

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 #1:

General comments: The paper is titled "Exploring Nature-based Solutions in Mountain Regions: A Review of Their Hydrological Functions". This is an important topic and of high relevance, considering the ongoing and rapid changes in mountain hydrology and their associated impacts for mountain communities. As the authors point out correctly, evidence of the effectiveness of Nature-based Solutions (NbS) in mountain regions is still limited and a strengthened and robust evidence base is needed to systematically assess the impacts of such measures. While the title and abstract clearly define the main aim and scope of the study, the manuscript would benefit from a clearer and more focused storyline that better aligns with the title and abstract. At present, some sections of the text seem to diverge from these central objective. The manuscript moves between topics such as a detailed description of the methodology of the literature review, to an extensive yet mainly descriptive presentation of the review results, a conceptual summary of potential hydrological functions of NbS, as well as a discussion of limitations of NbS measures regarding climate change aspects and the inclusion of Indigenous and local knowledge. As a result the focus promised in the title ('a review of hydrological functions of NbS in mountain regions') gets lost and the overall storyline needs more coherence and focus.

Overall, I would suggest a thorough revision of the manuscript with the aim of further refining and focusing its overall scope and objectives. If the intention is to discuss the hydrological functions of NbS, this focus should be reflected in the research questions and in a more quantitative/robust presentation of the results. Alternatively, if the primary goal is to identify gaps in the current NbS research/literature, this focus could be more clearly reflected in the title and in the main aim outlined in the abstract.

Below are several suggestions that may help to further focus the paper on the topic outlined in the title and the abstract, which in my mind would help to improve its impact and visibility.

Response: We would like to thank the reviewer for evaluating our manuscript and recognising the relevance and potential impact of the study. We agree with the reviewer's main observation that the original manuscript addressed several complementary dimensions of nature-based solutions (NbS), which reduced the prominence of the central storyline focused on hydrological functions.

While the primary objective of this review is to evaluate the hydrological functions and effectiveness of NbS in mountain regions, NbS are socio-ecological and transdisciplinary interventions. Consequently, we included complementary aspects such as ecosystem services, indigenous and local knowledge, and climate change because they influence the implementation, evaluation, and long-term sustainability of hydrological outcomes rather than representing independent objectives of the review. Nevertheless, we agree that these aspects should remain clearly connected to the central research questions. In response, we have revised the manuscript to improve the overall narrative, strengthen the alignment between the title, research questions, results, and discussion, and ensure that the main focus remains on the hydrological functions, evaluation approaches, and methodological gaps related to NbS effectiveness. As suggested, we have condensed the descriptive sections, reorganised the results and revised the discussion to more explicitly connect these complementary dimensions with the hydrological performance of NbS and their implications for water security in mountain regions.

Specific comments:

Comment 1: The two research questions and objectives outlined in the introduction (lines 53–55) could be more closely aligned with the topic stated in the title and abstract. Based on the title and abstract, a stronger focus on analysing the hydrological functions of NbS might be expected, rather than primarily presenting descriptive results from the literature review.

Response: We agree that the original manuscript did not always maintain a clear enough connection between the stated objectives and the overall narrative. Although the review primarily aimed to evaluate the hydrological functions and effectiveness of nature-based solutions (NbS) in mountain regions, it also incorporated additional analyses that addressed methodological approaches, ecosystem services, climate change and indigenous and local knowledge. These aspects were intentionally included because NbS are inherently socio-ecological and transdisciplinary interventions, and their long-term hydrological effectiveness depends on the context in which they are implemented and evaluated.

However, we agree that these complementary dimensions should be explicitly linked to the objective of the manuscript. In response, we have revised the introduction, refining the research questions to emphasise hydrological functions and processes, evaluation approaches, and the comparability of evidence across mountain environments.

Comment 2: The methods and results of the literature review are described very extensively with 14 figures. Can these sections be condensed to only the relevant findings for the main study aim (i.e. the hydrological functions of NbS) and figures reduced to the most important aspects/findings? I would focus on those aspects, which are picked up later in the discussion section, hence only those results which give a clear and robust information on 'the hydrological function' and effectiveness of NbS measures. Many of the bar graphs (e.g. Fig. 4, 5, 7, ...potentially others) could be expressed in word, in one sentence, which would help to further condense these sections.

Response: We agree that some sections of the original manuscript were descriptive, and that several figures summarised publication characteristics rather than directly supporting the central objective of the review. In response, we have condensed the descriptive sections, reduced the emphasis on publication statistics and made the presentation of results more streamlined. Previously presented findings that were shown graphically have been incorporated into the text, enabling the manuscript to focus more directly on the hydrological functions and effectiveness of NbS.

Comment 3: I see chapter 4.6 to be the central part of this study. However, it was not entirely clear to me how the findings in figures 11, 12, and 13 are linked to the literature review. If I understood correctly the indicators were taken from the reviewed studies, but what about the links (-/+ relationships)? It could be insightful to add another layer of information to the figures by quantifying these relationships further (e.g. visualizing by the thickness of the arrows how many studies found positive/negative/no/diverging relationships). In their current form, the figures provide limited additional insight beyond the information and conceptual understanding already known.

Response: We agree that Section 4.6 represents this review's core contribution. The indicators presented in Figures 11–13 were synthesised from the hydrological variables and controlling factors identified in the reviewed studies. The positive (+) and negative (–) links show the direction of the reported relationships. As the studies were conducted under different environmental and hydrological conditions, the figures intentionally include both positive and negative relationships where contrasting evidence was reported. This reflects the context-dependent nature of NbS performance rather than a single, universal response.

Following the reviewer's suggestion, we have clarified the methodology used to derive these conceptual frameworks and expanded the figure descriptions to explain more explicitly how the relationships were identified in the literature review. However, we recognise that the current figures synthesise the reported interactions, but do not convey the relative frequency or strength of the available evidence. We acknowledge this limitation in the manuscript and note that future developments of this framework could incorporate quantitative information, thereby providing a stronger basis for comparative assessments across mountain environments.

Comment 4: Some of the relationships illustrated in figures 11, 12, and 13 may benefit from additional clarification. For example, in the wetlands section, the positive relationship between topography and water retention capacity and the negative relationship between topography and runoff appear somewhat counterintuitive and could be explained in more detail. It would also be helpful to clarify why no connections are shown between topography and soil erosion, or between soil and soil erosion.

Response: We thank the reviewer for highlighting these points. The conceptual diagrams were intended to summarise the dominant relationships reported in the reviewed studies, rather than to represent universal hydrological processes. We recognise that, depending on local conditions, some relationships, particularly those involving topography, runoff and water retention, could be interpreted differently. We have therefore expanded the accompanying text to provide a clearer explanation of these relationships and revised the figures where necessary to avoid misunderstanding. We also explain why some relationships (for example, between topography and soil erosion) were not included, because the evidence was not reported across the reviewed studies or was not mentioned even though it was relevant.

Comment 5: Regarding the quantification of NbS effectiveness, lines 317-326 stand out positively. This section provides a level of detail that can be particularly valuable for decision-makers when evaluating such interventions, and for scientists aiming to test and further assess these reported impacts. Would it be possible to extract more such information from the reviewed literature?

Response: We appreciate this suggestion and agree that quantitative information is more valuable for researchers and practitioners. Following the reviewer's recommendation, we have expanded the synthesis of reported hydrological effectiveness wherever the reviewed studies provided sufficiently comparable quantitative information. However, we also acknowledge that the literature remains highly heterogeneous in terms of quantitative reporting, which limits the possibility of systematically extracting comparable values for all NbS types and hydrological functions. This limitation is now discussed more explicitly in the manuscript.

Comment 6: I would suggest reducing the number of figures substantially and focus on the most important ones.

Response: We agree and have simplified the presentation of the results by reducing the number of figures and incorporating some descriptive information into the text.

Comment 7: Figure appearance: I would ensure the figures have an appropriate size and are not distorted (e.g. Fig. 8 – maps). The figures appear to have been produced in Microsoft Excel. Excel is a perfectly valid tool for generating figures, which I do not mean to discard, but the visual presentation could be improved for publication in a scientific journal. The authors might consider recreating them using software more commonly used for scientific visualization (e.g., R or Python), as these tools allow figure sizes, styles, and font sizes to be easily standardized across all figures.

Response: We thank the reviewer for this recommendation. All figures have been revised to improve readability, consistency, and graphical quality.

Comment 8: Figure 15: are all the relationships equally strong (= same thickness of arrows)? Can the message of this figure be presented in a more refined way?

Response: We agree that the original figure could suggest that all relationships have the same strength. The figure has been revised to clarify its purpose as a conceptual representation of reported interactions rather than a quantitative network. We have also improved the accompanying explanation to better communicate the nature of these relationships and avoid implying equal levels of evidence.