Reviewer 1

The study analyses the effects of climate and tree cover changes on water availability used a wide range of available data and by combining different methods. The effects of climate change and tree cover changes are distinguished from each other in order to understand the importance of each for changes in evaporation, precipitation and runoff both on a global scale and on 5 specific basins. Overall they find that climate change induced increases in runoff can be cancelled due to decreases caused by tree cover change and argue that these effects should be considered in future restoration projects.

I find the study topic and approaches used highly interesting and relevant, however as the authors note it is a challenging topic given the many uncertainties. The authors use a blend of different data and approaches (budyko models, moisture tracking) to analyse the effects in a consistent way using the CMIP6 climate model simulations. These results and approaches are presented clearly and are highly relevant for the study topic despite the large uncertainties of the study topic. The limitations of the study are clearly and openly described which helps a lot in guiding the interpretation of the results. Overall I believe the study proposes an interesting data based approach which is a substantial addition to present day literature. I only have a few minor comments related to the approach and interpretation of the results:

We thank reviewer 1 for their positive feedback on the paper and constructive comments to improve the paper. We reply in detail to the comments below. The reviewer comments are made blue, and our reply is in black.

Methods:

- The used methodological workflow is creative and allows to use currently existing datasets to answer this complex problem. The authors spent a lot of time and effort in describing the limitations of this approach (such as the lack of an interactive atmosphere and thus climate feedbacks) which is important to take into account. However, one caveat in the analysis setup is barely discussed but could also be important. The authors base their analysis on CMIP6 climate model simulations and then apply the climate model data with different independent tree cover datasets. When the tree cover dataset is kept the same (e.g. both 2000 land cover) they attribute this difference in CMIP model results fully to climate change. However, this neglects the fact that each of these simulations have transient land cover related to their specific SSP scenarios as defined by the LUH2 dataset (https://luh.umd.edu/ , Hurtt et al. 2020). To my surprise this associated land cover pathway to the SSP scenarios is never mentioned despite the knowledge that those land cover changes can also cause climate effects in those simulations. The authors compare a mid-century period to a historical period so the land cover changes might be modest overall but it is currently unclear whether the authors checked this. I do not think that this caveat undermines the used approach (especially on the global scale) but I would find it important that the authors reflect upon possible biases due to this such as over areas of large land cover changes, such as in specific basins, in SSP3 as the climate change signal could also contain a land cover induced signal.

We thank the reviewer for raising this point which we indeed have not considered and discussed in this analysis.

In line 380 we mention the strong reduction in tree cover for scenario SSP3, but we do not discuss the potential effects on our scenario CC (climate change). In a new version of the paper, we will extend the discussion on this topic. We will add the references from Hurt et al. (2020) and the study by Hong et al. (2022) who investigated the impact of land-use scenarios including SSP3 on climate extremes globally and regionally. Hereby the suggested additional text for the discussion section, from line 380 onwards:

"The SSP3-7.0 pathway describes a resource intensive world with, unlike the other SSP scenarios, a strong reduction in tree cover in the coming decades (Hurtt et al., 2020, Shiogama et al., 2023). We do not consider the climatic impacts of these land-cover changes (which can vary between CMIP6 models) in our study, but rather attribute all changes in scenario CC to climate change. The land use changes corresponding to SSP3-7.0 can affect temperature and precipitation extremes, whereby the land cover impacts may be more pronounced on a regional level compared to the global level (Hong et al., 2022). Therefore, we might under- or overestimate the climate effects in our study on a regional level. For example, the large-scale deforestation presented by SSP3-7.0 in tropical regions could lead to decreased mean and extreme precipitation (Hong et al., 2022), which could indicate that the precipitation changes attributed to climate change in our study may show a weakened climate change signal in the tropics due to land use impacts.

To create the future potential tree cover map for SSP3-7.0 (Roebroek, 2023), the feedback between changing tree cover and climate for SSP3-7.0 was also not included. By using the potential tree cover map for SSP3-7.0 and assuming large-scale tree cover change, we deviate from this climate pathway, which subsequently should alter climate characteristics and therefore the future potential tree cover."

- A smaller methodological question: why did the authors apply different averaging periods for tree cover changes (2041-2060) and climate (2035-2064)? This seems strange and is not clearly explained in the methods section.

The mismatch in time range originates from a data availability issue, as the tree cover change maps are created for the time period (2041-2060), but we preferred to use a 30-year time period to determine a mean climatology of future climate from the CMIP6 simulations, as we did a 30-year climatology for current climate as well.

We will clarify this in the text in line 136:

"Note that this 20 year time range is shorter than the 30 year time period of the climatological data, as the tree cover maps are only available for 2041-2060."

Discussion and conclusion:

- The study presents a data driven approach which despite large uncertainties and limitations in setup and available data manages to deliver plausible results which is highlighted by the agreement between changes reported in this study and more local based studies. However, it remains unclear due to the variety of limitations within the approach how these results can be interpreted. Currently it is only described as a 'first estimate' which remains a bit vague. I believe that some more clarification would help regarding the meaning of the effects/calculated values. In essence how can one interpret/use these results? Do these results represent an upper boundary of potential effects or rather a lower estimate due to the neglected climate feedbacks? Are these values representative and applicable for local studies (e.g. region/basin scale) or only at the global scale of the utilised scenario (i.e. idealised case)? These are not questions that the study can quantify directly but as the proposed framework is flexible and applicable with available data hence it would be interesting to have some more indication on how the neglected effects could change the overall outcome.

We agree with the reviewer that in this article we do not go in detail on direct interpretation and meaning of the presented results. This is an academic study where we combine different datasets (at low spatial resolution) with a potential tree cover map, and a rather extreme climate scenario, which includes many uncertainties that can enhance or counteract each other. For that reason we formulated our conclusions with diligence, calling the results a first global estimate, as we do not think this study should be used as direct only input to plan current or future restoration projects. Instead, we hope this study highlights that a long-term vision is needed which considers both the impacts of climate change and tree cover change, since we show that these impacts might enhance or cancel each other, depending on the region (at a 1°x1° resolution). A long-term vision can help to prevent unexpected impacts on water availability.

In line 458-459 we suggest the following sentence change (indicated in orange) to make it more explicit that we talk about the long-term vision and highlight the need to consider the impacts of both climate change and land-use change.

"Ecosystem restoration projects should consider these long-term hydrological effects to limit unintended reductions for local, downstream, and downwind water availability. To confirm the hydrological responses presented here, local coupled modeling studies are a good next step to guide local forest restoration projects."

Please note that we address the comment on local coupled modeling studies below.

- line 460: It is a bit confusing what is exactly meant by local coupled model simulations. In general the text refers to the need (and lack of) coupled earth system model simulations, could you be more specific in highlighting which type of simulations are required and would help move research forward (or would be applicable for this approach). And to what extent those should be local (regional afforestation simulations maybe)?

We agree with the reviewer that we do not go in detail on what is meant with local coupled modeling studies in line 460, while we have explained our ideas on global coupled studies (in line 425-430). With local coupled modeling studies we indeed refer to limited domain (regional/local) future climate simulations which can include and exclude afforestation. Such simulations can for example be done with the weather and research forecasting model (WRF). This approach would allow for studying direct local feedbacks and it would capture sensitivities of changing tree cover to evaporation and precipitation, also based on the local atmospheric conditions. We suggest the following change to the last lines of the conclusion, indicated in orange, to make local couple studies more explicit (line 458-459):

"Ecosystem restoration projects should consider these long-term hydrological effects to limit unintended reductions for local, downstream, and downwind water availability. As a next step, we recommend the use of local coupled modeling studies. For example by implementing different afforestation scenarios in a regional weather model under future climate conditions. This would enable the analysis of direct local feedbacks and sensitivities of tree cover changes to evaporation and precipitation, based on local atmospheric conditions. Such studies could confirm the hydrological responses that we present here, and are a good next step to guide local forest restoration projects."

Technical comments:

- line 109: reference got messed up; fixed the reference
- line 254-258: good that you test for statistical significance but why only for Q and just for one scenario, why not include all models and scenarios and only show significant changes on the maps if most grid cells show significant effects in any case?

We only show the statistical significance for the change in Q as a result of the changing tree cover in a future climate since the focus of this study is mainly on the impacts of tree cover change on water availability, and because Q combines the effects of precipitation and evaporation. Furthermore, the climate-driven changes in Q have already been studied extensively (e.g. on global scale by Li and Li, 2022; Wang et al., 2022; Zhao and Dai, 2021) for a future climate using CMIP6 global climate models. If we would only display the significant changes in each figure, the comparison of the figures showing the evaporation and precipitation changes with the figure showing the discharge changes might become more challenging. This is because the regional significance of these changes could vary across the different fluxes. Hence, we prefer to only show the significance in a separate map for the discharge.

- Line 370 and 433: constrainTs: thanks, changed
- Line 339-340: this is confusing, if you want to highlight how important restoration potential is you can better report absolute values here (at least together with the relative values).

We understand that the sentence is confusing. With the sentence 'which could (partly) be attributed to its smaller surface area' we meant that the tree restoration potential will generally be lower for larger basins, because of the higher spatial variability on larger scales. We do not wish to create any confusion, and that is why we will remove this sentence from the new version of our manuscript.

References

- Hurtt, G.C., Chini, L., Sahajpal, R., Frolking, S., Bodirsky, B.L., Calvin, K., Doelman, J.C., Fisk, J., Fujimori, S., Klein Goldewijk, K. and Hasegawa, T., (2020). Harmonization of global land use change and management for the period 850–2100 (LUH2) for CMIP6. *Geoscientific Model Development*, *13*(11), 5425-5464. doi:10.5194/gmd-13-5425-2020
- Hong, T., Wu, J., Kang, X., Yuan, M. and Duan, L., (2022). Impacts of different land use scenarios on future global and regional climate extremes. *Atmosphere*, *13*(6), p.995. doi:10.3390/atmos13060995
- Li, X., & Li, Z. (2022). Global water availability and its distribution under the Coupled Model Intercomparison Project Phase Six scenarios. *International Journal of Climatology, 42*(11), 5748-5767. doi:10.1002/joc.7559
- Wang, A., Miao, Y., Kong, X., & Wu, H. (2022). Future Changes in Global Runoff and Runoff Coefficient From CMIP6 Multi-Model Simulation Under SSP1-2.6 and SSP5-8.5 Scenarios. *Earth's Future, 10*(12). doi:10.1029/2022EF002910
- Zhao, T., & Dai, A. (2021). CMIP6 Model-projected Hydroclimatic and Drought Changes and Their Causes in the Twenty-First Century. *Journal of Climate, 35*, 897-921. doi:10.1175/JCLI-D-21-0442.1