Response to RC2 – Submission NHESS-2025-1362

Dear Reviewer,

Thank you for taking the time to review our manuscript *"Polarization in Flood Risk Management? Sensitivity of norm perception and responsibility attribution to frequent flood experience".* We appreciate your evaluation and the insightful comments that help to improve the quality of our work. Below, we address each of your comments point by point and propose corresponding adjustments to the submitted manuscript.

Comment 1: The literature review on "perception of norms" covers topics on self-efficacy and ingroup identification, which are the chosen moderating variables in RQ2. This aspect is well-argued. However, the literature review on "attribution of responsibility" only discusses the potential influence of self-efficacy and the influence of ingroup identification is missing.

Answer: In the literature review, we present existing knowledge on the drivers of responsibility attribution and norm perception in general. This part is not intended to provide reasoning for the moderation analyses. Instead, the moderation analyses follow an exploratory approach aimed at understanding the relationships observed in RQ1. From your comment, we understand that we should clarify this better in the manuscript.

In your comment, you specifically refer to ingroup identification as moderator of the relationship between frequent flood experience and responsibility attribution. Here, we assume that the observed variations might be rooted in motivated cognition. We specifically argue that people who highly identify with their community might be particularly likely to ascribe responsibility for flood protection to the public to maintain a positive image of their group despite of potentially insufficient protection levels.

Comment 2: The literature review and theoretical link can better clarify how self-efficacy and helplessness is connected to perceived control. Or explain how previous literature often associates perceived control with self-efficacy and helplessness, motivating these two measures as moderating variables in the analysis.

Answer: In the manuscript, we subsume self-efficacy beliefs and expected helplessness under the umbrella of sense of control. The reason why we believe that this subsumption is reasonable is the following definitions of the three concepts:

Helplessness: "a state of incapacity, vulnerability, or powerlessness associated with the perception that one cannot do much to improve a negative situation that has arisen" (APA, 2025a).

Self-efficacy: "an individual's subjective perception of their capability to perform in a given setting or to attain desired results" (APA, 2025b).

Perceived control: "subjective belief that one can achieve desired sates and avoid undesired states through one's own efforts" (Dorsch, 2025; translated from German)

The three definitions have in common that they emphasize the (perceived) capacity to shape a certain situation or associated outcomes through own agency. Helplessness specifically refers to a state of powerlessness when facing an external demand, i.e. threatening situation. Self-efficacy highlights the perceived ability to undertake measures to avoid such a situation. From your comment, we understand that we did not make clear enough in the manuscript why we sometimes subsume both under perceived control. We propose emphasizing this more in the revised version and to add the above cited definitions.

Comment 3: The concept of helplessness is also underexplored in the literature review and theoretical link sections, compared to other key variables of the empirical analysis.

Answer: With the moderation analyses we follow an exploratory approach to better understand the patterns observed in RQ1. The section 2.2 on existing knowledge is mainly focused on drivers of norm perception and responsibility attribution. The theoretical section 2.3 is aimed at delivering reasoning for why we assume that a link between frequent flood experience, norm perception and responsibility attribution might exist.

This is clarified in *lines 135-136* in the current version of the manuscript: "In the following section, we attempt to theoretically reason the hypothesized effect of frequent flood experience on the development of perceived norms and responsibility attribution by combining existing theories and concepts."

From your comment, we understand that we should clarify better that the moderation analyses follow an exploratory approach.

Comment 4: RQ3 is largely unclear and it is important that there is further explanation. What does it mean when you explore the interaction of your dependent variables (norm and responsibility)? Interaction effects are normally for the independent variables. Furthermore, the methods (regression equation 8) and the results (figure 10 and figure 11) do not seem to answer the research question in a straightforward manner. Can the trends given from RQ1 also be used to answer RQ3?

Answer: The question that we want to answer with RQ3 is whether the observed differences in the development of norm perceptions and responsibility attributions over flood experience (observed in RQ1) vary statistically significantly.

In the current version of the manuscript, we delivered the reasoning for RQ3 in *lines 172-173*: "With the third research question, we aim to uncover possible discrepancies between how much individuals feel responsible and the perceived expectations of their community members regarding private flood protection."

We explained the respective methodological approach in *lines 250-251*: "We adopted the mixed-effects approach to answer RQ3. Instead of distinctly comparing norm/responsibility constructs, we incorporated them into one model (formula 8). We iteratively compared single norm constructs to all responsibility variables."

Specifically, instead of comparing norm constructs/ responsibility attribution separately (RQ1), we created a variable that allowed us to also compare the development of norm

perception and responsibility attribution in one model. From your comment, we understand that we did not make clear enough what specifically we want to answer with RQ3 and how.

In the revised version of the manuscript, we propose the following adjustment of *lines 172-173*: "With the third research question, we aim to uncover possible discrepancies between the respondents' perceived social norms for flood protection and respective responsibility attributions." Further, we try to make the methodological approach clearer and clarify which variables specifically we interact with each other.

Comment 5: **It is good practice to include the complete questionnaire as supplementary information if possible. In Section 4.2, it can be clarified how the survey items were formulated: whether questions or statements are standard/validated survey items, have been used in previous survey research, or have been developed by the author themselves.**

In Table 1, there are three constructs for norms: injunctive, descriptive, and personal. It is the first time these terms appear, which turns out to be important concepts in the discussion section. It may be helpful to introduce these norm constructs in advance, such as whether these distinctions have been recommended in previous literature.

Answer: We agree that this information would benefit the manuscript and its reproducibility. Therefore, in the revised manuscript we will add the full questionnaire to the Appendix. Moreover, in the revised manuscript we will integrate the information that the scaling of the variables is based on the 7-point-likert scale to section 4.2, where we will also add information on how the items were conceptualized. We further understand that we should define the applied norm constructs earlier in the manuscript and propose adding respective definitions to section 2.2 in the part on perception of norms.

Comment 6: **It is also good practice to present the descriptive statistics of the sample, besides the main variables that are included in the analysis, for the reader to get a better picture of the sample such as in terms of their socio-demographics. The sample sociodemographic characteristics can also be compared with population characteristics to determine the representativeness of the sample. It should be made clear if this is not possible, mentioning limited data availability or that these information are not elicited in the survey.**

Answer: We agree that presenting the sociodemographic characteristics of the sample enables a better understanding of the sample and the applicability of the results to a broader context. Therefore, we will add such information combined with the respective characteristics of the German population to the revised manuscript.

Comment 7: **Furthermore, if the survey data provides socio-demographics, the regression models can be improved by including these as control variables. If it is not feasible, it could be mentioned in the mixed effects model with random intercepts whether some part of the respondent characteristics is taken into account by the individual specific intercept, u_j.**

Answer: The survey data provide sociodemographic data on the individual level. However, we decided not to integrate these as control variables in the regressions as there is no theoretical framework nor empirical evidence (to our knowledge) supporting the assumption that these would influence norm perception and responsibility attribution. However, to sufficiently answer your question we tested whether the integration of age, gender, and ownership structure would affect the relationship between frequent flood experience and the outcome variables. Here, we observe that homeowners are statistically significantly less likely to attribute responsibility to the city and more likely to attribute responsibility to themselves. However, as these model adjustments do not change the effect of frequent flood experience, neither the effect direction nor its significance, and as our goal is not to build a model explaining as much of the variance in the outcome variables as possible, but to model the link between frequent flood experience, norm perception, and responsibility attribution, we do not support the respective model adjustment in the manuscript. However, we are open to integrate the respective regression tables in the appendix and mention the observed effects as a footnote.

Comment 8: It may be useful to provide a correlation matrix of the variables listed in Table 1.

Answer: In the revised manuscript, we can integrate this table into the appendix.

Comment 9: **Equation 2: The linear equation for norms lacks motivation. Does it serve as a baseline to test if any relationship exists? If so, there should also be a linear equation for responsibility attribution. Only having the linear equation for norms made it seem like it is intentionally for the purpose of showing an increasing relationship for norms (given the statistically significant result, even though the nonlinear effects with dummy variables are statistically insignificant). Do note that a linear equation with FFE as the independent variable may be less appropriate given that a value of 3 indicates experiencing 3 or more floods. FFE is not a continuous variable.**

Answer: The motivation for the linear equation for norm perceptions and nonlinear equation for responsibility attributions lies in the descriptive analyses. Here, we observe that the link between frequent flood experience and norm perception follows a rather linear path and the link between frequent flood experience and responsibility attribution a nonlinear path (i.e., changing directions and strengths of the relationship).

In *lines 205-206,* we stated: "For the norm constructs, the descriptive analyses suggest rather linear relationships, which we comparatively tested with a simple linear regression (formula 2)."

From your comment, we understand that we should make clearer in the revised manuscript why we decided in favor of these model specifications and should add the respective reasoning also for responsibility attribution.

Comment 10: **The terms "n_ij" and "r_ij" used in the equations may need to be "n_i" and r_i" instead because these norm and responsibility constructs are categorical/dummy variables that applies to all individuals and do not vary for each individual j.**

Answer: It is correct that the indices n_ij and r_ij do not differ between respondents. Instead, they are coded 1-3, respectively, 1-4 for each respondent. However, with this, we follow the proposed notation for mixed models, whereas j represents the group (in our case the respondent) and i the variable nested in that group (in our case the norm/ responsibility constructs). Therefore, we propose keeping that notation.

Comment 11: **Potentially crucial to consider: it may be inappropriate to include interaction effects in regression without including the main effects. This applies to equation 3-7. For instance, equation 3 should include n_i (given the correction above) so that each individual j has also different intercepts for the different norm constructs, such that the coefficients of n_i captures the average z_norm scores when FFE=0. The main effect of each FFE may also need to be included. This will make the interaction effect capture the additional differences in marginal effects on top of the main effect, instead of capturing both the main effect and interaction effect when the regression equations are as is currently written. I am also open to further discussing this point.**

Answer: We agree that the main effects should be integrated in the estimation to avoid the biases you mentioned. We already considered the main effects in the estimations but did not include them in the regression equations in the previous version. In the revised version of the manuscript, we will adjust the regression equations accordingly.

Comment 12: **The regression equation for RQ3 remains unclear. What do each of the nr_ij represent? Is it written with the appropriate notation? It seems that equation 8 estimates equation 3 and 4 jointly, instead of separately. It is unclear how this equation answers the research question RQ3. Looking at the corresponding results in Figure 10 and 11, what is the reason for choosing comparing injunctive norm with own responsibility and descriptive norms with collective responsibility, respectively? Testing these comparisons is not clear given regression equation 8 and RQ3.**

Answer: We also tested the other norm constructs and responsibility attributions against each other but only included those in the manuscript as they showed significant differences and target the same "stakeholder-level":

- the respondent's perceived individual responsibility vs. their perception of what others expect them to do
- the respondent's perception of others protective behaviors vs. the respondents perceived collective responsibility.

From your comment, we understand that we should add that reasoning to the revised manuscript.

Comment 13: **It could be raised as a limitation that the study treats all previous flood experience equally, not taking account the variations in severity or impact of previous flood experiences. The paper can further reflect upon this limitation, while it is only briefly mentioned in future research section, line 512-513. For example, it could be the case that the nonlinear effects found after the first flood experience are mainly driven by a severe flood, such as the 2002 flood mentioned in line 181-183.**

Answer: Whereas we agree that severity of the flood event might explain nonlinear relationships on the individual-level, we assume that such biases do not play a fundamental role in the estimations on the whole sample level. The reason for this assumption is that there are variations among the respondents regarding which flood event was their first, second, or third. For example, whereas for some respondents, the 2002 flood event was the first they were affected by, for others it might have been already the second event. However, in the revised manuscript, we can include this aspect in the discussion section along with our reasoning for why we do not consider it a fundamental limitation.

Comment 14: **An interesting direction for future research that can be mentioned in the paper is to survey the theoretical mechanisms that the paper has identified or hinted, but were not explicitly tested. For example, do frequent flood experiences increase social interactions with different actors in FRM (as in line 139-141)? Or does frequent flood experiences change the evaluation of the effectiveness of private protective behaviour (as in line 143-144)?**

Answer: In the section "directions for future research", we mention that a path for future research might be to investigate how frequent flood experience relates to "characteristics of the social setting, such as collective efficacy and social cohesion" (*lines 510-511*). Here, we are open to adding social interaction as a further example. Additionally, we support that the investigation of links between frequent flood experience and the assessment of protective behaviors would enrich the stated pool of further research ideas.

Comment 15: **In the introduction: Perhaps in line 50 before the sentence, "In Section 2…", also mention that the paper will explore moderating variables (self-efficacy beliefs and ingroup identification), since it is also an insightful finding of the paper.**

Answer: We agree that mentioning the moderation analyses in that section would benefit the manuscript.

Therefore, we propose the following adjustment in *line 50:* "To get a better understanding of the observed links between frequent flood experience, norm perception, and responsibility attribution, we performed moderation analyses, taking expected helplessness during future floods, perceived self-efficacy to protect from future flooding and stated identification with other residents as moderators."

Comment 16: Line 203: What was meant with iteratively adjusted the reference group? It should not matter which one is the reference group. The estimated coefficients for the flood experience dummies should all be relative to the reference group. So, there should not be a need to specify that the regression is estimated separately with different reference group if this is what was meant by iteratively adjusting the reference group.

Answer: We adjusted the reference groups to account for the effect of each additional flood experience separately. For example, to estimate the effect of the second flood event on norm perception, the defined reference group contained people who experienced one flood event. To estimate the effect of the third flood event, the respective reference group contained people who experienced two flood events.

In the manuscript this was described in *lines 203-205*: "We applied single-level linear regression models and iteratively adjusted the reference group to investigate the effect of each flood experience separately. In formula 1, we exemplarily present the equation for investigating the effect of the first flood experience, taking zero flood experience as the reference category."

Comment 17: Line 245-246: It is also common to test the coefficients against a significance level of 0.01, 0.05, and also 0.1. So, it does not have to be elaborated that p-values that slightly exceed 0.05 will still be interpreted as statistically significant. The coefficients that are significant at a 0.1 level can be interpreted as having "weak evidence", "some evidence", or "marginally significant" for the direction of the relationship.

Answer: The sample size of the applied dataset amounts to 1730 respondents, leading to sample sizes of 1638 to 1721 for estimations without moderators (depending on the outcome variable). Therefore, we decided that $p=0.05$ is the threshold for statistical significance. However, in the moderation analyses, the sample size is smaller and is even below 100 for some groups. Because of this and since the respective p-values only exceed 0.05 when accounting for heteroskedasticity-consistent standard errors (and only marginally), we decided to relax the chosen threshold a bit and still take the respective relationships into account when interpreting the results.

Comment 18: Showing the results visually with a line graph is practical. Perhaps, what can be considered is adding the standard errors to the points in the line graph so the readers can more easily infer the statistical significance.

Answer: We agree that including standard errors in the graphs would further assist readers in assessing statistical significance. However, given that the current graphs already present a substantial amount of information and are, in parts, relatively complex to interpret, we are concerned that adding further elements could additionally compromise clarity. Consequently, we would prefer to keep the current presentation.

Comment 19: Additional regression statistics can be shown in Table 3 and Table 4, such as sample size, f-statistic, and adjusted r-squared. This also applies to the tables in the appendix.

Answer: We support the idea that presenting the sample size for each estimation would benefit the study and agree to include this in the revised manuscript. Generally, we do not believe that presenting adjusted R-squares and F-statistics substantially increases the interpretability of the results or their empirical value as the overarching goal of our study is to model the link between frequent flood experience, norm perception, and responsibility attribution and not to define a model that explains a high share of variance in the outcome variables. However, we do not have a strong opinion against presenting the respective values for the sake of integrity in the revised version of the manuscript.

Comment 21: Abstract line 16-17: Specify how the gap in responsibility attribution widens. That responsibility attributed to the city/state increases, while responsibility attributed to self/the community increases.

Answer: We will adjust the respective text part in the abstract in *line16*: "(…) as individuals experience multiple flood events, the gap between assigned responsibility to the self/ the community (decrease) vs. the city/the state widens (increase)."

Comment 22: **Abstract line 17-18: Also specify in what way norms are less dynamic. That results show that norms perception weakly increases with frequent flood experience.**

Answer: We will adjust the respective text part in the abstract in *line 18*: "(…) are less dynamic. Specifically, variations in effect strength and direction can only be observed for the perception on injunctive norms."

Comment 23: Line 220: Do not write "n_ij/r_ij" in the text to prevent confusion. It could be initially thought as a fraction. Instead what can be written is "To compare the effects of flood experience between different norm and responsibility constructs, we added n_ij and r_ij as interaction effects, respectively."

Answer: We understand that this notation may cause confusion, and we agree to change it accordingly in the revised version of the manuscript.

Comment 24: Line 229: Can replace "low self efficacy" with just "self efficacy" for consistency, since the moderating variables are categories of perceived helplessness and self-efficacy.

Answer: We will change the formulation in the revised manuscript to

" (…) (i.e., perceived helplessness, self-efficacy beliefs) (…)"

Comment 25: Equation 6: the notation of the dependent variable can be consistent with how the dependent variable is written in other notations.

Answer: This notation was unintentional and resulted from an automatic adjustment by the writing software. In the revised version of the manuscript, we will ensure that such automatic adjustment does not occur.

Comment 26: Tables in the appendix: Instead of writing the p-values that are just above 0.05 in the cells, you can give a note below the tables indicating three significance levels, "*: p<0.1; **: p<0.05; ***: p<0.01".

Answer: As discussed above, we would generally maintain the threshold of p=0.05 for statistical significance.

Thank you again for your valuable input and critical assessment of our manuscript. We are looking forward to your feedback on the proposed revisions.

Sincerely,

Lisa on behalf of the co-authors

References:

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