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August 18, 2022

**Response to reviewer comments for:**

“Global monthly sectoral water use for 2010-2100 at 0.5° resolution across alternative futures” (Manuscript ID: SDATA-22-00583), submitted to Nature Scientific Data

**Reviewer Comments Received: 01 August 2022**

Dear Guy Jones,

We would like to thank you and the reviewers for your invaluable feedback and comments. Please find a list of all editor and reviewers’ comments we received followed by an explanation of where and how each comment has been addressed in the revised manuscript. We think that with the suggested changes the paper has become much stronger.

Adasasdas

Sadasdq

Thank you for the guidance,

Sincerely,

Zarrar Khan

Contents

[List of All Reviewer Comments 3](#_Toc105336468)

[R1 Comment 1 5](#_Toc105336469)

[R1 Comment 2 6](#_Toc105336470)

[R1 Comment 3 6](#_Toc105336471)

[R1 Comment 4 8](#_Toc105336472)

[R1 Comment 5 8](#_Toc105336473)

[R1 Comment 6 9](#_Toc105336474)

[R1 Comment 7 10](#_Toc105336475)

[R1 Comment 8 11](#_Toc105336476)

[R1 Comment 9 11](#_Toc105336477)

[R1 Comment 10 11](#_Toc105336478)

[R2 Comment 1 12](#_Toc105336479)

[R2 Comment 2 13](#_Toc105336480)

[R2 Comment 3 15](#_Toc105336481)

[R2 Comment 4 16](#_Toc105336482)

[R2 Comment 5 16](#_Toc105336483)

[R2 Comment 6 16](#_Toc105336484)

# List of All Reviewer Comments

The following is a list of all reviewer comments received on **31 May 2022**. Each comment has been addressed in the text as described in the corresponding section. Comments are numbered by referee as R1 for Referee 1.

E1 Comment 1: Note that "meta-repository" is not a widely understood term at this journal. If I understand correctly, this provides wider explanations of the methods used and external links to other deposited resources (e.g. Tethys v1.3.1 at Zenodo). Please note that:

* All experimental methods relating to this work should be available in the manuscript itself. I understand that a lot of this content may be duplicated in the paper, but if not, I would encourage you to share any additional workflow, validations, Basin examples, etc within the paper. A single supplementary document can be used if there are large amounts to add. Data visualizations are fine to share soley on this site as long as the underlying data has been been formally deposited
* All external resources should be cited in the manuscript - use the reference list for any citable objects with formal metadata (i.e. DOIs, author names, etc) and simply embed the ULRs in the text in ()s for websites without these. From quick inspection it looked like all the links were in the former category (i.e DOI'd objects that can be formally cited). Again, it looks like a number of these are already included in the paper (e.g. the Code Availability statement), but please check and confirm there is nothing exclusively shared at the met repository.

E1 Comment 2: Please change the Custom licence terms for the Dataverse dataset to a recognizable open licence (CC0 and CC-BY are usually required for this journal).

E1 Comment 3: Please add a data citation for the Dataverse dataset to the reference list using these instructions (https://www.nature.com/sdata/publish/submission-guidelines#data\_citations - note that a DOI URL should be used). Please add the reference number to wherever the dataset is mentioned in the text - the main position should be the first part of the Data Record in a sentence describing where the data has been deposited.

E1 Comment 4: Please also formally cite the items listed in the table in the Code Availability sections in the reference list. Please also note that all tables need a table label and a legend.

E1 Comment 5: Please change the Custom licence terms for the Dataverse dataset to a recognizable open licence (CC0 and CC-BY are usually required for this journal).

R1 Comment 1: Please provide a more detailed description of basin boundaries and selection principles in the manuscript.

* Discovery of the problem: Irrigation water accounts for a higher proportion of the total water consumption in the region, and the combination of region and basin can indeed be better constrained. But I am confused about the basin boundary in Figure 2 and how to select the basin for constraints. For example, the boundary of the Yangtze River Basin in Asia is not correct ([1], etc.), and the Yukon River Basin in North America [2] mentioned in the background that there is irrigation in the Basin, but is not isolated in Figure 2.
* References:

[1] Zhang Q, Xu C, Becker S, et al. Sediment and runoff changes in the Yangtze River basin during past 50 years. Journal of hydrology, 2006, 331(3-4): 511-523.

[2] Yang D, Zhao Y, Armstrong R, et al. Yukon River streamflow response to seasonal snow cover changes. Hydrological Processes: an International Journal, 2009, 23(1): 109-121.

R1 Comment 2: Please give a reasonable explanation for the degree to which the historical data results deviate from the 45° curve, and add the verification of the historical water data in time and space.

* Discovery of the problem: The dataset is to serve users, and the first consideration of users should be more about the quality of the dataset. When verifying the reliability of downscaling, the downscaled data must be compared to the original input data. However, the quality of the dataset also includes the accuracy of the water withdrawal/consumption data in time and space, this needs to be verified and should be reflected in the manuscript [3]. (1) Since neither the manuscript nor the meta-repository has found the result data used for the verification of this paper, the data verification has not been carried out. It is recommended to add the result data of the historical period of this article in the data set to facilitate the verification of the historical period for users and reviewers. (2) Through the comparison of two similar datasets in the meta-repository (Huang et al. 2018, Mekonnen, M.M and Hoekstra, A.Y. 2011), the discrete differences between regions can be explained,but the degree of deviation from the 45° curve doesn't seem to be well answered. (3) Therefore, it is further suggested to supplement the manuscript validation section with the available tabular data or integration results of government departments (such as USGS water withdrawal, water resource bulletins in China, etc.) or international organizations (FAO-AQUASTAT data). Comparison with the regional statistical results in this manuscript [4].
* References:

[3] Chiarelli D D, Passera C, Rosa L, et al. The green and blue crop water requirement WATNEEDS model and its global gridded outputs. Scientific data, 2020, 7(1): 1-9.

[4] Zhang, K., Li, X., Zheng, D., Zhang, L., Zhu, G. (2021). Satellite-based Global Irrigation Water Use data set (2011-2018). National Tibetan Plateau Data Center, DOI: 10.11888/Hydro.tpdc.271220. CSTR: 18406.11.Hydro.tpdc.271220.

E1 Comment 5: Please change the Custom licence terms for the Dataverse dataset to a recognizable open licence (CC0 and CC-BY are usually required for this journal).

R1 Comment 3: Please add the verification of future forecast data in the manuscript.

* Discovery of the problem: There may not be a similar combination method and cannot be accurately compared for the future sector's forecast data. But the similarities, differences ,trends or ranges of its predictions can still be compared in some aspects [5-6]. Future forecast data is another key content in the manuscript, and the availability needs to be further analyzed.
* References:

[5] Wada Y, Bierkens M F P. Sustainability of global water use: past reconstruction and future projections[J]. Environmental Research Letters, 2014, 9(10): 104003.

[6] Fujimori S, Hanasaki N, Masui T. Projections of industrial water withdrawal under shared socioeconomic pathways and climate mitigation scenarios. Sustainability Science, 2017, 12(2): 275-292.

R2 Comment 1: First, the methods of temporal downscaling are similar to Huang et al., 2018. The authors were required to demonstrate the manuscript's novelty.

R2 Comment 2: Second, there are no detailed description that can be applied to future water withdrawals and consumption in the Methods chapter.

R2 Comment 3: Third, the authors do not provide rigorous verification. The content of the technical validation section does not guarantee the accuracy and availability of this dataset.

R2 Comment 4: The manuscript describes the importance of water withdrawals and consumption, but the research progress on spatial and temporal downscaling methods is insufficiently described. Authors should explain the limitations of existing spatial and temporal downscaling methods and clearly explain how they have addressed them in this manuscript.

R2 Comment 5: L30-63 This paragraph is about the models and datasets used in this manuscript, which is more like what is in the Methods chapter. The authors should have organized the logical structure of the Background & Summary chapter.

R2 Comment 6: The Region/Basin Scale (Electricity and Irrigation) in figure 3 shows a very large differences in water withdrawals between adjacent regions, so how did authors deal with making the spatial distribution smooth in the Gridded Scale in Figure 3, because there are some regions with clear boundary in the northern Africa and in the northern North America. Meanwhile, many methods of spatial downscaling are average methods, how did authors ensure the accuracy of results between adjacent regions. In addition, how did authors eliminate the impact of some cross-regional water transfer projects and water facilities on the spatial downscaling of water withdrawals and consumption.

R2 Comment 7: L361-370 Authors did not validate the accuracy of the water withdrawals and consumption. Although the spatial and temporal downscaling methods were validated, the results of this validation verification are obvious according to the methods presented earlier by authors. It is recommended that authors increase the comparison results with statistics published by government agencies to prove the accuracy of the historical part of this dataset.

R2 Comment 8: L375-402 Authors explains some differences between this dataset and the other two datasets, but do not explain in detail whether these differences will affect the accuracy of the results. Furthermore, although the authors list the scatterplots of the validation with other datasets on a meta-repository, they do not give detailed explanations. The correctness of the validation results is not known only from Figure 5 and 6. Using the data of only one year (2010) is not very convincing. It is recommended that the author extend the period (e.g., 2005-2010) of validation results of this dataset and other datasets in detail to prove the stability of the prediction data.

R2 Comment 9: There are some regions with clear boundary in the Gridded Scale of Figure 3, such as in Sahara in Africa and in northern North America. What is the reason for this situation?

R2 Comment 10: In the formula 15 and 16, two identical “tempmax” appear in the denominator.

R2 Comment 11: There is no label in the first figure of “Temporal” of Figure 4b.

R2 Comment 12: L238 What is the meaning of “pρ values”?

# R1 Comment 1

**R1 Comment 1: The biggest issue I see is an unquestioning presumption of benefit from nexus integration and policy coordination. The term “trade-off” is mentioned several times later in the document but usually, nexus trade-offs are discussed in terms of sector (e.g., water for energy). I would ask the authors to turn a more critical lens onto nexus integration, as we have a lot of literature from other policy domains that question the presumption of benefit. What are the actual (not just potential) benefits of shifting policy from siloed to coordinated? What are the transaction costs involved with the shift to coordination? What resources are required for nexus integration, such as legal authority, administrative capacity, leadership, and public support? My understanding is that we do not have much evidence on actual nexus integration efforts. The paper notes the relative lack of study on nexus implementation and this point cannot be overstated. It is dismal, honestly.**

**Response:** Thank you for raising this important point. We had several survey questions that do question the presumption of benefit and value of the nexus. Several responses also pointed out the lack of evidence for clear benefits as well as expected challenges in actual implementation. There was a specific question about actual benefits (not just potential) of integrated vs. siloed approaches and responses touched upon some of the points you raise about legal, administrative capacity and public support.

**Edits Made:**

* **Text added to Section** **“Introduction”: “**While the theoretical benefits of the nexus have been demonstrated in several modeling exercises and example case-studies there remain several challenges and hurdles in implementation of these ideas in real policy and governance mechanisms which require securing strategic and financial support from leadership to modify long-established single-sector institutional and administrative structures. These challenges partially arise from a lack of clear and measurable evidence of the benefits of actual nexus integration efforts.”

# R1 Comment 2

**R1 Comment 2: How were the participants identified and recruited to participate in this effort? Who coordinated the effort?.**

**Response:** We have expanded the **Methodology** section to better explain the process of identifying and recruiting participants.

**Edits Made:**

* **Text added to “Methodology”: “**The initial idea for the paper was the result of discussions between several presenters and conveners of multisector nexus sessions at the American Geophysical Union (AGU) conference in December 2019. This group then solicited expressions of interest from other researchers actively working on multi-sector nexus research based on their participation in relevant nexus sessions at major conferences such as the European Geophysical Union (EGU) and American Geophysical Union (AGU) as well as by reaching out to authors of recent relevant publications. Over the course of two years each participant was asked to reach out to their own networks to solicit additional interest.”

# R1 Comment 3

**R1 Comment 3: Were there any questions or responses on citizen involvement in nexus studies?**

**Response:** We had the following question and responses provided (copied below) in the Supplementary information related to citizen awareness and the importance of citizen involvement in the success of nexus applications. We discuss some of these points in the section “Nexus Methodologies”: “*Finally, to increase awareness and acceptability of nexus approaches, both input data and inter-model comparison results should be made easily accessible to allow the community and decision makers to assess these across scales and sectors for their specific needs. The visualization of results and communication to the public are key to increasing the success of the implementation of the nexus, as also highlighted in other studies75–7795–97.”*

We further expand the section “**Applying the Nexus in Practice**” to discuss this point further as shown in the edits made.

* SI – Supplementary Note 3: Question 2b (Line 208): Do you consider that the society appreciation to a NEXO approach is relevant to the success of the application of public policies?

Extracts from the responses to this question are provided below:

* SI – Supplementary Note 7: Responses to Question 2 (Line 1983):
  + I think societal awareness of systems is important, at least letting society know that the government is thinking according to the nexus. In some ways, the green new deal is a good example of a (expanded) nexus approach, where the policy says climate change isn't just an energy and temperature issue, but a health, food, jobs, and population issue. More policies like this would be good.
  + Public awareness and ACCEPTANCE are key... it's not just about awareness, it's about accepting that issues need to be addressed through behavioral change. I do think regulation will be necessary, and it should be well-considered and holistic.
  + I think societal awareness could improve the success and popularity of Nexus approaches. However, given the complexity of Nexus iterations, it is probably easier to inform a restricted group of already technical experts, rather than large shares of population.
  + Increased societal awareness is critical, both for conducting the research and having it get implemented. Ultimately, societal viewpoints shape those of the elected officials responsible running decision making institutions and for funding our research
  + I agree that societal awareness is an essential point in public policies. It has been explicitly defined as a dimension in some near and long-term sustainability strategies in my region. However, I don't see why it is more (or less) important for this kind of integrated policies.
  + I'm not sure societal awareness is needed, but I think policy makers need to understand the vast gains that are possible from taking the more holistic nexus approach. There need to be some well-publicized WINS.
  + Public awareness helps, in parallel to making policy makers aware and convinced.
  + Societal awareness of a nexus approach is significant to the success of application of public policies in the framework of existing general laws of territorial organization, and water resources use, that contain legal provisions for the regulation of land use in order to maintain the equilibrium of ecosystems in areas of water protection, and for the priority ranking of water use (human consumption, irrigation/food security, ecological flow, productive activities).
  + Increased social awareness is important to mobilize support and adoption from the governments. I really think the nexus is not well recognized broadly.
  + It is important to spread nexus studies to the society. Communication in science must not be focused on politicians exclusively, all people should be able to know and understanding new science findings. In many places population pressure has more capacity to drive public policies than science, therefore it is necessary to make nexus studies to reach regular people in order to check how it will appeal to the societal.
  + Societal awareness of a nexus approach certainly helps the success of the application of public policies.
  + I think increased societal awareness is critical, since many people do not see the interlinkages between systems. Once they become aware, policy makers must become more accountable, and I think there are examples of this we can point it.

**Edits Made:**

* Section “Applying the Nexus in Practice”: “Organized, transparent and accessible results can help inform societal viewpoints which in turn are important in shaping those of elected officials and for guiding future funding of research.”

# R1 Comment 4

**R1 Comment 4: Similarly, what do we know about what stakeholders and policy-makers want from nexus studies?**

**Response:** This is an important point. Given the expansive scope of the nexus discipline it is important to capture the voices of a range of stakeholders and we try to address this point in the paper. 10% of the co-authors of this study work in government and 4% identified their discipline as related to stakeholder management and engagement. Section “Scope & Definition” touches upon this point: *“Care should be taken to ensure that the community of practice maintains a diverse membership from different regions, backgrounds, and disciplines to capture the voices of a broad spectrum of stakeholders.”.* From a research perspective studies like these can capture some of these voices and we expand on this in the response to R1 Comment 6. We also expand the text to include additional metrics to capture stakeholder perspectives.

**Edits Made:**

* See response to R1 Comment 6.
* Text added to section “Applying the Nexus in Practice”: “Additional metrics using Environmental, Social and Governance (ESG) criteria can also be used to identify stakeholder and policy-maker perspectives127,128.”

# R1 Comment 5

**R1 Comment 5: Were there any questions or responses on interdisciplinarity within research teams, funding, etc.?**

**Response:** Yes, the following questions from the Supplementary Notes touch upon these themes.

* Supplementary Note 3, Q2c (line 210): How can we help new climate and sustainable financing tools (such as subsidies, financial instruments and funds/finance facilities, policy instruments and related support mechanisms) to include WEF consideration? For example which criteria should be included to identify a sustainable economic activities sustainable and eligible to sustainable financing ?
* Supplementary Note 3, Q4 (line 232): To what degree do you think the Nexus is an academic initiative rather than a way of operating public policy? Will modelling/studying the Nexus really have an impact if countries do not implement this Nexus view at a government level? Do we need to train scholars and professionals differently, in order to successfully design and implement nexus approaches?
* Supplementary Note 4, Q3 (line 284): “Do you believe that the amorphous scope and breadth of nexus research creates challenges for students in building core disciplinary strengths (i.e. expertise) within a focus area, or does it provide more opportunities? In other words, are we just branding a group of generalist scientists without deep expertise in a subject, or does the nexus, itself, present a separate discipline, where expertise can be developed?”

The responses to these were summarized and captured in the corresponding sections.

The section “Applying the Nexus in Practice” discusses this: “*Once established, we envision the nexus data reporting and metrics mechanisms becoming best practice across sectors as well as in the evaluation and appraisal of new large-scale projects. These can then supplement and become part of other evaluation frameworks such as the environmental and sustainable impact assessments used by governments, funding agencies, and multi-lateral banks125–127”.*

Section Challenges & Future Direction alludes to the challenges on interdisciplinarity within research teams and academic programs: *“There is concern that nexus studies as a discipline may create a generation of generalists without sectoral expertise. Similar to the need for an overarching nexus body to connect individual sectoral institutions, it is clear that such generalists are needed to help connect the dots between the different sectors or to provide a holistic view of the broader system. Like systems thinking, the nexus approach is an important discipline in its own right and is necessary in order to complement advancements in individual sectors.”*

# R1 Comment 6

**R1 Comment 6: Can you add a few sentences about what you want the reader to see with Figure 1? What is formal science? (Also, the methodology text references Figure 2, should be Figure 1.)**

**Response:** We expand on the purpose of Figure 1 in the methodology section as shown below. We add a note to expand on the disciplinary background definitions as defined in the original survey which explains “formal science”. We fix the reference to Figure 1 in the methodology.

**Edits Made:**

* **Figure 1 (Note added on disciplinary backgrounds):** “Note that disciplinary backgrounds in the survey were defined as: Professional & Applied (Engineering, Law, Business, Medicine, Journalism etc.); Natural Science (Physics, Chemistry, Biology, Earth Sciences, Space etc.); Humanities & Social Science (Anthropology, Sociology, Psychology etc.); and Formal Science (Math, Logic, Computer Science etc.).”
* **Text added to Section “Methodology”:** “Given the core concept of “nexus” studies and the corresponding implications across socio-economic and geographic boundaries, the need for a diverse authorship is all the more compelling. A key feature of this study has been the attempt at documenting the diversity of the many co-authors. Both intellectual diversity (diversity of cognitive approach and disciplinary background) as well as demographic diversity (diversity of gender, race, geography) have been clearly shown to improve problem-solving, creativity, and scientific outcomes33–40. In spite of the proven value of diversity, progress on diversity in the sciences has been slow41. A summary of the diversity statistics determined via an anonymous survey sent out to all co-authors is provided in Figure 1. While the results show an imbalance in the representation across disciplines, institution types, ethnicity, and regions of focus, they provide insights into where efforts should be made to further diversify future studies such as these.”
* **Section “Methodology”:** Reference to Figure 2 corrected to Figure 1.

# R1 Comment 7

**R1 Comment 7: Can you clarify what you mean by “nexus regulation” in the 6th question in the longer-term research list?**

**Response:** Yes. The point about “nexus regulation” was raised in one of the original nexus questions. It refers to the idea of regulating nexus ideas into laws or decrees.

* Supplementary Note 3 Question 2a (line 207): “Do you think the NEXUS approach should be regulated, i.e. law, regulation, decree, etc.?”

Several responses were then submitted to address this. Extracts from original responses:

* Supplementary Note 7 Q2 (Line 1983):
  + I do think regulation will be necessary, and it should be well-considered and holistic.
  + At the moment, laws that enforce the use of Nexus approached sound quite far from reality at national or international level. However, it might be already the case for very specific local regulation with well-known issues that can be connected to WEF solution. I hope that this could change in the future, for instance stimulating more Nexus research at various scales. One way to do it could be to incentivize funding to Nexus projects
  + It will be critical, but not as much as for other issues. In this case, administrations can realize by themselves the benefits of an integrated approach. So I do not think that regulation will be required.
  + Laws are unlikely to be effective on a global scale. What needs to happen is that the economic benefits of nexus approaches need to become clear to those involved in strategic planning. Money talks!
  + However, I don't see why it is more (or less) important for this kind of integrated policies. Same for regulation, I believe that an appropriate tracking is an essential element for the effective implementation of any public policy, but nothing particularly important for this study in my view…
  + Too early to talk about laws and regulations. We need to do a lot more work to present case studies with concrete evidence of its advantages and limitations.
  + It is not obvious to me how nexus approaches could be regulated. May be certification of policy/and approaches by recognized bodies would work (eg. think of extending the green certification to a nexus one).
  + I believe regulation is one of the ways that can be used to implement nexus policies but it is not the only one neither the most effective for all cases. There is a need for a foundation framework to support nexus implementation. It must be much more discussed. There are a lot of studies trying to understand the complex interactions between nexus systems but very few studies about how to implement and regulate nexus approaches.
  + Regulatory supports on nexus application is important, but well-designed business models that make nexus approaches profitable will be even more powerful when implementing.

# R1 Comment 8

**R1 Comment 8: I think Figure 2 is adequate in the conclusion without the bullets listed since the text is repetitive with the previous sections.**

**Response:** Agreed. Text has been removed.

**Edits Made:**

* **“Discussion” Section:** Bullet list removed.

# R1 Comment 9

**R1 Comment 9: Related to my earlier big comment is to add the word “failures” in Figure 2, 3rd section, 1st bullet under recommended action. Failures or even mixed results are particularly important to document so that we can design better policies and plans moving forward.**

**Response:** Agreed. This is key and we have included this in the table. Several responses from the survey also referred to this and was briefly mentioned in the “Applying the Nexus in Practice” section: “*Finally, in addition to the metrics and reporting mechanisms, a library of policy successes, wins, failures, and examples is needed127–129 and can be built based on existing efforts such as the Arizona State University’s Social-Ecological Systems (SES) case study library130 or the SIM4Nexus library of case studies131.”*

**Edits Made:**

* Figure 2: Updated to add the word “failures”

# R1 Comment 10

**R1 Comment 10: Last, as you describe, the nexus literature is sprawling and growing rapidly so there are a few recent papers that have emerged to address some of your concerns and should be referenced. Look for 2019-2021 papers by AM Urbinatti and colleagues.**

**Response:** Thank you for the relevant suggested literature. We have included these at the appropriate locations.

**Edits Made:**

* Literature added:
  + Benites-Lazaro, L. L., Nascimento, N., Urbinatti, A., Amaral, M. & Giatti, L. L. The Social Network Analysis to Study Discourse on Water–Energy–Food Nexus. in The Water–Energy–Food Nexus : Concept and Assessments (ed. Muthu, S. S.) 127–144 (Springer, 2021). doi:10.1007/978-981-16-0239-9\_5.
  + Urbinatti, A. M., Benites-Lazaro, L. L., Carvalho, C. M. de & Giatti, L. L. The conceptual basis of water-energy-food nexus governance: systematic literature review using network and discourse analysis. Journal of Integrative Environmental Sciences 17, 21–43 (2020)
  + Urbinatti, A. M., Dalla Fontana, M., Stirling, A. & Giatti, L. L. ‘Opening up’ the governance of water-energy-food nexus: Towards a science-policy-society interface based on hybridity and humility. Science of The Total Environment 744, 140945 (2020).

# R2 Comment 1

**R2 Comment 1: The paper needs to explain the history of nexus discourse properly, and state the missing gaps in policy and decision making very clearly. Please note that the nexus discourse started at the World Economic Forum with the need for better policy coordination at the global level when the close relationship between the rise of energy prices and food prices and resource scarcity was evident. Further, the debate did not start with the research gap in nexus modelling but calls for institutional innovation to prevent governance failure in policy coordination failure.**

**Response:** We have expanded the introduction to briefly explain this background. Given the word count limit of 3000 words and the forward-looking scope of this perspective article we are constrained as to how much we can expand on the historical context of the nexus discourse.

**Edits Made:**

* **Text added to Section “Introduction”:** “The nexus discourse was highlighted at the World Economic Forum in 201110,11 in response to the recognition of the need for better global policy coordination to manage the relationships between multi-sector commodity prices and resource scarcity. The event was followed by an exponential increase in research associated with defining, scoping, and modeling nexus interactions which have important implications across human and earth systems at variable scales ranging from the globe to cities and from centuries to hours.”
* **Text added to Section “Introduction”: “**While the theoretical benefits of the nexus have been demonstrated in several modeling exercises and example case-studies, there remain several challenges and hurdles in implementation of these ideas in real policy and governance mechanisms which include securing strategic and financial support from leadership to modify long-established single-sector institutional and administrative structures. These challenges partially arise from a lack of clear and measurable evidence of the benefits of actual nexus integration efforts.”

# R2 Comment 2

**R2 Comment 2: System approach as well as many integrated approaches and models ( including several ecological models, and multi-agent systems model) already incorporate the cross-relationship and feedback between different inputs ( land, water, soil, energy as input ) use and outputs ( food, water as output, energy as output). The authors need to describe the interlinkages in the system approaches, for instance, and how nexus is different to the system approach. This exercise will enable us to identify the research gap.**

**Response:** These concerns were brought up in our survey questions. As discussed in the perspective article a comparison of the growing number of nexus models and methodologies is a major challenge of the nexus discipline as it stands today and there is a need to conduct such a cross-model comparison in an organized and standardized manner. This is one of the main consensus of the perspective and the co-authors make suggestions on the best way to organize such an exercise. The relevant questions related to the discussion on the nexus vs. existing systems approaches are copied below. We expand on this discussion in the section “Scope & Definition”

* + Supplementary Note 1, Q3 (Line 69): Is "nexus" a new approach and is it different from integrated management? If so what are the differences and are there any benefits to a nexus approach as compared to integrated management?
  + Supplementary Note 6, 3 (Line 740) provide the responses to the question above. Relevant extracts from these are copied below:
    - From my understanding, if integrated assessment includes feedbacks between different components, then it is the same as nexus study.
    - The new part is that the neuxs appraoch is balanced. I mean that with integrated water resource management you focus from the water perspective and take the other sectors as boundaries, while solutions and innovations should be part on all parts.
    - I think that the line between integrated management/assessment and ""nexus"" is very difficult to identify. There are well-accepted IAMs and CGEs that are continuously increasing their capacities, which means that they can represent an increasing number of interconnections.
    - In my “philosophical” opinion, the difference between the nexus and integrated management is very little. The theoretical definitions of the “integrated management” are almost perfect “nexus approach”, but applications always fell short, which led to the emergence of the nexus approach as a way of scientists to reiterate concepts with new names when they see that the old package did not function as anticipated. However, integrated management seems to be sector-centric; for example integrated water resources management is water-centric, taking into consideration consequences on all other sectors. But the nexus is supposed to be multi-centric in a way that all sectors are treated equally and competing to achieve realistic societal welfare. I see the ultimate decision-maker in a nexus system to be the highest level in a jurisdiction, e.g. Governor of an American State, a Premier of a Canadian Province, a Prime Minister of a country.
    - The Nexus approach is not only about integrated management, but also integrated assessment and awareness of the natural-economic-social dynamics that characterize the world we live. Integrated management is just the final step of this approach, which links assessment to management or policy implications.
    - While I don't think a nexus approach is completely new, I do believe it offers new perspectives from integrated management. Integrated management generally focuses on prioritizing one resource and managing it by considering trade-offs with related resources or sectors, making it mostly cross-disciplinary (viewing one discipline from the perspective of others). While the nexus approach can, and often does, use a similar approach, it offers opportunity for more equal integration where all three food, energy, and water sectors are considered equally. This provides opportunity to move towards multi-disciplinarity (multiple disciplines working together) or full interdisciplinarity (integrating methods and knowledge from across disciplines to create a true synthesis).
    - Integrated management studies the combined systems as a whole, and often without feedbacks. Nexus approaches concern with the actual connections between systems and focuses on specific points of feedback. In nexus approaches, the connections between systems are often more important than the individual systems themselves. While in integrated management, the individual systems are more important and take center stage.
    - This is one of the main criticism of the nexus approach (new wine in an old bottle?) [FAO, 2014. The Water-Energy-Food Nexus A new approach in support of food security and sustainable agriculture.] [Altamirano, M. A., van Bodegom, A. J., van der Linden, N. H., Rijke, H. D., Verhagen, J., Bucx, T., ... & van der Zwaan, B. C. C. (2018). Operationalizing the WEF nexus: quantifying the trade-offs and synergies between the water, energy and food sectors.]. I think one the novelty of the nexus approach is to promote the overcoming of institutional barriers and power imbalances between different sectors. Another novelty of the nexus approach is to involve all the stakeholders through engagement and collaboration to have a holistic solution of the problem. This kind of approach allows to find new opportunities, interlinkages and synergies among different sectors and stakeholders.
    - Yes, it is different. I guess that the main difference is that the nexus view is focused in the interactions between all the sectors. This is a benefit because is part of the analysis take into account all the linkages and their eventual issues.
    - To me Integrated management is a part of NEXUS system, mostly linked to the operational part of productive systems while NEXUS appeared to me more focused on greater system’s complexity spanning from interlinkages to feedbacks. The challenges of a NEXUS could be more holistic, while integrated management is usually oriented to optimize resources for specific production systems. It is clear however that a clear distinction between integrated management and Nexus is not evident ….. and the paper may give some interesting feedback.
    - Both approaches seeks the same and have the same core. Nexus is more specific, regarding sectors and tools to be implemented. Integrated mgment can be applied more widely.
    - In theory, yes, "nexus" is different. Integrated management is a broad approach (umbrella) that can utilize "nexus" research and applications. Specifically, nexus is the inter-dependences and feedbacks among systems - this may or may not be captured in integrated management. The benefits of nexus is the simultaneous consideration of multiple systems.
    - I think nexus thinking can lead to integrated management but not the other way around.

**Edits Made:**

* **Text added to Section “Scope & Definition”:** “There is also ambiguity in the status of “nexus research” as its own discipline and what sets it apart from similar fields of study such as systems dynamics and integrated resource management. While still unclear, together with the evolution of its scope, nexus research as a discipline is adopting its own characteristics by combining methodologies from these other fields of studies with a focus on inform multi-sector policy and governance.”

# R2 Comment 3

**R2 Comment 3: The profile of the authors and respondents may not be representative of the broader nexus community as it is heavily research-focused. Hence it became another supply-driven effort to identify research gaps.**

**Response:** An attempt to be very transparent about the diversity and inclusion in this paper was a key focus. That is the purpose of figure 2. We expand the text to discuss this point further and acknowledge the imbalances in the diversity that may not always be straightforward to resolve and require continual efforts..

**Edits Made:**

* **Text added to Section “Methodology”:** “Given the core concept of “nexus” studies and the corresponding implications across socio-economic and geographic boundaries, the need for a diverse authorship is all the more compelling. A key feature of this study has been the attempt at documenting the diversity of the many co-authors. Both intellectual diversity (diversity of cognitive approach and disciplinary background) as well as demographic diversity (diversity of gender, race, geography) have been clearly shown to improve problem-solving, creativity, and scientific outcomes33–40. In spite of the proven value of diversity, progress on diversity in the sciences has been slow41. A summary of the diversity statistics determined via an anonymous survey sent out to all co-authors is provided in Figure 1. While the results show an imbalance in the representation across disciplines, institution types, ethnicity, and regions of focus, they provide insights into where efforts should be made to further diversify future studies such as these.”

# R2 Comment 4

**R2 Comment 4:** **The authors need to give examples or case studies that can be connected to the different challenges ( as shown in Figure 2). For example, in XX case study, if this YY model was used with certain assumptions, then it could help better in decision-making regarding the prevention of ecosystem degradation,etc..**

**Response:** We agree that having representative examples could be illustrative but providing a library of case studies is not within the scope of this perspective. This is one of the key conclusions of the paper i.e. to curate and maintain an on-going database of case studies which will require appropriate funding. This is discussed in the Section “Applying the Nexus in Practice”: “*Finally, in addition to the metrics and reporting mechanisms, a library of policy successes, wins, failures, and examples is needed130–132 and can be built based on existing efforts such as the Arizona State University’s Social-Ecological Systems (SES) case study library133 or the SIM4Nexus library of case studies134. These should include clear cross-sectoral benefits and trade-offs from economic, SDG, and ecosystem perspectives. This library of real-world case studies will provide others with motivation and examples for adopting similar practices in other regions and under other planning frameworks.”*

# R2 Comment 5

**R2 Comment 5: I also want to point out that many important references are missing related to the nexus topic, definition, gaps related to nexus tools, and recent articles published related to the future of nexus.**

**Response:** We have added several references since our first submission (total references in the original submission were 124 and are now 139). We are happy to include additional references the reviewers or editors feel should be included.

# R2 Comment 6

**R2 Comment 6: I suggest a major revision of the paper where the authors clearly position the paper by identifying pathways to help 21st-century policy-making with innovative tools and scientific models. The readers need to understand the value of this paper through concrete examples of the use of tools, approaches and methods in meeting policy gaps, rather than a list of non-authoritative recommendations.**

**Response:** We appreciate the reviewer’s concern and point out that this is a “Perspective” article that has a specific and limited scope (and word count - 3000 words) that encourages **personal viewpoints** of authors and is distinct from a “Literature Review” or regular “Research Article”. The recommendations made and personal opinions shared in the article are in line with the expectations of this scope.

**Scope of Perspective Article from:** <https://www.frontiersin.org/journals/environmental-science/sections/environmental-systems-engineering#article-types>: “Perspective articles present a **viewpoint** on a specific area of investigation. They should provide the following: 1) Discuss current advances and future directions, 2) Clear presentation of the **authors’ perspective**, 3) Accurate presentation and citations of other authors’ work, 4) May include original data as well as **personal insights and opinions**. Perspective articles are peer-reviewed, have a maximum **word count of 3,000** and may contain no more than 2 Figures/Tables.”

**Edits Made:**

* References added, figures updated, and text added across all sections of the paper in response to each reviewer comment. Each of these edits have been documented in this “Response to Reviewer”.