be important drivers of flood protective behaviour according to the extended PMT did not appear to be significant in our study (this is in particular the case for “coping appraisal” but this result may be imputed to our poor measure of this process). Moreover, the relatively modest predictive power of our explanatory models of protective behaviours suggests a high level of heterogeneity in terms of individual preferences for specific mitigation options. This heterogeneity should be taken into account when designing public flood management policies targeted at Vietnamese households.

Second, we have shown that flood risk perceptions—being defined as the combination of perceived flood probabilities and perceived flood consequences—can also be explained by variables derived from the extended protective motivation theory. We have however demonstrated that perceived flood probabilities and perceived flood consequences have some specific determinants. Perceived flood probabilities are affected by threat appraisal and coping appraisal cognitive processes, but not by threat experience appraisal. Perceived consequences of floods are driven by threat experience appraisal and threat appraisal processes, but not by coping appraisal. These results call for a further analysis of the role played by emotions (such as fear) in decision-making under risk, since emotional reactions to risky situations might diverge from the cognitive assessment of those risks.⁸¹ These results also suggest the need to take into

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⁸¹ Slovic *et al.* (2004); Loewenstein *et al.* (2001).

account, when designing flood risk management policies, measures of both perceived flood probabilities and perceived flood consequences.

Our analysis bears on a respondent's perception of his/her situation with respect to flood. This perception may differ from the actual situation: For instance, a respondent who has experienced a traumatic flood may overestimate flood consequences due to an alteration of his/her decision-making system. For non-traumatic events, experience may lead to an underestimation of probabilities, as indicated by the "description-experience gap". If working on people's perception is a priori appropriate when the objective is to understand households' protective behaviours and to assess welfare, it might not be so when evaluating and ranking different flood management policies. The divergences between perceived consequences and real (observed) consequences of floods might be a relevant question, both for researchers and policymakers.

Finally, we believe that our results could help understand flood risk perception and protective behaviours in other countries. Vietnam is clearly specific due to its history, culture, economy and political organisation. From a policy perspective, the role played by the Communist Party and the highly centralised organisation of the country make it difficult to extrapolate our results to other countries. However, flood patterns (role of monsoon, importance of coastal areas, etc.) and socio-economic characteristics of households (importance of rural populations, concentration of populations in delta and coastal areas, etc.) in Vietnam and in some other flood-prone countries located in the same region (Bangladesh, Nepal, Thailand, Indonesia, Philippines) are quite similar. A better knowledge of flood perception and protective behaviours in Vietnam may also be useful for these countries.

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