

Exploring Nature-based Solutions in Mountain Regions: A Review of Their Hydrological Functions

Response to reviewers' comments

The authors of the current manuscript would like to thank the editor as well as the reviewer for the time they took to read and comment our work.

All their comments were carefully studied and taken into account. Finally, the reviewer's comments were addressed in the text below.

We think that their suggestions improved the current version of the manuscript.

Reviewer #2:

Specific comments:

Comment 1: Abstract is very vague with few specific findings.

Response: We agree that the original abstract emphasised the background and objectives of the review more than its principal findings and contributions. To address this, we have included more specific quantitative results from the review, such as the number of studies analysed, the prevalence of certain NbS types, the most commonly evaluated hydrological functions and the significant methodological gaps identified in the literature. Additionally, we emphasised the identification of recurrent hydrological features and the methodological limitations that affect the assessment of NbS effectiveness in mountain environments. This can be seen between L9-27.

Comment 2: Introduction:

L 26: Water towers typically refer to some of the highest peaks where snow, glacier & permafrost melt are the primary runoff contributors.

Response: We thank the reviewer for this clarification. We agree that the term 'water towers' is commonly used in literature to describe mountain regions where the melting of snow, glaciers and permafrost contributes to the downstream water supply. However, we wanted to express the concept in terms of mountain systems generating, storing and regulating freshwater supplies through their hydrological processes.

We have therefore revised the text to acknowledge these interpretations and clarify that this review adopts a broader perspective. This allows us to detail mountain regions with diverse hydroclimatic characteristics, including areas where cryosphere contributions are limited or absent (L29–31).

Comment 3: L 40-46 It is not at all surprising that IUCN does not adequately address water issues in the context of NbS; IUCN mostly focuses on biodiversity and conservation.

Response: We agree that the IUCN Global Standard is not intended to provide a detailed assessment of hydrological performance. The framework was designed to provide a comprehensive evaluation of NbS implementation, governance, biodiversity outcomes and societal benefits, rather than a process-based assessment of hydrological functions. We did not intend to criticise the IUCN framework for lacking hydrological indicators; rather, we wanted to highlight that the currently available NbS assessment frameworks are not specifically designed to evaluate hydrological performance in mountain environments. We recognise that this limitation reflects the intended scope of the IUCN Global Standard, rather than being a deficiency of the framework itself. To clarify this, we have revised the text to emphasise the complementary role of hydrological assessment approaches alongside existing NbS evaluation frameworks, and to avoid implying that the IUCN Standard should provide detailed assessments of hydrological processes (L43-51).

Comment 4: L46-51 Likewise the EC approach is yet another indicator approach with little emphasis on hydrological process linkages.

Response: We appreciate the reviewer's comments and agree that indicator-based assessment frameworks alone may not fully capture the hydrological processes underlying NbS performance. We did not intend to dismiss the value of the European Commission Handbook, which provides an important framework for evaluating the impact of NbS across multiple dimensions. However, we wanted to emphasise that the representation of hydrological processes remains relatively limited within existing assessment frameworks, particularly in mountain environments, where hydrological responses are strongly influenced by local biophysical conditions. In response to this comment, we have revised the text to acknowledge the EC Handbook's contribution more clearly, and to clarify that our review aims to identify the commonly reported indicators, as well as the hydrological functions and conditioning variables that influence NbS performance. We have also strengthened the discussion regarding the need for a process-based understanding and for indicators to be interpreted within their hydrological context.

Comment 5: L54-55 The second objective listed here seems liked a flawed approach to me – firstly, most indicator approaches do not consider processes in sufficient details and secondly, standardizing these would add yet another level of disconnect from reality.

Response: We agree that hydrological indicators should not be interpreted in isolation from the processes that govern nature-based solutions (NbS) performance. Furthermore, we acknowledge that mountain environments exhibit substantial heterogeneity, which limits the applicability of rigid, universal assessment schemes. However, we did not intend to propose a fixed set of universally applicable indicators. Instead, we aimed to explore whether a core group of commonly reported hydrological indicators could facilitate comparisons between NbS studies conducted in different mountain regions, while still allowing for context-specific indicators and process-based analyses. We recognise that local hydroclimatic, geomorphological, ecological and socio-economic conditions have a strong influence on NbS performance and should remain central to assessment frameworks.

To emphasise this, we have revised the manuscript to clarify that the proposed approach seeks to improve comparability across studies through a flexible framework of commonly used indicators, rather than advocating strict standardisation. We have also strengthened the discussion on the importance of interpreting indicators within their hydrological and environmental context.

Comment 6: L56-57 The stated focus on water security seems to get lost in the results that are later presented.

Response: We agree that the link between the review findings and the broader concept of water security was not made clearly enough in the original manuscript. Although the review examined the hydrological functions, indicators and assessment approaches associated with mountain NbS, these elements were intended to contribute the understanding of how NbS support the different dimensions of water security. However, this link was not consistently articulated throughout the Results and Discussion sections.

We have therefore revised the manuscript to establish a clearer link between the identified hydrological functions and NbS outcomes, and the key dimensions of water security. These include the regulation of hydrological processes, ecosystem resilience, and support for downstream water users. We have also strengthened the discussion and conclusions to explicitly highlight the implications of our findings for water security in mountain regions.

Comment 7: This short section comes across as initially very general (i.e., the OECD definition of NbS) followed by a rather restrictive application – only looking at water in the contexts of forest conservation, wetland restoration, and water harvesting. It seems that the potentially greatest benefits from NbS are ignored – e.g., reducing overland flow and increasing infiltration to alleviate surface erosion, support baseflow in streams, and reduce peak flows (although later in the paper soil erosion is marginally addressed). Also, no mention of water-induced or mediated hazards – an area where NbS can offer significant benefits. As such, it almost seems like categories of water-related NbS were selected based on this automated literature search rather than a pragmatic assessment of where NbS could offer the most benefits.

Response: We agree that NbS encompass a broader range of interventions and hydrological benefits than were analysed in this review. These include flood mitigation, erosion control, slope stabilisation, drought resilience and other functions that reduce water-related hazards.

However, the intervention categories considered in this study were not selected solely from the results of the literature search. Instead, they were derived from the World Water Assessment Programme (WWAP, 2018) framework for NbS that contribute to the regulation of the water supply, which provided the conceptual basis for our analysis. The review therefore focused on NbS categories associated with this specific water-related service: re/afforestation and forest conservation; wetland restoration and conservation; and water harvesting interventions.

To avoid any misunderstanding, we have revised the manuscript to clarify the rationale behind adopting the WWAP classification, as well as explicitly acknowledging that this framework does not encompass the full range of NbS applications in mountain environments. We have also expanded the discussion to recognise additional hydrological functions and hazard-mitigation benefits that may be addressed through other NbS approaches and frameworks (L83-85). Moreover, we added the section of limitation highlighting the approach of the framework that was used for this review.

Comment 8: Methodology: These automated ‘scoping reviews’ of the literature without including critical insights are becoming far too common in papers. They reveal very little important process information. Of course, screening criteria were used to help fit your pre-designated “forest conservation, wetland restoration, and water harvesting” focus. However, I fail to see the innovation here. Even with this automated approach, you missed several key, recently published NbS papers that deal with NbS interventions in mountain environments.

Response: We recognise that the value of a scoping review lies in its ability to identify broader hydrological patterns, methodological challenges, research gaps and opportunities for future investigation, rather than simply providing a descriptive synthesis. For this reason, the objective of this study was not to provide a detailed mechanistic analysis of individual NbS interventions. Instead, we aimed to examine the hydrological functions, processes and indicators reported in studies of nature-based solutions in mountain environments, as well as the assessment approaches used. Additionally, the review explored the extent to which these studies incorporate transdisciplinary perspectives and address the interactions between the hydrological, environmental and societal dimensions.

We agree that the original manuscript did not sufficiently emphasise the broader insights emerging from this synthesis. In response, we have strengthened the discussion section by emphasising hydrological process interpretations, methodological limitations, the challenges of selecting indicators, the implications of environmental heterogeneity for NbS assessment in mountain regions and the role of transdisciplinary approaches in improving future evaluations.

With regard to the coverage of the literature, we acknowledge that any review is inherently constrained by the selected search strategy, databases, language criteria and temporal coverage. These limitations have been clarified in the revised manuscript. We have also incorporated additional relevant studies where appropriate, to improve the representation of recent developments in the field. However, due to the rapidly evolving nature of NbS research, new studies continue to emerge beyond the temporal scope of any review.

Comment 9: L103 Ignoring publications that are not in English is somewhat understandable but nevertheless injects potential bias.

Response: We agree that language restrictions can introduce bias and potentially exclude relevant studies published in languages other than English. However, we would like to clarify that the review was not limited to English publications. The initial database search identified studies published in both English and Spanish (L100). Nevertheless, we recognise that studies published in other languages may have been omitted, which could limit the representation of experiences and evidence from certain geographical regions. In the revised manuscript, we have clarified this limitation so that future reviews can benefit from incorporating multilingual search strategies to reduce potential linguistic bias and improve geographical coverage further.

Comment 10: Results: *Section 4.1*

This section only presents a summary of the automated reviews based on the authors predetermined structuring of the criteria. Lots of simple graphs and a literature map, but, once again, I do not see much innovation here.

Response: We recognise that Section 4.1 focused primarily on describing publication patterns, geographical distribution and the characteristics of the literature, while offering only limited interpretation of their implications for NbS research in mountainous environments.

The primary purpose of this section is to provide the context and quantitative evidence base for the subsequent analyses. Although the section is largely descriptive, the identified patterns are significant as they reveal geographical concentrations of studies, variations in research intensity across mountain regions, and the prevalence of particular intervention types. These patterns may influence the current understanding of the effectiveness, transferability and applicability of NbS across different mountain environments. In response to the reviewer's concerns, we have enhanced the interpretation of these findings and strengthened the link between the descriptive results and the broader objectives of the review in subsequent sections. In particular, we now discuss how the observed distribution of evidence may introduce geographical and methodological biases, highlight knowledge gaps, and affect the generalisation of findings across mountain systems.

Comment 11: L125-126 Of course more recent publications will be less cited.

Response: We agree that lower citation counts are expected among recently published studies due to their shorter exposure time in the scientific literature. To avoid misinterpretation, we have changed the text to make it clear that citation patterns largely reflect publication age rather than scientific relevance or impact (L135-136).

Comment 12: *Section 4.2*

I understand the connection with NbS and societal issues, but this begs the question of why a broader approach to water-related NbS was not used in this paper. Overall, this short section contributes few new insights.

Response: We agree that the importance of this section was not emphasised correctly in the manuscript.

The objective was not to document the societal dimensions associated with NbS, but rather to analyse how the reviewed studies addressed the different components of the ecosystem services cascade framework. The results reveal that research is concentrated on ecosystem properties and functions, with fewer studies assessing ecosystem services, societal benefits, or value dimensions. This imbalance is an important finding because it highlights the ongoing discrepancy between the biophysical evaluation of NbS and the assessment of their socio-economic outcomes. The limited attention paid to the latter may constrain our understanding of their overall effectiveness and long-term sustainability. In response to the reviewer's concerns, we have reinforced the interpretation of these findings and clarified their implications for future NbS evaluations.

Comment 13: *Section 4.3*

Similar to my comments on Section 4.2, simply categorizing NbS as including or not including indigenous knowledge, provides few new insights.

Response: We agree that classifying studies according to whether they include Indigenous, traditional or local knowledge only provides limited value when considered descriptively. Nevertheless, this analysis aimed to evaluate the extent to which mountain nature-based solutions (NbS) studies explicitly incorporate local knowledge systems and community participation in their design, implementation or evaluation processes. The results revealed that only 31% of the reviewed studies explicitly reported the inclusion of indigenous, traditional or local knowledge, while 69% did not. We consider this pattern to be a significant finding as it highlights the limited integration of knowledge systems which are widely recognised as crucial for the implementation, governance, and long-term sustainability of NbS.

We acknowledge that the connection between this result and its broader implications was not sufficiently articulated in the original manuscript. To address this, we have revised the Discussion section to explicitly link the underrepresentation of local and traditional knowledge to broader challenges in NbS assessment. These include the predominance of biophysical evaluation approaches and the limited consideration of socio-cultural dimensions. We also highlight the need for more integrated, transdisciplinary assessment frameworks in mountain environments.

Comment 14: *Section 4.4*

These very brief results suggest better documentation of climate change impacts in NbS studies are needed, but with no other recommendations. What is really needed in NbS interventions is granular scale climate assessments and these are incredibly difficult to capture in mountainous terrain.

Response: We agree that more detailed climate assessments could provide valuable insights into local hydroclimatic variability and extreme events, thereby supporting the evaluation of NbS performance under future conditions. However, as the reviewer notes, such analyses remain challenging in mountain regions due to complex topography, strong spatial heterogeneity and limited data. This review did not seek to evaluate the suitability, spatial resolution or uncertainty of climate models, but rather to determine how climate change is currently addressed within the NbS literature. The aim of including climate change in this review was to examine the extent to which climate considerations are incorporated into studies assessing NbS in mountain environments. An important finding of the review is that climate change is unevenly represented across NbS categories and is not explicitly addressed in several intervention types.

In response to the reviewer's concerns, we have expanded the discussion to explore the types of climate-related analysis reported in the reviewed studies further (e.g. climate scenarios, impact assessments and modelling approaches, where available), and clarified the implications of limited climate integration for the long-term effectiveness, resilience and adaptive capacity of NbS in mountain regions.

Comment 15: *Section 4.5*

L210-213 I may be wrong, but I have a hard time believing that studies on wetlands covered the largest scale – this could be an artifact of the total catchment areas, but it is difficult to comprehend that wetlands covered larger areas than forest conservation and water harvesting NbS interventions; or it could simply be a bias of the types of reported studies. In any case, it does not seem logical.

Response: We agree that the statement may appear counterintuitive when interpreted as referring to the physical extent of the wetlands themselves. However, this analysis aimed to characterise the spatial scale of the studies and catchments used for evaluation rather than the area covered by the NbS intervention. Consequently, the reported values reflect the scale at which hydrological processes were assessed in the reviewed literature. Several wetland studies evaluated ecosystem functions and hydrological responses at catchment or regional scales, resulting in study areas that were larger than the actual wetland extent.

We acknowledge that this distinction was not clear enough in the original manuscript. To avoid any further misunderstanding, we would like to clarify that the reported scales correspond to the spatial units used for the assessment, and that these scales may be influenced by the design of the study, the boundaries of the catchment, and the approach to reporting, rather than by the size of the intervention itself.

Comment 16: *Section 4.6*

Generating a set of NbS indicators based on this automated literature search and the reported metrics is not solidly grounded in hydrological processes and it could possibly set dangerous or erroneous precedents.

L246-253 This contains several examples of why such automated reference searches leave knowledge gaps. The hydrological controls noted are mostly obvious relations that are covered in any introductory hydrology textbook. Soil erosion is now mentioned, but no new insights are presented.

Response: We agree that hydrological indicators should not be interpreted in isolation from the processes that govern the behaviour of the system, and that indicator frameworks may overlook significant environmental differences between mountain regions. However, this analysis was not intended to propose a universal or standardised set of indicators for all nature-based solutions (NbS) applications. The objective was rather to identify the hydrological variables, metrics and evaluation approaches most frequently used across different NbS types and mountain contexts. While many of the reported processes effectively established hydrological concepts, this review's contribution lies in documenting how these variables are applied to evaluate different NbS interventions, and in identifying commonalities, methodological gaps and inconsistencies across studies.

Understanding these patterns may facilitate future comparisons between mountain regions while acknowledging the necessity of context-specific assessments. This could provide a useful starting point for developing conceptual assessment frameworks that improve comparability between studies while still allowing adaptation to local environmental, hydrological and socio-economic conditions.

In response to the reviewer's concerns, we have clarified in the manuscript that the proposed indicators should not be interpreted as a universal framework, but rather as a synthesis of the most commonly used indicators in the reviewed literature.

Comment 17: *Section 4.7*

One concern here with this type of analysis is that most studies tend to publish positive results while few publish negative results. This will bias such an analysis. One example herein is the discussion of the erosion control benefits of terraces – this is not always the case and terraces can exacerbate landslide erosion and even surface erosion under certain circumstances. Nevertheless, this sub-section is more informative than the previous six sub-sections of the Results.

Response: We agree that publication bias is a limitation when synthesising evidence on the effectiveness of nature-based solutions (NbS), as studies reporting positive outcomes are often more likely to be published than those reporting neutral or negative results. Consequently, the available literature may not fully capture the range of outcomes associated with NbS interventions in different environmental contexts. However, we would like to note that this limitation originates from the evidence base itself, rather than the review methodology. The objective of this analysis was to summarise the outcomes reported in the existing literature and evaluate the degree of agreement among studies. To account for uncertainty, the assessment framework explicitly distinguishes between consensus, possible effects, controversy and knowledge gaps. This recognises situations where evidence is limited or inconsistent.

We agree that the effectiveness of NbS interventions is highly context-dependent. As the reviewer noted, terraces may reduce erosion under certain conditions, but potentially increase erosion or slope instability under others. Similar context-specific responses have been documented for many NbS interventions. This underlines the importance of interpreting effectiveness indicators in relation to environmental characteristics, hydrological processes, and implementation conditions.

To address this concern, we have expanded the discussion to acknowledge the potential influence of publication bias, emphasising that reported effectiveness should not be interpreted as universally applicable. Instead, the identified indicators and reported outcomes should be viewed as a basis for improving comparability across studies, bearing in mind the need for context-specific assessments and further evidence from diverse mountain environments.

Comment 18: L349-352 I question whether developing NbS strategies at individual sites or areas is a negative as implied. These NbS interventions typically address several issues – not just the three water related issues noted in this paper – and thus they need to be carefully developed for specific areas, including concerns related to climate, soils, anthropogenic stressors (including legacy effects), hydrology, native vegetation, and the potential for NbS to address these in a holistic manner that supports local livelihoods.

Response: We agree that NbS interventions should be carefully designed according to the specific conditions of each site. However, we did not intend to suggest that the development of NbS strategies on a site-specific basis is a limitation or a negative characteristic. Rather, the statement refers to the limited methodological and conceptual interconnection among studies within the current literature. The review found that many studies evaluate NbS within specific local contexts, using different indicators, assessment approaches and reporting methods. This makes comparison and synthesis across cases challenging. Therefore, the concern highlighted in the manuscript relates to the fragmented nature of the evidence base, rather than to the site-specific nature of NbS interventions themselves. Context-specific implementation remains essential. At the same time, improving the comparability of studies through clearer reporting, shared conceptual frameworks and more consistent assessment approaches could facilitate the transfer of knowledge and strengthen our collective understanding of NbS performance in different mountain environments.

To avoid any misunderstanding, we have revised the text to make it clear that the observed lack of integration refers to the research landscape, not the need for locally adapted NbS strategies. The text now read as follow: *However, the limited methodological and conceptual interconnection among studies suggests that NbS research in mountain regions has primarily evolved through locally focused case studies, making cross-comparison and synthesis more challenging.*

Comment 19: L362-375 I would argue that NbS ‘strategies’ have been used for many decades going back to the integrated catchment management practices of the 1970’s – yes, they had a different name and may not have been as sophisticated, but implying the Chinese scientists are leading this field is not accurate. Most of the work you see published is relying heavily on earlier research that may not have been called NbS investigations, but nevertheless provided the backbone for the more recent papers – there is nothing wrong with this, except for the impression that all of the papers you cited represent unique research.

Response: We agree that many practices currently categorised as nature-based solutions have a much longer history and are related to earlier concepts. One of the motivations behind the search strategy adopted for this review was to identify studies describing relevant interventions, even if they were not explicitly labelled as NbS. This is why the review includes numerous studies published long before the NbS concept emerged and was widely adopted. Therefore, we did not intend to imply that recent NbS studies represent entirely novel research, disconnected from previous scientific developments. Rather, we recognise that contemporary NbS research builds upon a substantial body of earlier hydrological research.

With regard to the geographical distribution of studies, we did not intend to suggest that Chinese researchers are leading the field alone. Rather, this reflects the distribution of publications identified in the review, which shows a comparatively high concentration of studies from China and other parts of Asia. We consider this to be an observation about the current evidence base, rather than a judgement about scientific leadership. The main implication of this review is that the available literature is unevenly distributed geographically, raising important questions about the transferability of findings to underrepresented mountain regions with different environmental and socio-economic characteristics.

To avoid potential misunderstandings, we have revised the text to clarify our interpretation of the geographical distribution of the studies observed. It now reads: *“...although many of the interventions reviewed have been studied for decades under different conceptual frameworks, the period after 2010 marks the increasing consolidation of the NbS concept within scientific and policy agendas”*

Comment 20: L376-383 NbS should address both restoration of ecosystems as well as societal benefits. This is a complex, granularly- focused task and is why broad ‘one-size-fits-all’ NbS interventions will not work.

Response: We agree that NbS can generate both ecological and societal benefits, and that their implementation must be adapted to local conditions. However, this section does not advocate a particular NbS design philosophy or suggest prioritising either ecological restoration or human benefits.

Instead, the discussion examined how the objectives of NbS interventions are framed and reported in the reviewed literature. The distinction between ecosystem restoration-oriented and human benefits-oriented interventions emerged from the classification of study objectives reported by the authors and was used to explore broader conceptual trends within the evidence base. In this context, the reference to the human–nature dichotomy was intended as a conceptual reflection on the different ways in which NbS are justified and evaluated in the literature. This builds on previous discussions by Welden et al. (2021), who analysed how the literature portrays the nature of NbS, considering whether it is merely a greenwashing effect or if it actually results in restoration and social benefits. Moreover, the subsequent paragraph emphasises the need for caution when interpreting these findings. Many of the reviewed studies did not explicitly identify as NbS interventions and were classified during the screening process based on the analysed intervention. Furthermore, some studies did not clearly report whether the interventions were primarily intended to achieve ecological restoration, socio-economic benefits, or both. Consequently, the observed patterns may reflect reporting practices as much as underlying intervention objectives. Therefore, the main insight from this section is not that NbS should favour one rationale over another, but rather that clearer reporting of intervention objectives and ecosystem conditions

is needed to improve the assessment and comparability of NbS effectiveness in the long term, and that a framework could help to address this research gap. This is particularly relevant because many studies did not explicitly state whether ecological restoration, socio-economic benefits, or a combination of both constituted the motivation, making cross-study comparisons difficult.

Comment 21: *Section 5.2* The ecosystem services cascade approach is worthy of consideration, but it is far too simply addressed here.

Response: We agree that the ES cascade approach was only briefly mentioned in the original manuscript. We intended to use the ES cascade framework as a conceptual lens through which to interpret one of the review's key findings: the strong predominance of studies focusing on ecosystem properties and functions, compared with the much lower representation of ecosystem services, benefits and value assessments. This interpretation emerges directly from the review results. This imbalance suggests that current NbS research in mountain regions focuses primarily on biophysical processes, while the ecosystem functioning and societal outcomes are often less explored.

In response to the reviewer's concerns, we expanded this section to provide a more detailed discussion of how the ES cascade framework can connect hydrological processes, ecosystem functions, ecosystem services and societal benefits in NbS assessments. We also explain how integrating multiple levels of the cascade can lead to more comprehensive evaluations of NbS effectiveness and water security outcomes in mountain regions.

Comment 22: *Section 5.3* Some good ideas here, but it is difficult to see if any of these were derived from the literature search.

Response: We agree that the link between the review's findings and the wider discussion was not clear enough in the original manuscript. However, the discussion was based on a key finding of the review: only 31% of the analysed studies explicitly reported the inclusion of local, traditional or indigenous knowledge, and the majority of studies did not incorporate these dimensions or did not report them. This finding prompted broader reflections on the implications of limited community participation and the integration of traditional knowledge within NbS research in mountain regions. In particular, it raises questions regarding the extent to which existing NbS assessments capture local perspectives, cultural values, and community-based management practices that may influence both implementation and long-term effectiveness.

We acknowledge that some of the arguments presented in this section draw on complementary literature discussing the role of Indigenous and local knowledge in governance and NbS implementation. To address the reviewer's concern, we have clearly distinguished between observations derived directly from the literature review and broader interpretations informed by previous research. We have also strengthened the connection between the empirical findings and their implications for future NbS assessments, water governance, and community participation in mountain regions.

Comment 23: *Section 5.4* I see no new insights here; the statements in L420-424 could apply to most studies in mountainous terrain where climate change predictions are of little value compared to the more granular needs of NbS applications and the societal benefits that could be derived from these.

Response: We agree that climate change poses challenges for many studies in mountain environments, and that assessments of local conditions are often more useful for NbS design than general climate projections. However, this section did not seek to argue that climate change assessments should replace site-specific analyses, nor did it aim to evaluate the quality of climate projections used in NbS studies. Rather, as explained in the previous response regarding the results section, the review sought to examine the extent to which climate change considerations are incorporated into the assessment of NbS interventions in mountain regions.

The review revealed that climate change was explicitly addressed in only a limited proportion of the analysed studies, with several intervention types lacking any explicit climate change assessment. We consider this an important finding because climate variability and extreme events may influence the long-term performance and resilience of NbS interventions.

We agree that locally relevant assessments remain fundamental for NbS planning and implementation. At the same time, climate change information can complement these analyses by helping to evaluate how interventions may perform under future hydroclimatic conditions and increasing climatic uncertainty, particularly in mountain environments where hydrological responses are highly sensitive to climatic variability.

In response to the reviewer's concerns, we have revised the discussion to distinguish more clearly between broad climate change considerations and the need for locally relevant hydroclimatic assessments.

Comment 24: *Section 5.5* The first sentence addresses my previous point – i.e., most NbS strategies need to be designed for specific areas with granular biogeophysical data along with site specific socioeconomic concerns and information.

Response: We agree that NbS strategies must be adapted to the specific biophysical, hydrological, and socio-economic characteristics of individual sites. Local-scale studies are therefore essential for understanding the performance of interventions.

However, this section was not intended to question the importance of local-scale assessments. Rather, the review identified a strong predominance of local-scale studies and a relative scarcity of studies examining how NbS effects propagate across larger spatial scales. While local studies provide critical insights into site-specific processes, larger-scale and multiscale analyses can complement these findings by improving our understanding of cumulative hydrological effects, downstream impacts and interactions across catchment and socio-ecological systems.

To emphasise this, we have revised the manuscript to highlight that local and multiscale assessments should be considered complementary approaches for evaluating NbS effectiveness in mountain environments.

Comment 25: L434-440 The call for applying multiple methods to address NbS is a good point, but certainly not unique, as this is a well-recognized approach in transdisciplinary investigations.

Response: We agree that methodological integration is a sound principle for transdisciplinary research. We did not intend to present the use of multiple methods as a novel concept. Rather, the review highlights that relatively few studies have combined multiple methodological approaches. Therefore, the finding relates to observed practices within the reviewed literature rather than to methodological innovation itself.

We have revised the text to clarify that the combination of field observations, modelling approaches, experimental methods and participatory assessments is widely recognised as good practice. This review's contribution is to demonstrate that such integration remains relatively uncommon within the analysed studies, and that greater methodological complementarity could strengthen future NbS evaluations in mountain regions.

Comment 26: *Section 5.6* The first referenced sentence encapsulates a major point I have been making in this review – i.e., the bio geophysical characters and societal context of individual sites need to define the NbS strategies. But in the next sentence the authors express disagreement with this statement saying this automated literature review and analysis “demonstrate a consistent pattern among NbS types, while also highlighting significant methodological gaps”. Saying that such an empirical automated approach provides new insights into such patterns is not justified nor established in this paper.

Response: We agree that the effectiveness of NbS is influenced by local conditions, hydrological characteristics and socio-ecological contexts. This contextual dependency is a fundamental feature of NbS implementation and evaluation. However, we did not intend to suggest that the review identified consistent responses across all mountain environments. Instead, the analysis revealed that certain hydrological functions and evaluation approaches were recurrently reported for specific categories of NbS. These recurring observations should be interpreted as broad tendencies within the available literature, rather than as universally applicable outcomes.

For instance, forest-based interventions were more frequently associated with runoff regulation and erosion control, whereas wetland studies commonly emphasised water retention and groundwater-related processes. At the same time, substantial variability among sites, methodological approaches and environmental conditions was evident throughout the reviewed studies.

In response to the reviewer's concern, we have revised the manuscript to avoid implying universal patterns and instead emphasise that the review identifies recurring tendencies, methodological gaps, and areas where evidence remains limited. The purpose of this review is not to establish universal causal relationships between NbS interventions and hydrological responses, but rather to synthesise where evidence converges, where it diverges, and where important knowledge gaps remain. We believe this provides a more robust basis for guiding future NbS investigations and improving the comparability of hydrological assessments in mountain regions.