

Response Letter 1

Manuscript: "Identifying the drivers of private flood precautionary measures in Ho Chi Minh City, Vietnam" by Thulasi Vishwanath Harish, Nivedita Sairam, Liang Emlyn Yang, Matthias Garschagen, and Heidi Kreibich

General Comments:

Incorporation of flood risk mitigation measures taken by the residents is an important part of flood risk analysis/management. This study aims to identify the drivers of the private sector to implement these measures in Ho Chi Minh City, Vietnam by analysing the survey data collected from 1000 at-risk households. For this purpose, the researchers used 'Protection Motivation Theory' in combination with the 'Transtheoretical Model' by accounting for both non-structural and structural measures based on both 'Proactive' and 'Reactive' behaviours. The article includes some interesting contents that are substantially practical in the real-world flood risk analysis. However, there lies a number of fundamental concerns, mostly related to the organisation and the flow of the information on the methodology and application.

R: We thank the reviewer for taking their time to provide a comprehensive review of our manuscript. We have restructured the manuscript in accordance with the reviewer's comments. In addition, we have provided a detailed explanation to our approach in the response letter and the manuscript accordingly. The responses are in Italics and the lines cited from the manuscript are provided in quotes.

Major Comments:

- **It would appear that the majority of the contents are parts of a larger document that are put together without a decent amount of cohesion and linearity. This significantly disturbs the reader to follow the flow of the article and understand the novelty of the proposed method as well as the usefulness of its output in the context of flood risk management. More specifically:**

1. A bulk body of information in the ‘Introduction’ section constitutes the historical data on the flood events (lines 21-37), introduction to Flood Risk Management (lines 39-48) and the private precautionary measures (lines 49-65). Though important elements (and probably important for a thesis or dissertation), they are not specific to the research novelty and the method that the authors employed to “Identify the drivers of the private flood precautionary measures in Ho Chi Minh City, Vietnam”. However, Section 2, ‘Study area – Ho Chi Minh City’, appears to include the introductory information that the reader should obtain from an introduction section which is more focused on research itself. Also, the introductory information in Section 3 could aim the authors to rewrite the introduction section.

R: Thank you for the comment. Yes, the study was performed as a part of a Master’s thesis. We have now improved the structure and coherence of the manuscript by removing large parts of background information from the introduction that are not directly relevant to the study. The study area is already introduced in the introduction. However, we would still like to have a separate section on the study area to talk about the survey methodology.

2. Section 3, which is expected to convey the information on the ‘material and method’ in the research is not self-explanatory of what is specific to the research considering the aim and objectives. The authors could use the framework introductory information, explained in Section 2 (lines 99-124), in the rewritten ‘Introduction’ section and focus more on the materials and methods in the new section (such as lines 127-204).

R: We have incorporated most of the suggested changes. Materials and Methods now includes sub-sections on the questionnaire survey, application of the PMT-TTM framework relevant to the study and the description of data-driven ML models. We mention the PMT-TTM framework in the introduction lines 50-55:” In order to bridge the knowledge gap in understanding the level of flood preparedness and uptake of private precautionary measures, several studies have applied Protection Motivation Theory (PMT) to identify the drivers that motivate households to uptake protective measures (Babcicky and Seebauer, 2019; Bubeck et al., 2018). In order to include a household’s willingness to uptake measures, the PMT was complemented with a Transtheoretical Model (TTM) (Weyrich et al., 2020). TTM is a behavioural change model which emerged from clinical psychology and represents decision stages which indicate an individual’s degree of readiness to act upon danger to protect themselves from a risk (Bočkarjova et al., 2009).”. Additionally, a separate section within Data and Methods helped improve the coherence of the manuscript.

3. Section 4, Results and discussion, does not respect the standard of a decent academic article and therefore should be rewritten to comply those requirements (authors could use other examples published in NHESS). More specifically, the section and the subsections lack introductory sentences to acquaint the readers with appropriate preparatory information for what sort of outputs will be discussed with respect to a specific purpose in the coming subsections. Take the instance of line 206, which jumps directly to the specific outputs without any preparation to answer: ‘what’, ‘why’ and ‘how’ with respect to what was said before in the ‘materials and method’ section. Also, this section includes a large

amount of discussions on the previous research other than specifying the key findings of the present research.

R: Thank you for the comment. We have now improved the 'Results and discussion' section by including appropriate preparatory information, as suggested. Also, thanks for the specific comments on this section. Please see answers to specific comments where this is explained in detail.

- 4. Section 5, conclusion, should include the key findings of the research alongside the brief summary of the research. It should also include specific limitations in more details and suggestions for future research. It would also help the quality of the conclusion to provide information on the reproducibility of such outputs for other place/countries.**

R: The conclusion section has been revised to include the key findings and the summary of the research along with the scope for further improvements. We could provide literature comparing the drivers of private precaution from studies from other countries. However, we could not test the transferability/applicability of this approach to other countries within the scope of this study.

- The article does not weigh the privilege of the proposed research over other existing methods. For example, questionnaire surveys. In simple words, the article does not highlight the importance of using 'Protection Motivation Theory' and 'Transtheoretical Model' for conducting such research.**

R: The study uses a combined protection motivation theory - trans-theoretical model as the analysis framework and uses data from questionnaire surveys to quantitatively derive the drivers of private precautionary measures. The privilege of the research is that the framework provides an understanding of the cognitive processes - threat and coping appraisal and the decision stages involved in implementing private precaution. The questionnaire data provides case study relevant inferences which is the quantitative calibration of the PMT-TTM framework specific to HCMC.

Technical/Minor Comments:

- The 'Abstract' should be revised so as to clearly elaborate on the method, what has been specifically analysed from the survey datasets, and what are the key findings of the research and what do they imply/show. Especially line 13 onwards, the flow of information does not seem to be correct; therefore, makes it difficult to understand. Also, avoid using long sentences as short ones would help the readability of the abstract and all your work.**

R: Thank you for the comment. Abstract is revised to include details on the methods, key findings and implications.

"Private flood precautionary measures have proven to reduce flood damage effectively. Integration of these measures into flood response systems can improve flood risk management in high risk areas such as Ho Chi Minh City (HCMC). Since uptake of such measures is voluntary, it is important to know what drives householders to implement precautionary measures. In this study, we developed a framework

representing the uptake of private precautionary measures based on Protection Motivation Theory and Transtheoretical Model. Using empirical survey data collected from 1000 flood prone households in HCMC, we implemented lasso and elastic net regression to identify the drivers of private precaution. The measures were classified into structural measures and non-structural measures based on whether structural changes to the building were required. The households were classified into proactive and reactive households based on whether their decision to reduce risk (i.e., uptake precautionary measures) was preceded by experiencing flood. The data-driven model revealed that the household's level of education, the degree of belief in the government to implement regional flood protection measures and the degree of belief that in case of flooding, one has to deal with the consequences of flooding by themselves positively influence the proactive uptake of non-structural measures. Among the households that experienced flooding before implementing the measures, the uptake was found to be driven by the severity of the experienced damage. For the same group of households, perceiving high severity of future flood impacts was found to negatively influence the uptake of structural flood precautionary measures. These results highlight that efforts to improve the implementation of private precautionary measures should consider the socio-economic characteristics of the household, their past flood experience and their perception of flood risk management for communicating flood risk and incentivizing private precaution."

- The 'Introduction' section has many repetitions, which could be made more concise with respect to the aim and objectives of the research. For example, doesn't line 24-26 convey similar meanings to the previous two lines?

R: Thanks for the comment. These lines were extracted while revising 'Introduction' and other repetitions are now removed.

- In-text citations does not seem to follow a uniform template. In some instances, a comma is used after et al. while in the others there is none. Compare for example, line 31, (Nguyen, et al. 2021(b)) and line 36, (Cao et al., 2021).

R: In-text citations are rechecked for uniformity in the revised manuscript.

- Line 31-33, 'Developing countries ... 'could be more specific. For example, by specifying 'What limited capacity?'

R: Thank you for the comment. The text is now removed in the revised manuscript.

- Line 36. The authors have not reviewed any research yet; therefore, it would be better to provide some more explanatory information on the physical and environmental drivers of flood risk before providing such conclusion.

R: Thank you for the comment. We referred to the literature review by Nguyen et al., 2021(a) (<https://doi.org/10.1111/jfr3.12689>) concludes that most studies tend to prioritize physical and environmental drivers. However, Line 36 is removed to maintain coherent flow in the modified introduction of the revised manuscript.

- Line 37. "To counteract the trend of increasing flood risk due to global change, improved flood risk management is necessary." is a trivial piece of information and sounds unnecessary as it has neither related to what has been said before nor has been specifically in line with the flow and aim and objective of your research.

R: We agree. The sentence has been extracted.

- Line 42 is a good place to explain about proactive measures in the context of the

implementation of flood risk management strategies.

R: Thanks for the comment. The word 'proactive' has a specific definition in the context of this study – i.e. we refer to households' uptake of private precaution without flood experience as a driver as proactive decision-making. Therefore, we would like to explain this term in 'Data and Methods' section where we explain the decision stages relevant to Trans-Theoretical Model.

- **Lines 42-45: the authors could elaborate more. Do you mean: because the flood hazard changes rapidly in urban areas amongst the household units, implementation of the conventional large-scale flood protection measures, such as dikes and retention basins, is challenging?**

R: Thank you and yes, the explanation is correct. We have provided more explanation in the revised manuscript – "Based on the design specifications, there is a possibility that conventional large-scale flood protection infrastructure may fail due to rising flood hazard levels. The growing city also poses a challenge to implement regional measures as new settlements rapidly develop. Hence, a transition to integrated flood risk management strategies is imperative (Botzen, et al., 2019(a); Nguyen et al., 2021(a)). This means, complementing large-scale protection structures with small scale private precautionary measures (Du et al., 2020; Scussolini et al., 2017; Yang, et al., 2018)."

- **Lines 45-48: is not comprehensible as the previous paragraph is not structured based on the research scope.**

R: After updating the manuscript based on the previous comment, we believe this sentence is now comprehensible – please see answer to the previous comment.

- **Line 49: use 'Private precautionary measures have demonstrated to be effective in reducing flood damage.' instead.**

R: Thank you! This sentence is now removed from the updated manuscript

- **Line 53: use "There is a knowledge gap in ..." instead.**

R: Yes, we have corrected the sentence.

- **Line 60: "Experiencing repeated flooding can change this attitude (Bubeck et al., 2018; Chinh et al., 2016)." Using such sentences from other sources requires mentioning further backup from other research. For instance, what did they specifically conclude in their research? Using such assertion for your purpose in the introduction does not provide the reader with the required clarity.**

R: Thanks for the comment. The statement has been extracted from the introduction in the revised manuscript. We now mention some influencing factors identified by other relevant studies lines 47-49: "At household level, certain indicators including education, income, household composition, occupation, social networks and place attachment were identified to influence protective actions (Okayo, et al., 2015, Ji, et al., 2021)."

- **Line 63:** “These insights can guide the design of targeted risk communication campaigns and incentives to improve flood preparedness” The authors should elaborate more on such sentences.

R: Thank you! The sentence is removed from the introduction and included in the conclusions based on the results. Lines 295 - 299: “Based on the results of this study, we recommend that, all households (especially the ones with low levels of education), should be made aware of the future risk, protection measures by the government and also their individual responsibility to protect their houses. Risk communication and awareness campaigns covering these aspects has the potential to motivate the households to proactively implement precautionary measures.”

- **Lines 49-71:** This paragraph should be more specific and concise to fit the purpose of this study. The authors should provide a summary of what has been done in the present research as well as its basis and novelty.

R: Thank you. The revised introduction is shortened to only include the aspects directly relevant to the study.

- **Line 76:** add reference for “The city's population is expected to grow even faster in the coming years.” Also, it is good to mention the population growth rate.

R: The reference is from a 2010 report from the Asian Development Bank. However, the sentence is now removed in the updated manuscript.

- **Line 82:** The flood risk is exacerbated by climate change, ongoing urbanization, increasing population and infrastructure density leading to a higher proportion of sealed surfaces.” Is a repetition. The authors should consider removing the repetitive sentences in the revised/rewritten manuscripts, especially in the ‘Introduction’ and ‘Materials and Method’ sections.

R: We have removed the redundant sentences.

- **Line 94-96:** as last lines of your subsection should conclude your discussion on the issue. Please consider to follow a more linear approach in providing the reader with the required information before they reach the next section of your manuscript.

R: Thank you for the comment. The case study relevant information is now included in the introduction and we improved the text to follow a linear approach.

- As mentioned above, the majority of Section 3 could be used in the revised ‘Introduction’ sentence and this section should be more concise and specific to the researcher’s own work and method.

R: We agree. The section is reduced to only the data and methods directly relevant to the study.

- **Line 119:** use “The present approach” or “The proposed framework” instead of “This framework”.

R: Thanks! It is altered in the revised manuscript.

- **Line 129: “The survey collected 1000 valid responses from local households who suffered from floods in the recent 10 years.“ here the authors are expected to mention the representation percentage of the selected number of household with respect to the total population (9 million + 2 million?). And also, how this rate would influence the validity of the research findings?**

R: Thank you for the comment. In this study, the selection of survey areas (see figure1 in the revised manuscript) was done in a comprehensive way. The households were selected in random within these survey areas. The survey areas were identified together with local stakeholders and research partners in HCMC. The chosen areas were diverse and represent various heterogenous urban characteristics. They were all prone to frequent floods. Hence, the sample is representative of the diverse characteristics of households in the growing urban areas of HCMC that are prone to frequent flooding. Owing to the diversity across the surveyed areas, changes of the specific number of surveyed households, e.g. from 1000 to 1500 or 800 is supposed to influence the research findings at a very limited level. We have included this point into the updated manuscript.

This is now included in the revised manuscript (Lines 69 - 78) –

“The survey collected 1000 valid responses from local households which suffered from floods in the last 10 years. The questions were drafted based on expert knowledge from flood risk researchers, social scientists and local stakeholders in HCMC. The survey locations were established in order to cover a broad range of socio-economic profiles and flood types such as tidal, fluvial, pluvial and compound flooding in the city. A survey pre-test involving 60 households from three districts (Binh Tan, District 7 and District 2) was conducted in December 2019 in order to test the validity of the questionnaire. The questionnaire was revised, based on the responses from the pre-test. The questionnaire covered aspects concerning two past flood events experienced by the households - the most recent and the most serious event in the last 10 years. The questions pertained to the hazard and damages suffered by the households, implementation of precautionary measures, early warning quality and lead time, household’s risk perception and socio-economic profile.”

- **Lines 131-132: Could be more specific. For example, what class of socio-economic profiles and what types of flood types have been investigated?**

R: We didn’t intend to select specific households based on socio-economic profiles. In contrast, based on expert advice from stakeholders and researchers in Vietnam, we invested on covering diverse urban neighborhoods in HCMC based on expert knowledge (see, section 2.1). Within these neighborhoods, the households were selected in random. At the household level, the only criteria in the survey was that “the household must have experienced floods in the last 10 years”. The flood types included pluvial, fluvial, tidal and compound events.

- **Line 152: use “Each precautionary measure is categorised into ... “.**

R: Changed accordingly

- **Figure 2. Is this figure necessary? The authors could use a simple table instead.**

R: Figure replaced by 2X2 matrix

- **Line 164: the authors should explain the reason that the lasso and elastic net regression models lead to identification of drivers. And in-detail explanation is required here.**

R: The explanation for lasso and elastic-net regression are improved in the revised manuscript (section 2.3). The explanation includes how lasso and elastic net performs identification of explanatory variables. However, the capability of the models is validated only after applying the models (based on the deviation metric).

- **The authors should explain the notations in all the equations and avoid explaining the repeating ones. This can be done by providing a couple of lines below each equation/formula.**

R: Notations are explained in the revised manuscript. For example, see the response for the previous comment.

- **Date shown in Figure 4: where did the authors derive/obtain the ‘Implementation cost of the private precautionary measures’? If it is a part of the present research, there has to be some explanation. If not, the authors should provide information on how they obtain them. Also consider it in the further discussion.**

R: The costs are part of the present research. They were a part of the survey questionnaire. Since we are interested in the average implementation cost of each measure, the figure is replaced with the average cost in the manuscript text. E.g. lines- 205-206: “The average cost of purchasing pumping equipment and mobile barriers were 3.2 and 1.4 million VND, respectively.”

Also, the costs are introduced in the data and methods section – lines 120-122:

“In addition to the timeline of implementation, the survey also collects data on the cost of implementing the measure. The corresponding question is presented below.

Question: If you implemented the measure, how much did it cost to implement the measure? _____ million VND”

- **Lines 240-245: Study worth analysing the difference in the socio-economical drivers between the countries that influence households to take flood mitigation measures at individual levels. What are the differences and how they might change according to each country socio-economical driver?**

R: Thank you for the comment. We could not substantiate the attribution of socio-economic drivers between countries to flood mitigation measures at the household level. So, in the updated manuscript, we have removed the statements on country-specific analysis.

- **Section 4.2 (starting from line 245):** The variables discussed here are not mentioned/explained previously in the article, therefor the reader is not familiar with these terms. The authors can make a table and explain each before the reader reaches to Section 4.2.

R: All the variables are described in Table 3 and Appendix A. The reader is also directed towards these tables. However, we understand the lack of coherence and have restructured the section in order to get acquainted with the variable description in the Table before reading them in the text.

- Lines 251-253: Good to know what Table 3 has. It should be explained before discussion on the results. Please do not mix the discussion of Table 3 with Figure 5. The authors should first explain Table 3, then discuss figure 5. The authors should ensure that they explain about the variables before jumping into the discussions. It can be in a few lines in the introductory paragraph of this section explaining what has been studied with what aim and how.

R: This section has been restructured as suggested and Table 3 is presented before Figure 5 (now figure 4). However, for the discussion, Table 3 and Figure 4 go together – since both present the influencing variables.

- Lines 253-258: the meaning of these sentences are not clear. For example, what is the difference between 'house damage' and 'house impact'? The authors should explain 'house damage' and 'house impact' before reaching here to give the readers an idea of what they mean.

R: The sentence is more comprehensible after reading the variable description column in Table 3 which has now been moved to the starting of the section. 'House Damage' variable represents the damage already experienced by a household from past flood experience. 'House Impact' variable depicts the level of damage to the house anticipated by the household due to future flood events.

- Line 294: use comma after 'Next'.

R: comma added to the text.

- Lines 297-299: There is no need for mentioning the findings of the previous research in your discussion if they are not related to the results' discussion.

R: Thank you! We have removed unrelated references from the discussion.

- Lines 301-305: require further elaboration.

R: Thanks for the comment. We are unfortunately not able to infer more on the drivers for structural proactive measures. This is now explained in lines 271-279: "A limitation of the analysis is that, the structural proactive household group did not reveal any significant influencing variable (Figure 4a). One potential reason is that many proactive households that have implemented structural measures would have often implemented them while constructing the house or they might have also bought the house with the measure already implemented. In both these cases, we are not able to ascertain whether the householder made a conscious choice to implement the measure. The study is limited to the householder's independent decision stages based on the questionnaire survey. Hence, there are several external factors such as building code requirements by the government, influence by neighborhood networks that are not considered in this study. This calls for a future research based on comprehensive participatory approach with institutional stakeholders and private householders to develop a systemic understanding of the external factors influencing the

uptake of private precaution.”

- **Lines 306-319: This is not a concluding paragraph for the discussion section. The authors can clearly explain what their discussion suggests with respect to the aim and objective of the research.**

R: Thank you for the comment. The concluding paragraph of the section has been revised – lines 279 - 284: “The identified drivers of private precaution in proactive households can be used to better motivate all the households exposed to flooding to uptake of private precaution. For example, risk communication could focus on the measures undertaken by the government to improve flood protection enhancing the trust in government; information and guidance on the responsibility of households to protect themselves and deal with their flood damage should be provided; retrospectively, the self-efficacy of households that experienced flooding may be increased by providing them with information on the effectiveness of private precaution and incentivizing the uptake.“

- **In ‘Competing interests’, Is this necessary to mention that one of the authors is an executive editor at Natural Hazards and Earth System Sciences (NHESS) journal? Please do check it with the editor. Also, make sure that the Appendix is located in a correct place.**

R: We have removed the statement mentioning one of our authors is an executive director at NHESS under ‘Competing interests’ section. According to the Manuscript composition ([NHESS - Submission \(natural-hazards-and-earth-system-sciences.net\)](#)) Appendix is rightly placed after conclusion.

- **Titles of the sections and subsections should be more informative elaborating on their contents by also preserving the linearity in the revised manuscript.**

R: Revised as suggested

- **Also consider using more informative caption for the figures and the table 1.**

R: Revised as suggested.

Response Letter 2

Manuscript: "Identifying the drivers of private flood precautionary measures in Ho Chi Minh City, Vietnam" by Thulasi Vishwanath Harish, Nivedita Sairam, Liang Emlyn Yang, Matthias Garschagen, and Heidi Kreibich

General comments

The drivers of individual choices in the context of flood protection and flood risk mitigation are not clear. This study takes an interesting and new approach into understanding such drivers, and it selects a very interesting local case for this scope, Ho Chi Minh City, in Vietnam, a city plagued by frequent flooding and with still lackluster government solutions on flood protection. The methodology is statistically advanced, and the size of the survey is impressive. The presentation of results is correct, and useful lessons can be drawn from the analysis. The study grapples with theoretical frameworks from the social and psychological sciences, and I commend the authors for explaining the key concepts and methods with sufficient care that someone without that background – like me – is still able to follow adequately. Terminology throughout the text is consistent. The article is quite concise, with the exception of some lengthy parts of the Introduction. The text is well written and generally clear, though I recommend that the authors revise it again to improve simplicity of some sentences and correct minor mistakes. The paper could be published in this special issue, pending careful revision on a number of aspects, both general and specific, as explained below.

R: Thank you very much for taking the time and effort to review our manuscript. We have considered all the comments to improve our manuscript and implemented the recommended changes. We have also provided relevant explanations in the response letter. The responses Sentences from the manuscript are given in quotes.

The reference to the literature in the Introduction is largely inadequate. I include below specific comments on this issue, limited to the first lines of the introduction. It is necessary that the authors verify every statement and its supporting references carefully throughout the manuscript.

R: Thank you very much for the comment! We have corrected the references and also, restructured the introduction (also, in respect to comments from Reviewer 1).

The Transtheoretical Model as implemented in the study distinguishes between households at two 'risk reducing stages': proactive and reactive. It is not clear to me, especially after seeing how this differentiation is carried out in the survey (lines 141-on), whether it is possible to determine whether the moment when the interviewee responds to the survey is before or after 'the flood'. In a context where floods occur with remarkable frequency, are attitudes and behaviors influenced by thoughts of past floods or rather by expectations of future floods? And is it even possible to tell them apart? Can the authors clarify how they deal with this ambiguity, and how sensitive are the results with respect to this dubious point?

R: Thanks for the comment. We agree that the categorization of households in HCMC (given high flood frequencies) into proactive and reactive groups is challenging. We categorize households that implemented precaution measure before experiencing a serious event in the last 10 years as proactive and households that implemented measures after experiencing a serious event in the last 10 years as reactive.

The results indicate that households are influenced by both – past floods and anticipated future floods. Past floods positively influence them to adapt precautionary measures due to the high level of damages already sustained. But surprisingly, anticipating more severe floods in the future demotivates the households to uptake precautionary measures. The discussion in section 3.2 is now updated to improve clarity.

And is it even possible to tell them apart? The questionnaire survey is specific about the temporal precedence of the implementation of measure with respect to the flood event. In order to obtain valid responses, we ensured that the respondents understood the temporal precedence.

The key choice of aggregating responses according to whether the measure is structural or non-structural is not motivated. Even after reading the discussion of the results, I am not convinced that this is one of the two most relevant ways to discriminate among households or measures. I understand that the research is broadly framed in the context of a need for non-structural measures to also be implemented, next to structural ones, so that 'integrated flood risk management' is achieved. But it is not clear to me that this implies that structural vs non-structural is a key dimension along which the results of this behavioral survey should be analysed. I think that there is no clear a priori reason to assume that the type of measure matters heavily for the behavior of flood-prone actors, whereas it would seem more reasonable that factors like price (an hypothesis in fact disproven by this study) or familiarity with the measure should matter more, a priori. Please motivate this choice, or alternatively analyse and present

results with the only differentiation of preventative vs reactive households, or other relevant differentiations.

R: Thank you for the comment. Precautionary measures are classified into structural and non-structural measures based on whether their implementation requires making structural changes to the building via re-construction or renovation. We classified households based on structural and non-structural measures in order to control for how the permanence component of a precautionary measure which influences the household's decision.

In the Methods, there is no presentation of the explanatory variables that are taken into consideration in the survey and for the regressions. Nor is it stated whether households are surveyed about the cost of the measures, of whether costs are taken from other sources.

R: All the explanatory variables are presented in Appendix A, while only the important explanatory variables are described in Table 3 under 'Results and Discussion'. We have added the source of implementation cost in the revised version (section 2.2) – the costs were obtained from the survey.

Specific comments

In the abstract we read that two seemingly contrasting beliefs both promote proactive implementation of private measures: "degree of belief that the government will implement effective flood protection measures and degree of belief that one has to deal with the consequences of flooding by themselves". How is this possible?

R: The first belief is an assurance that the government is taking measures to prevent flooding by implementing on a large scale (at city level) measures. This was found to motivate households to uptake private precautionary measures to complement the measures of the government. This is directed towards reducing flood impacts. The second belief is that the household believes they have to deal with the consequences when a flood occurs by themselves.

L 24: whereas Botzen et al 2019a is a fine review of the trends and drivers of economic impacts of floods in the past and future, it doesn't seem to support a statement specifically on the physical aspect of floods and climate change. There are several papers that can be picked for that, e.g., Winsemius et al. 2015 (10.1038/nclimate28930) for river flooding, or those referenced in the following sentence.

R: Thank you for pointing out. We agree the review by Botzen et al 2019a, does not support the statement regarding climate change. In the updated manuscript, we have removed the statement.

27: Whereas sea level rise obviously increases coastal flooding, it is not clear that it will bring more frequent or intense storm surges. E.g., Muis et al. 2020

<https://doi.org/10.3389/fmars.2020.00263>

R: Thank you. The statement has been removed in the revised manuscript.

L 30: Mendoza et al. does not seem an appropriate study to support that Vietnam is the country most vulnerable to climate change. Further, Dasgupta et al is a dated study. This is a bold statement that requires credible support.

R: Thank you for the comment. We have updated the statement and references –lines 28-29: Ho Chi Minh City, Vietnam is one of the cities most exposed to flood risk under current socio-economic conditions (Hallegatte et al., 2013).

31: The study of Nguyen et al. 2021b does not show that floods are the most damaging hazard in Vietnam, as it is concerned with a very different issue.

R: We agree and have extracted the statement in the revised manuscript.

32: How can Hagedoorn et al. 2021 discriminate between the impacts of floods in developing and in other countries, when they only study flood adaptation behavior in Vietnam?

R: We agree and have removed Hagedoorn et al. 2021.

L 55: whereas Sairam et al 2019 (previously referenced) empirically verify the effectiveness of measures, the studies of Scussolini et al and Du et al are based on modeling, and undertake many assumptions. This has to be made clear in the manuscript, as the empirical and modeling approaches have different value when it comes to show-prove-support-report effectiveness of measures.

R: Thank you! We have mentioned “Expected Annual Damage” for the modelling-based studies in the revised manuscript.

lines 40-44: “Private precautionary measures include elevating buildings, shielding with water barriers, waterproof sealing, fortification, flood adapted use, flood adapted interior fitting and safeguarding of hazardous substances (Chinh et al. 2016). Elevating and dry-proofing buildings in HCMC was found to reduce expected annual flood damages by 52-55% and 82% respectively (Scussolini et al. 2017). Another study conducted in Shanghai by Du et al. (2020) reported 69% reduction in expected annual flood damages from wet-proofing.”

67: “evaluate how these drivers are associated with the willingness of households to adopt private flood precautionary measures”. Isn’t this a tautological sentence? Once the drivers of behavior are known, we also know what makes people willing to adopt the behavior. I might be missing something here.

R: It is based on the heterogeneity across the decision-making stages of people. For example, if quitting smoking is the goal, some are only thinking about quitting, others are in the process while few others have already quit. Similarly, when implementing private flood precautionary measures, willingness tells us in which decision-stage they are at, given the drivers of private precaution – based on timeline of the implementation of measures. These stages are modified in our study based on prior flood experience as proactive and reactive groups to especially identify the drivers for proactive groups so that the reactive and passive households can be motivated based on these drivers to implement

measures.

L 68 “we develop an empirical data driven approach complementing theoretical protection motivation theory and transtheoretical model frameworks”. I don’t think the meaning/content of this sentence will be clear to the reader. Further, the following sentence is repetition of previous sentences.

R: Thank you! The sentence is rewritten in the revised manuscript and we have included the information on the framework before the sentence. Lines 50 -57: “In order to bridge the knowledge gap in understanding the level of flood preparedness and uptake of private precautionary measures, several studies have applied Protection Motivation Theory (PMT) to identify the drivers that motivate households to uptake protective measures (Babcicky and Seebauer, 2019; Bubeck et al., 2018). In order to include a household’s willingness to uptake measures, the PMT was complemented with a Transtheoretical Model (TTM) (Weyrich et al., 2020). TTM is a behavioural change model which emerged from clinical psychology and represents decision stages which indicate an individual’s degree of readiness to act upon danger to protect themselves from a risk (Bočkarjova et al., 2009). In this study, we develop empirical, data-driven analysis based on the combined PMT-TTM framework to understand what drives households in HCMC, Vietnam to uptake private precautionary measures.”

Section 2: I think much detail about physical/climatic aspects of HCMC can be shortened, as these are not highly relevant to this study. To any extent, if referring to the drivers of floods, this recent study rigorously looked at the key drivers and their dependencies: Couasnon et al. 2022
<https://doi.org/10.1029/2021WR030002>

R: Thank you! Section 2 ‘Study Area’ is shortened and only the relevant information is included within the ‘Introduction’ of the revised manuscript.

88: “Protection of livelihood from flood events has a high priority and it is leading to high investments in extensive flood defense systems (Kreibich et al., 2015; Weyrich et al., 2020).” This section is about HCMC, so why this statement with references on investments elsewhere?

R: Thank you! In the revised manuscript Cao et al., 2021 is cited as a more suitable reference.

Fig. 1. The figure is helpful in sketching the framework. Some questions: if ‘dependency on government influences the coping appraisal (and not the threat appraisal), wouldn’t it make sense for that block to link with the coping appraisal before its joining to the threat appraisal? Does the same apply to ‘household profile’ and threat appraisal? It is possible that I am wrong here. Why is ‘past flood experience’ not linked to the other arrows, and in a dashed-line box?

R: Thank you for the comment. PMT (Protection Motivation Theory) has only two factors at its core – coping appraisal and threat appraisal. PMT is further extended to add two more independent factors - ‘Dependency on government’ and ‘Household profile’ which are not connected to the former core factors - they are all independent. The explanatory variables representing ‘past flood experience’ are only applied to the reactive household groups in the regression model since proactive households implement measures before experiencing a serious flood event – that is why ‘past flood experience’ shown in dashed-line box. We hope this clarifies our approach.

109: “Effectiveness of the PMT framework is limited as a household’s willingness to adopt protective measures in flood risk areas is not considered.” This is surprising, since the

paragraphs above seemingly explained how PMT is precisely helpful to conceptualize households behavior towards flood protection measures. Please clarify, because otherwise the need for the transtheoretical model is not motivated.

R: Thank you for the question. We have answered this question in the response to L67 regarding the significance of the transtheoretical model. We have also rephrased the sentence to, "The combined PMT-TTM has the capability to identify the factors that motivate households to uptake private precaution and the factors that help in changing the decision stages of households (e.g. reactive to proactive households)."

128: It could be useful to know where those districts/wards are in HCMC, maybe via a map, so that an impression can be gathered of how their position relates to flood-prone areas of the city, potentially discriminating different types of flood, which you mention in the following sentence. This is only a suggestion, not a necessity.

R: Thank you for the suggestion. A map demarcating the survey locations is included in the revised manuscript (Figure 1).

Fig. 2. The figure is correct in principle, but I think it would be much clearer to the reader if a matrix format were chosen instead, with one level of classification along the columns and one along the rows. This is a much more common way to conceptualize the intersection of two classes.

R: We agree and have made the change.

Section 3.3: I suggest making more explicit the relationship between drivers and explanatory variables, and between 'decisions' and response variables. I suspect these coincide, respectively, but I am not sure.

R: You are correct, they coincide and their relationship has been explicitly stated in the beginning of the section. Lines 145-147: "In order to identify the drivers influencing uptake of precautionary measures in each household group, responses from the questionnaire survey pertaining to the PMT-TTM framework (see, Appendix A) are considered as the explanatory variables and regressed against a binary indicator of uptake of measures (i.e. response variable) (see, section 2.2)."

L 176: "and when a group of variables have high pairwise correlation, then lasso randomly selects one variable from the group." It is not clear that groups here consist possibly of more than 2 variables. In this case, there are several pairs of variables that can be correlated, and it is not clear how the variable(s) are selected in case of high pairwise correlations. Also, change to "before the lasso model saturates".

R: Thank you for the question. Here "group" just refers to the group of highly correlated explanatory variables. This information is only to provide a general introduction to lasso regression technique. In our study, we did not encounter this as no set of variables resulted in a high pairwise correlation.

L 178: it may be due to my lack of familiarity with these methods of regression, but it is not clear to me how terms L1 and L2 play a role in eq. 2, supposedly via hyperparameters alpha and

lambda.

R: Yes, they play a role via the alpha and lambda hyperparameters. In lasso regression, the lambda term controls the amount of coefficient shrinkage and eliminates explanatory variables that have no influence on the response variable. In elastic net regression, another hyperparameter alpha is added to compute the contribution of L1 and L2 penalty terms. This combination helps in overcoming the drawbacks of lasso regression by shrinking together the coefficients of correlated explanatory variables. We have improved the explanation of the models in the revised manuscript.

198: What do you mean by “aspects of the PMT-TTM framework”? are these the independent/explanatory variables, or classes of them? Linked to this, I cannot understand the following sentence starting with “Since the predictors...”: what are the predictors, again the explanatory variables?

R: Thank you for the question. Here, “aspects of the PMT-TTM framework” refer to how the components of the PMT-TTM framework are represented by the explanatory variables derived from the survey responses. The term ‘predictor’ is replaced by ‘explanatory variable’ in the revised manuscript.

“PMT includes six aspects: (1) risk perception, (2) severity, (3) self-efficacy, (4) household profile, (5) dependency on government, and (6) past flood experiences (Figure 2). The survey responses that represent these aspects and potentially influence the uptake of precautionary measures were selected (see, Appendix A for the Questionnaire).”

L 206: Please consider whether it is appropriate to report results of the questionnaire as coinciding with information on the actual implementation of the results that respondents state to have implemented. Also, please explain again what both events are, as the reader can't be expected to memorize all aspects of the Methods.

R: Yes, we believe it is appropriate to mention the numbers as they substantiate our inferences on uptake of measures and cost of implementation. We have introduced the events in this section again.

232 and throughout the text: ‘dry-proofing’ is commonly a structural measure consisting of preventing water from entering the house. I think that what you mean by dry-proofing is what the literature commonly understands as wet-proofing, i.e., placing elements inside the house on higher ground, so that flood waters entering the house will cause less damage. Just one informal, arbitrary reference: <https://www.coastal-management.eu/measure/wet-proofing-sealable-buildings.html>

R: Thank you. Yes, we agree to the comment. The term Dry-proofing valuables has been changed to Wet-proofing valuables in the revised manuscript.

233: “Highest number of respondents have elevated their houses only after experiencing serious and recent flood events (Figure 3) because the flooding is getting worse in HCMC (Paulo and Rivai, 2021).” The causality in this sentence doesn’t seem clear. Also, if possible I would use a source different from a journalistic article to support the higher frequency of flooding in

HCMC.

R: We agree and have removed the causality from the statement in the revised version.

237: it is not clear what the contradiction is, here. Similarly, in the following sentence, the other contradiction needs to be made more explicit. Further, in the following sentence, a vast generalization is proposed about differences between developed and developing countries, on the bases on only three data points: HCMC, Denmark and Germany: this does not seem warranted, or should be played down. Lastly, note that 'rapidly growing economy' does not stand in contrast with 'developed economy'.

R: Thanks for the comment. Yes, we agree and we have removed the socio-economic comparisons in this context. The statements have been restructured.

Lines 217-224: "Among the precautionary measures, the elevation of the building has a special position. Despite the high cost of elevating the house, this measure which prevents the floodwater from reaching the living area, is very popular in HCMC and helps to live with floods. The process to elevate can be done to the entire building or only a new elevated ground floor can be constructed within the building (Garschagen 2014, FEMA, 2007). Hence, houses are often built elevated or are elevated during renovations, which is frequently done by households in HCMC. It might be decisive that the building codes have been subscribing a minimum elevation of buildings in Vietnam since 2008 (Garschagen 2014) and discouraged the implementation of only wet-proofing measures. Most respondents have structurally elevated their houses after experiencing flood events (Figure 3), which occur frequently almost during every rainy season in HCMC."

251: what are house impacts, in contrast to house damage? Here the shortcoming of not having explained these variables becomes evident. Similarly, one is left to wonder about the meaning of other variables too, like 'people'. Only later is the reader informed that there is an annex that supports this.

R: 'House Damage' variable represents the damage already experienced by a household from past flood experience. 'House Impact' variable depicts the level of damage to the house anticipated by the household due to future flood events. All the important variables are described in Table 3 which is moved to the beginning of the 'Results and discussion' section in the revised version So that the reader is acquainted with these terms before reading them in the text.

258: this counterintuitive effect is very interesting: could you try to explain the mechanism behind it briefly, also on the basis of the other studies that report it elsewhere?

R: According to Protection Motivation Theory, protective measure is adopted only when coping appraisal reaches a certain threshold. An increase in the 'House impact' variable (i.e., belief that one's house will be more severely impacted from floods in the future) increases the threat appraisal of the household. However, it also decreases their coping appraisal as they feel it is beyond their capacity to adapt to the future events. This has the potential to discourage the adoption of structural flood protective measures (Babcicky and Seebauer, 2019; Gebrehiwot and van der Veen, 2015; Grothmann and Reusswig, 2006).

This is now explained in lines 242-248: "On the other hand, 'House impact' variable with an average

coefficient value of -0.91 (note the negative coefficient) indicates that households which strongly believe that their house will be more severely affected by flooding in the future are less likely to adopt structural precautionary measures. The 'House impact' variable relates to the severity factor of threat appraisal (Appendix A). This is in accordance with results of several previous studies which have found that perceived increase of severe flood damage in the future causes a sense of helplessness and incapacity to adapt further, thus, discouraging the implementation of structural measures (Babcicky and Seebauer, 2019; Gebrehiwot and van der Veen, 2015; Grothmann and Reusswig, 2006)."

300. You offer an explanation for the lack of results for this group of households. But it is not clear to me how the methods simply fails to produce any importance level above zero with this dataset: could you also offer an explanation of what happens here methodologically? Also, maybe I missed it, but how come for the non-structural proactive group the lasso and net-elastic models yield precisely the same results?

*R: Thank you for the question. We could not find any explanatory variable that strongly correlates to the implementation of structural measures in proactive group. There is a methodological challenge that there is limited variability in the response variable, only 264 out of 1000 households have proactively implemented a structural measure (value = 1). Since we use penalized regression, the model with just an intercept performs the best for this case. **How come for the non-structural proactive group the lasso and net-elastic models yield precisely the same results?** Net elastic regression is a combination of L1 lasso penalty term and L2 ridge penalty term which is controlled by the hyper parameter, alpha. When alpha = 1, the L2 penalty ridge penalty term becomes zero (Eq.2) and hence only the L1 lasso penalty term is followed. Hence, net elastic regression behaves like lasso regression. For non-structural proactive household group, alpha becomes equal to 1.*

312: it doesn't seem that ground elevation and precautionary savings (a concept that requires clarification) belong to dry- or wet-proofing.

R: We agree and have removed the statement in the revised manuscript.

326: I don't think you can state that "costs do not restrict the implementation of precautionary measures in HCMC". This is an exceptional claim that needs stronger evidence than the lack of correlation between the cost of measure and their rate of implementation.

R: We agree and the statement has been removed.

Technical corrections

I have a number of suggestions regarding readability of the article.

L.13-on: This sentence is huge. It contains both methods and results, whereas methods were exposed already in the previous sentence. Also, for readability, I suggest reversing the sentence, like "Analysis reveals the factors that positively influence the proactive ... : education; degree of ...".

R: The sentences are shortened and improved in the revised abstract.

L 16: “Households that experienced increasing... were more likely to implement measures reactively” or something similar seems more easy to understand.

R: The sentence is modified in the revised abstract

L 18: I would leave to the reader to decide what is ‘important’.

R: Thank you! The sentence is modified in the revised abstract.

25: “long-duration precipitation events”

R: The statement was removed in the revised introduction.

59 “often not willing to take the responsibility and fail to implement”. Please revise for ambiguity

R: The statement has been revised

75: I am not sure, but I reckon HCMC is less than 80 km away from the sea. Please check.

R: Thank you! It is correct, it is only 50km away from the sea. The statement has been extracted in the revised introduction.

76: ‘even faster’: it’s not clear what the reader should compare the faster future rate or growth to.

R: Thank you! The statement is removed in the revised manuscript.

129: “households which suffered”

R: Corrected in the revised manuscript

Fig. 3: Building elevation and Elevate are the same measure? Please stick rigorously to the same terminology to prevent ambiguity. Also, is there no respondent that did not answer any question?

R: Thank you for the comment! In the revised manuscript Elevate has been used consistently. Since, the survey was conducted in-person, the respondents answered all the questions. If they didn’t know the answer, the response was excluded from the analysis.

211: sentence incomplete.

R: statement rephrased. Lines 217-219: “Despite the high cost of elevating the house, this measure which prevents the floodwater from reaching the living area, is very popular in HCMC and helps to live with floods.”

230: “lack of support to increase responsibility among households to implement other private measures”. It is not clear what this means. Also, if elevation is largely implemented, it is hard to argue that there is a general lack of responsibility regarding implementing measures privately.

R: Thank you for the comment. In the revised manuscript, we focus why elevate is prevalent, rather than the other measures. So, this statement is removed.

232: eliminate ‘yet’.

R: Done!

Section 4.2: title is unclear: why not just “Drivers of...”

R: The title is changed as suggested.

L 248: I suggest “except for the group of households that proactively undertook structural measures”. In general, throughout the text, you can turn around many sentences in this way, using verbs and active clauses instead of substantives, improving clarity.

R: Thank you! Yes, we have turned around the passive sentences to active.

249: again, I don’t think ‘importance’ is clear in this context. Also, there is probably no need to pre-emptively present what the manuscript section does, here.

R: Thank you! This statement is removed in the revised manuscript. It is replaced by lines 189-19: “Since the explanatory variables used in the model correspond to the aspects of the PMT-TTM framework, the variable importance based on a weighted median value greater than 0.5 are considered to drive the uptake of precautionary measures in the household groups.”

325: change to “there is no correlation between the costs of a [type of] measure and its rate of implementation”

R: Thank you! The conclusion is re-written in the revised manuscript based on the comment.

328: I would skip “identified a set of important aspects that motivates the implementation of precautionary measures” and straight away recap the key drivers of behavior. In the following sentence, ‘pragmatic’ does not seem the right word. Perhaps ‘activating communication’ or similar.

R: Thank you! The conclusion is re-written in the revised manuscript based on the comment.

331: as for other sentences, this should also be turned around for clarity: “The analysis further shows that factor that positively influence the decision of proactive groups are...”. The same

goes for the following sentence: “Therefore, to motivate proactive behavior of households ...”.

Last, I would skip the last sentence, as it doesn’t add anything meaningful.

R: Thank you! The conclusion is re-written in the revised manuscript based on the comment.