

□ **General comment**

This study examines the long-term effects of vegetation restoration policies in the Sahel region on groundwater dynamics. While it is known that artificial vegetation restoration in arid regions has both positive and negative aspects, there are few studies that have examined its long-term impacts. Therefore, this study can be considered a valuable contribution that demonstrates the hydrological impacts of vegetation changes and soil and water control policies based on changes in vegetation, microtopography, and groundwater levels. In particular, the assessment of negative impacts, such as a decline in groundwater levels, is expected to be beneficial for future policy-making.

We thank very much the reviewer for his constructive, in depth and detailed review of our paper. As the reviewer rightfully points out, there are virtually no studies that have examined the long-term, pluri-decadal impact of artificial vegetation restoration in the Sahel region - all the more when considering fine-scale changes over several (six) decades.

□ *However, there are several concerns regarding the hydrological impacts of the greening practices concluded in this study.*

1) I understand that soil and water conservation (SWC) reduces erosion and affects the drainage network; however, there is insufficient evidence to support the claim that greening contributes to a decline in the groundwater level. While factors such as climatic influences (e.g., fluctuations in rainfall), population growth, and dam construction are likely also at play, the extent of the impact attributable to greening has not been examined. Consequently, there is a concern that the conclusion may be drawn without sufficient support.

We do acknowledge the need to better describe the basis that support our claim that SWC, by reducing erosion and affecting the connectivity of the drainage network, did also contribute to a decline in groundwater levels. The main hydrological process in play here is Hortonian runoff, resulting in focused recharge through gullies and the seasonal river course ; this indirect recharge process was described to be in play in the MRW in the 1960s (Sauvel, 1966) as well as through recent investigations (Chaweye et al., 2026). Focused recharge is frequently observed in african drylands (Massuel et al., 2006 ; Cuthbert et al., 2019 ; references cited) ; it does result in reduced inputs (annual recharge fluxes) to the aquifer (cf. Figure 2) when runoff decrease on the long term; Within the MRW, this lowered groundwater recharge created a disequilibrium in the Quaternary alluvium aquifer balance and hence, a lowering in the water table (decreasing piezometric heads). This process is play in this region implies that changes in rainfall do impact recharge indirectly, through induced runoff and surface water fluxes. These parameters were measured at the outlet of the watershed (location shown in Fig 1, data shown in Fig 9f). Population growth have had a negligible direct contribution on domestic water use (daily consumption is of the order of a few tens of litres per inhabitant). Dam construction was indicated to have local effect, and we do acknowledge that point need to be better emphasized (Dam impact on groundwater levels trends were shown in Fig 8a, TB01). The revised version will include a comprehensive description (cross section based on actual data and in-situ observations through time) of the various processes in play, in order to clarify the respective influences of the different factors on the drainage network and groundwater dynamics.

□ *In particular, I recommend evaluating the effects of greening and climate on water yield. As a reference study, Sun et al. (2026) in the Water Resources Research assessed the impact of reforestation and climate change on water supply in China. I believe such a quantitative analysis is necessary.*

Sun, G., Zhang, Y., Hao, L., Song, Z., Duan, K., Sun, S., et al. (2026). Large-scale forestation aggravates water supply decline: Mounting challenges to forest management in China. *Water Resources Research*, 62, e2025WR043189. <https://doi.org/10.1029/2025WR043189>

We welcome this stimulating recommendation for estimating the effects of regreening on groundwater resources. However, in our own study, one key difficulty in applying the suggested Budyko modeling methodology for attribution (described in Zhang et al., 2001) is the highly heterogeneous dataset, for which we have little or no freedom to improve it – both in time or space. First, runoff is available in just one single hydrological station (located Figure 1) with non-consistent or non-existent data after mid-1980s, a period of time when most of the changes have occurred. Secondly, most of the area has been, for various reasons including travel insecurity, of limited accessibility for scientific research during the past few years. While reconstructing hypothetical data might be possible with audacious hypotheses, we believe that this would be beyond the scope of this research. The suggested reference will be quoted in part 5 (perspectives) of our revised paper.

□ 2) *Changes in vegetation cover are expected to alter evapotranspiration, which in turn leads to changes in groundwater levels and runoff; however, these changes are likely attributable not only to the Valley but also to evapotranspiration across the entire watershed. While changes in vegetation cover are shown for each landscape (Plateau, Valley, Slope) (Table S1, S2), it is necessary to quantify the extent of these changes resulting from regreening practices from the perspective of the entire watershed and to evaluate whether they correlate with changes in groundwater levels.*

We thank the reviewer comments that will greatly help in refining the context presentation and results. We do agree that changes in vegetation cover alter ET, which in turn change surface water redistribution, runoff and eventually for the MRW, indirect groundwater recharge (Fig. 7). In addition, reforestation by non-native tree species occurred solely within the valley, and most of the regreening that have impacted increased groundwater evapotranspiration fluxes are expected to be restricted to the valley. We do agree to quantify as much as possible these changes and this will be done accordingly in the revised paper. Groundwater level changes analyses will take into account connectivities and piezometric heads changes computed through the unconfined aquifer.

□3) *Regarding the reduction in surface runoff and erosion caused by soil and water conservation (SWC), the change in drainage network length is used as an indicator. While this is not a problem in itself, since only changes in values for the entire watershed are shown, it is unclear how SWC is affecting these changes. I believe it is necessary to show the drainage network length changes for each landscape type (Plateau, Valley, Slope). Tables S1 and S2 show changes in vegetation cover for each landscape type. Similarly, I think it would be better to present data on the areas where SWC was implemented within each landscape type. Based on that, whether the changes in drainage network length correspond to these areas should be demonstrated.*

We do agree that this point needs clarification. Changes in the drainage network occurred mostly through slopes, and the computed values reported in Figure 9 b are for the slope part of the MRW. There is virtually no drainage network change in terms of density or length on plateaus or in the valley part of the MRW.

□Furthermore, *drainage network length corresponds to gully erosion and is thought to correlate with flood runoff. The authors should use water runoff data to verify whether changes in drainage network length directly correspond to runoff rates.*

We thank the reviewer for this comment. We share his understanding and would have been keen to provide more conclusive results on this point. However, there are no data available at sub-scale for the MRW and for the whole basin, most of the hydrological surveys stopped by the early 1980s, a period of time when gullies connectivity started to decrease (Fig. 9b and 9f). An indirect, somehow qualitative evidence lies, however, in the inverse relationship between annual river flow and annual rainfall inputs during the 1970s. We will point out this indirect justification more clearly in the revised manuscript.

□4) *It is believed that runoff, particularly baseflow, corresponds to fluctuations in the groundwater level—can it be verified? If possible, I think it would be better to include a long-term hydrograph. It would be even better if flow data were available for both the upstream and downstream areas.*

We welcome this comment – it does indicate that we need to add clarity to the hydrological processes in play. In the revised paper, we will make it clear that there are no groundwater-fed baseflow, and we will add a cross section showing the processes during peak flow and low flow (in addition to Fig 7). This will make it clear that groundwater is fed by surface waters.

Since these points are crucial to this paper, I believe these issues need to be addressed before the paper can be published; therefore, I have determined that a major revision is required.

□ Specific Comments

Line 119. The percentage of the total watershed area accounted for by each topographic category (Plateaus, Slope, Valley) should be shown here. It would also be helpful to show the percentages for the Upstream and Downstream areas in the same way.

This will be done accordingly.

Line 291. Please briefly describe the methods for measuring flow rate and groundwater level.

The methods used are robust classic methods and we will describe them briefly (piezometric probe, flow reel)

Line 329. It would be easier to understand if, in addition to changes in vegetation cover ratio in Plateau, Slope, and Valley, changes in land cover and land use relative to the total watershed area were shown. Ideally, it would be clearer to show changes in the percentage of land area occupied by land uses such as woody vegetation, farmland, and residential areas relative to the total area.

We will update Figure 9

Line 515. While “Drainage network length” for the entire watershed are shown, what about fluctuations in drainage network length within the Plateaus, Slope, and Valley areas? It is unclear whether changes in vegetation and soil water conservation (SWC) practices in each of these areas correspond to fluctuations in the drainage network.

Fluctuations in the drainage network length correspond to the slope area, this will be added in caption of Fig. 9.

Line 540. I think preventing flooding during heavy rainfall tends to reduce water loss caused by flooding and has the effect of increasing groundwater recharge. Therefore, I do not believe it will lead to a decline in the groundwater level.

We do agree that this point need better and a more thorough discussion. Examples through the Sahel region have showed that this increased diffuse recharge process could take decades to occur (see for instance Ibrahim et al., Hydrogeology Journal, 22 (6) (2014), p. 1293). We will expand on this in the revised manuscript to indicate that the observed decline is related solely on reduced (rapid) focused recharge.

Line 544. How much area was covered, and what percentage of the entire watershed’s vegetation was restored?

This will be computed and the data added in the revised manuscript (these data are shown in supplementary materials)

Line 556-562. The annual river flow is shown, but I think it would be clearer to also illustrate the continuous changes in water flow. Specifically, whether stormflow has increased or baseflow has decreased is important to understand how the greening initiative has affected runoff processes—. Additionally, confirming whether changes in the groundwater table correspond to changes in baseflow would be beneficial.

The data on river flow are shown at daily time scale in figure 7 over two years. The full available data set (daily when available and monthly otherwise) will be made available in supplementary material for record in the revised manuscript.

Figure 1. The captions do not include explanations for a) and b)

This will be corrected

Figure 5. Compared to the 1983 image, the 2014 image appears to have lower resolution—is that comparable? Could this difference affect the identification of the drainage network?

In part 2.3 « image processing », we indicated that all images were analysed at the same resolution to produce a time series of equal resolution (LL 252-253). In order to make details more obvious, the visual resolution was chosen at the highest resolution for each year in figures shown. This indication will be added in captions of each figure of the revised paper.

Citation: <https://doi.org/10.5194/egusphere-2026-4118-RC2>