

## Author Response to Referee #1 (RC1)

We thank Anonymous Referee #1 for their thorough and constructive review. We are grateful for the positive assessment of our study's originality and significance, and we appreciate the detailed feedback on how to improve the manuscript. The reviewer raised two principal concerns: (1) a conceptual issue regarding our treatment of robustness vs. adaptiveness (and potential confusion with the concept of regret), and (2) extensive language and clarity problems in the writing. We address each point in detail below, with planned revisions indicated (including specific sections and line numbers from the original manuscript where changes will be made). We have also carefully noted all the detailed line-by-line comments in the annotated PDF and will incorporate those corrections. Once again, we thank the reviewer for these invaluable comments, which will help us significantly improve the paper.

### Comment 1 (Conceptual): Distinction between Robustness and Adaptiveness, and confusion between Robustness and Regret

**RC1:** *"The authors characterize their study as not solely relying upon robustness criteria... but also engaging adaptivity considerations as well. This is curious... Adaptation and flexibility have long been understood as being some of the principal tools for ensuring the robustness of a planned course of action... Yet, in this paper they are presented as alternative approaches... There may be several misunderstandings. One is that 'robustness' is a much abused term... Another possibility is that the authors are confusing the concept of robustness with that of regret in terms of decision analysis. They discuss at one point different approaches to measuring 'robustness' when in fact they are citing different methods for calculating regret... They introduce alternative metrics such as adaptability and do so convincingly. The problem is that they do so in a false opposition to a straw man that they term 'robustness'."*

**Response:** Thanks for the suggestion and we apologize for the confusion caused by our framing of **"robustness"** and **"adaptiveness."** We agree with the reviewer that in the context of decision-making under deep uncertainty, **adaptiveness (flexibility)** is not a separate or opposing concept to **robustness**; rather, it is often an integral means of achieving robustness over time. Our intention was not to set up a false dichotomy. Instead, we aimed to highlight that focusing **solely** on near-term robustness (in terms of performance across scenarios) can overlook the long-term benefits of adaptability. We realize that this intent was not clearly communicated. In the revised manuscript, we will clarify our conceptual framework to eliminate any suggestion that robustness and adaptiveness are mutually exclusive approaches. Specifically, we will make the following clarifications and changes:

- In the Introduction and framework description (see Section 1, lines 83–89 and 108–112; and Section 2.1, around lines 173–180 of the original manuscript), we will define

clearly of “robustness” and “adaptiveness.” For example, we will state that robustness in our context refers to *the ability of a strategy to maintain acceptable performance across a wide range of plausible future scenarios*, while adaptiveness refers to *the ability of a strategy to be adjusted or augmented over time in response to how the future actually unfolds*. We will emphasize that flexibility and adaptation are key tools to achieve robustness under deep uncertainty, rather than a separate objective. This addition will ensure readers understand that our use of “robust” and “adaptive” are complementary aspects of a strategy’s performance.

- We will reframe the text wherever it implied that robustness and adaptiveness were alternative or opposing approaches. In particular, the sentences in the Introduction (lines 105–112) that currently discuss a trade-off (suggesting that maintaining a high level of robustness may compromise adaptiveness) will be revised. We will clarify that while there can be a tension in practice (e.g., an initially over-engineered solution might reduce future flexibility), **our framework is designed to balance both** – ensuring a strategy is robust **and** remains adaptable over time. The revised narrative will stress that **our contribution lies in integrating adaptiveness into robust decision-making**, not treating it as a separate paradigm. For instance, we will explain that our framework builds on Robust Decision Making (RDM) principles *combined with* Dynamic Adaptive Policy Pathways (DAPP) concepts, so that **short-term performance** and **long-term flexibility** are both evaluated. This addresses the reviewer’s point that adaptation and flexibility should be seen as part of robustness: we will make it clear that our approach explicitly combines them, rather than introducing adaptiveness as an opposed idea.
- Clarifying Use of “Robustness” vs. “Regret”: We acknowledge the reviewer’s observation that our manuscript in places may have conflated robustness with regret-based metrics. In the original text (Section 2.1; see lines 225–233), we discussed “different approaches to measuring robustness” and cited methods that are essentially different ways of calculating regret (e.g., using satisficing criteria or minimax regret as performance measures). We agree that regret is a distinct concept: it measures the difference between the outcome of a strategy and the best possible outcome in each scenario (i.e. the opportunity loss), and is often used in decision analysis to evaluate robustness, but regret itself is not synonymous with robustness. To avoid confusion, we will correct our terminology in those sections:
  - We will revise statements like “*robustness metrics (i.e. satisficing and regret)*” to more precise wording. For example, we will replace that phrase with “*decision-making performance metrics (such as satisficing criteria or regret-based criteria)*”. This makes it clear that regret is one way to evaluate

outcomes under uncertainty, rather than a definition of robustness itself.

- Where we wrote “*different approaches to measuring robustness*” while referring to regret calculations (Herman et al., 2015; McPhail et al., 2018), we will rephrase to “*different approaches to quantifying a strategy’s performance under uncertainty*”. We will explicitly mention that **minimax regret** is one common criterion used to identify robust strategies (by finding options that minimize the worst-case regret). This clarification will ensure readers understand we are using regret as a tool within robustness analysis, not confusing the two concepts. These changes will be made in Section 2.1 (Framework development) around lines 223–235, where we introduce how robustness is assessed in our study.
- Additionally, we will ensure our use of the term “**robustness**” throughout the manuscript aligns with how it is used in policy and decision science literature (i.e., focusing on strategies that perform satisfactorily across uncertainties). The reviewer is correct that the term can carry different meanings in other fields (statistics, engineering, etc.), so we will add a brief note in the Introduction (near line 85) acknowledging this and stating that in the context of DMDU (Decision Making under Deep Uncertainty), robustness is about insensitivity to uncertainty rather than, say, over-designing to a safety factor.
- **Addressing the “expense of robust solutions”:** The reviewer noted our reference to the “considerable expense of robust solutions” and pointed out that a purely engineering notion of robustness (overbuilding to withstand worst-case forces) might have influenced our wording. We will clarify this to avoid misunderstanding. In the **Discussion** (and where applicable in Introduction), we will explain what we meant: a strategy that is **robust** against extremely adverse scenarios (e.g., constructing the highest possible flood defense immediately) can indeed require high up-front cost or lead to over-design if the worst-case never occurs. In policy terms, a **robust** strategy need not always be the most expensive – especially if it is combined with adaptive staging. We will adjust the text (for example, in Section 4 Discussion, around lines 590–599) to make it clear that **our approach seeks robust outcomes in a cost-effective way by using adaptiveness**. In other words, rather than building an immensely over-sized infrastructure now (high-cost “robust” solution), it may be better to start with a moderate solution and then adapt (expand or add measures) if needed – achieving robustness through flexibility. By revising this explanation, we will reinforce that **robustness and adaptiveness work in tandem**: adaptiveness can reduce the cost of achieving robustness by allowing adjustments over time instead of one costly irreversible investment. This directly addresses the reviewer’s point and removes the

implication that we view “robust = expensive” as a general rule.

In summary, we will substantially revise the introduction and conceptual framework sections to clearly convey that our “robust adaptive pathways” approach is a synthesis where robustness is pursued in conjunction with adaptiveness (ability to adjust strategies over time). All mentions of these concepts will be reviewed to ensure consistency. We will eliminate any language that sets up robustness versus adaptiveness as a straw man or false opposition. Instead, the revised manuscript will consistently present adaptiveness as an essential component of robust long-term planning under deep uncertainty. We believe these clarifications will address the reviewer’s concerns and help readers better understand our framework. Thank you for highlighting this important conceptual issue – our revision will make the manuscript’s framing much clearer.

### **Comment 2 (Stylistic): Grammar, Syntax, and Clarity of Writing**

**RC1:** *“The second problem is one of syntax, grammar, and English usage... There are syntactical problems with the use of articles, verb agreement, incomplete and awkward sentences and other issues that it simply was not within the resources of this reviewer to correct... Once the manuscript has been revised in light of my comments..., it would be wise for the authors to engage the services of a native English speaker or copy editor to provide the light edit that would immensely improve the readability of this draft. Please find comments of a more detailed character in the attached PDF.”*

**Response:** We sincerely apologize for the language issues in the manuscript. We appreciate the reviewer’s acknowledgment of our work’s value despite the readability problems, and we fully agree that the paper must be polished to meet the journal’s standards. We take this critique very seriously. In response, we will thoroughly revise the manuscript’s language for clarity, grammar, and style. Our plan for addressing the stylistic concerns is as follows:

- **Incorporating PDF Comments:** We have reviewed all the detailed line-by-line comments and corrections provided in the annotated PDF. These comments pointed out numerous specific issues (incorrect articles, verb tense/agreement errors, awkward phrasings, run-on or fragment sentences, etc.). We will implement each of these corrections in the revised manuscript. For example, instances of missing articles (“the”, “a/an”) will be fixed (e.g., changing “in urban area” to “in urban areas” or “the urban area” as appropriate), and grammar mistakes such as improper verb forms will be corrected (for instance, where the original text might say “the method provide” we will change it to “the method provides”). We will also restructure any incomplete or awkward sentences noted by the reviewer to ensure they are clear and grammatically complete. Every single suggestion from the PDF annotations will be addressed to

improve readability on a micro-level.

- **Overall English Editing:** In addition to the specific fixes above, we will conduct a comprehensive edit of the entire manuscript for English usage. This includes checking for consistent tense use, clarity of pronouns and references, and smooth flow of ideas. We will simplify or break down overly long sentences for clarity. We have identified certain sentences that were particularly clumsy or hard to follow, and we will rewrite them. For example, a sentence like “*Options with high performance often mean higher cost input and potentially longer construction periods... The single-objective in either performance assessment... provided limited information for long-term planning, indicating a potential for lock-in...*” will be reviewed and rewritten for clarity and conciseness so the ideas are easier to parse. We will ensure that each paragraph conveys its point clearly before moving to the next.
- **Professional Proofreading:** As recommended by the reviewer, we will seek the assistance of a native English speaker (a colleague) and/or a professional copy-editing service once we have incorporated all content revisions. One of our co-authors is indeed based at an English-speaking institution, and we will leverage that resource; additionally, we are prepared to use an external proofreading service for an extra layer of quality control. This step will help catch any lingering subtle issues in syntax or diction that we might miss. The goal is to bring the manuscript to a polished, publication-ready standard of English. We fully agree that this will “immensely improve the readability” of the paper.
- **Acknowledging Specific Patterns:** The reviewer specifically mentioned issues with *articles*, *verb agreement*, and *incomplete/awkward sentences*. We have noted patterns such as omission of “the” in several places, inconsistent singular/plural usage, and some sentence fragments. We will pay special attention to these patterns. For instance:
  - All technical terms or specific references will be checked for proper article usage (e.g., “the RDM approach” instead of just “RDM approach” where appropriate for clarity).
  - We will ensure verbs agree with their subjects (e.g., “approaches have” instead of “approaches has” if such errors exist).
  - Awkward constructions will be rephrased. If a sentence was identified as incomplete or hard to read, we will either connect it with the preceding/following sentence or add the necessary words to complete the thought. In some cases, splitting a long sentence into two clearer ones will be the solution.

- **Consistency and Terminology:** As part of the language editing, we will also improve consistency in terminology (some of which overlaps with the conceptual clarifications in Comment 1). For example, we will use terms like “strategy” vs. “option” consistently, and ensure that terms like “robustness” and “adaptiveness” are used in their clarified sense throughout. This will prevent any further confusion and enhance clarity.

After these revisions, we will double-check the entire manuscript to make sure no new errors were introduced and that the text reads smoothly for an international audience. We are confident that with these extensive language corrections, the manuscript’s readability will greatly improve.

In conclusion, we thank the reviewer again for pointing out the numerous language issues and providing detailed suggestions. We understand that the current draft’s readability was not up to the mark, and we are committed to delivering a much cleaner revised version. The manuscript will undergo native-level English proofreading before resubmission, and all identified stylistic problems will be corrected. We believe this will address the reviewer’s concerns fully and make the paper more accessible to the HESS readership.

Once again, we thank Referee #1 for their valuable insights and careful review. The feedback on both the conceptual framing and the writing has been extremely helpful. We will implement all the above changes in the revised manuscript. We are confident that these revisions will resolve the raised concerns – clarifying our methodology’s positioning (robust vs adaptive strategies under deep uncertainty) and improving the overall clarity and quality of the text. We appreciate the reviewer’s positive comments about our study’s merit, and we are committed to improving the manuscript accordingly. Thank you for helping us strengthen this work.