

Please find below our response to the main comments of both Reviewers. Detailed answers to the reviewer's other, specific comments will be submitted in a forthcoming comprehensive response with proposed detailed manuscript modifications.

RC#1

□ *This manuscript mainly presents an interesting study on examining how pioneering re-greening and soil and water control (SWC) efforts have affected both surface water drainage and groundwater dynamics within a transboundary watershed in the central Sahel, West Africa. Overall, this research is potentially valuable for analyzing the main drivers of groundwater decline in this region. However, several important methodological and validation issues need to be addressed before the manuscript can be considered for publication.*

We thank very much the reviewer for his constructive review of our paper. As the reviewer rightfully points out, this paper provides an analyse of the main drivers of groundwater decline within a transboundary watershed in the central Sahel of west Africa. The originality of the paper, however, in our opinion, may not be fully acknowledged : Indeed, there are very few, or virtually no evidences or detailed examples of long-terms « groundwater decline » over the whole Sahel region, a fact that is shown by relying on proxies or non-african studies when dealing with the impacts of large scale reforestation schemes on surface or groundwater resources (e.g., Turner et al. 2023, that we quoted LL.84-86 : « (...) with cases shown in semiarid northern China »). In addition, simplistic description of global changes impacts on rising (not declining) groundwaters / total water storage (TWS) are most often proposed for West Africa (eg., Scanlon et al., 2022 ; O'Neil et al., 2026), due to a overall lack of detailed, in-situ information. To the best of our knowledge, this study represents the first documented research to show a long-term decrease in the water table in West Africa / Sahel region, an evidence that may trigger further research on the distribution of total water storage changes through the earth critical zone system in response to land use / land cover changes. This, along with - to the best of our knowledge - the longest multidecadal (6 decades – long) changes in regreening strategies and their impact on water fluxes, represent the true core originality of our paper. We will more clearly emphasize these points in the revised manuscript (within the « abstract », « introduction » and « Discussion » parts).

References cited :

Scanlon et al. (2022) Linkages between GRACE water storage, hydrologic extremes, and climate teleconnections in major African aquifers. *Environ. Res. Lett.* 17 014046 doi : 10.1088/1748-9326/ac3bfc
O'Neill et al. (2026) Spatially refined satellite gravimetry captures human signatures in global terrestrial water storage trends, *Proc. Natl. Acad. Sci. U.S.A.* 123 (38) e2600775123, <https://doi.org/10.1073/pnas.2600775123>.

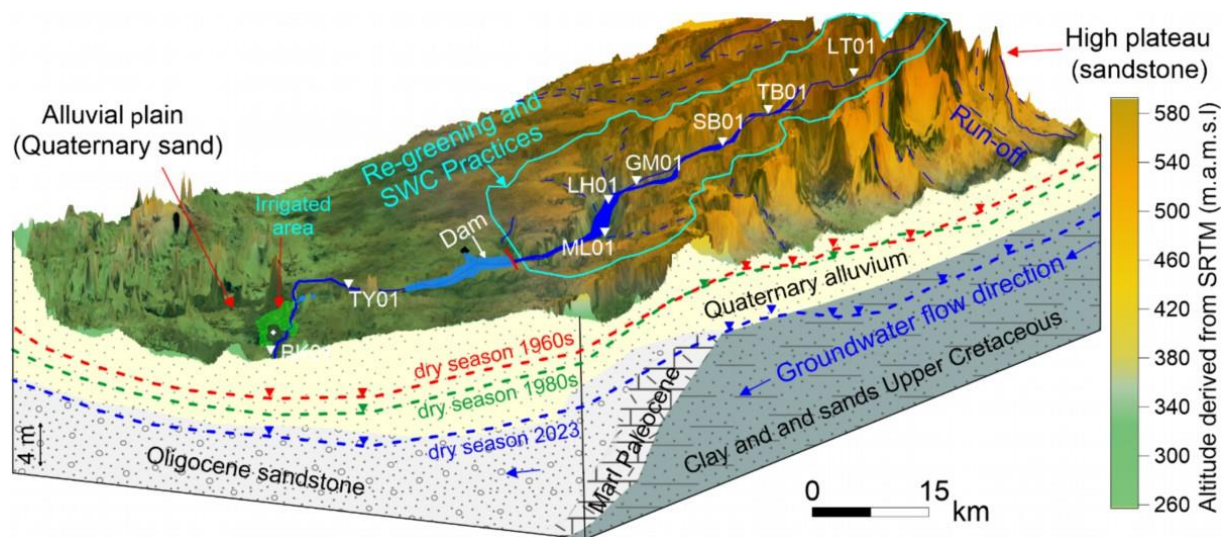
□ **Major comments**

1. *Section 4.2: The attribution of groundwater decline to re-greening and SWC practices is not sufficiently supported. Although several potential drivers, including drought, dam construction, groundwater pumping, SWC practices, and reforestation, are discussed in this section, their relative contributions are not quantitatively separated and the underlying hydrological mechanisms are not fully examined. This limits the mechanistic insight and scientific novelty of the study.*

We do agree that the attribution of the observed groundwater decline could be better explained. We propose to better organize the discussion in this section, to firstly, better explain the limits of the exercise considering i) the available dataset (time span, uncertainties) and ii) examining step by step each of the potential drivers. Each of the cited drivers occurred at different times periods through the six decades long survey, as shown in Figure 9c: reforestation dynamics by the non-native species *Azadirachta indica* mainly occurred between ~1980 and ~2000; SWC practices (stone bunds, contour ridges, half-moon) started in the early 1960s and

were still expanding in the 2010s. We propose to add the now computed dynamics in i) small dams development since early 1960s and ii) irrigation practices (using surface water and/or groundwaters) in this sub-figure 9c. The drought dynamics that reached its maximum intensity during the 1970-1990 period is shown in Fig. 9f. Using these completed pieces of information, we are better able to show that, although all of these drivers have contributed to the observed groundwater decline, each played a role at different time periods over the ~ 6 decades-long of this watershed survey.

In addition, we acknowledge that the hydrological mechanisms in play (Hortonian runoff, focused recharge with surface waters feeding the unconfined aquifer; return flow from irrigation in the downstream part under the main irrigated fields in Fig 1b) need to be described more explicitly. We will provide an updated Figure 2 with more details on hydrological processes (see below) and an additional figure at finer scale with groundwater data that show hydraulic gradients at the vicinity of the Maggia River (detailed cross-section showing documented surface water–groundwater relationships). It will be then more easily to understand that a decrease of Hortonian runoff (regardless its origin) leads to a decrease of focused recharge and thus a drop of groundwater levels within the quaternary alluvium aquifer.



[Proposed revised figure 2]

2. *Section 4.2: As mentioned in this manuscript, groundwater decline “most certainly preceded” the decrease in the drainage network and expansion of SWC practices. This temporal sequence is difficult to reconcile with the proposed causal relationship. The chronology of SWC implementation, reforestation, drainage changes, and groundwater decline should be explicitly examined in this manuscript.*

We certainly do agree that the temporal sequence does need to be better defined and completed. Groundwater decline was shown to occur between the mid-1960s and early 1980s, as a consequence of early small dam influences (e.g. Fig 8a) and /or early SWC practices (e.g. Fig 9c) and/or lower rainfall during the sahelian drought period that started by the end of the 1960s (Figure 9f). Later on, reforestation schemes by non-native phreatophytic tree species ("main regreening period", mid-1970s-1990s Figure 9a), and much later on, local withdrawal for small scale plots irrigation (new Figure 9c) added their discharge contribution to the decline in groundwater resources. In the revised manuscript, the chronology of these different factors will be more explicitly stated, illustrated by a revised Figure 9 with clearer main period of changes shown.

3. *Section 4.1: The upstream and downstream areas are used as a comparative pair, although they differ substantially in geomorphology, aquifer properties, dam regulation, and irrigation activities. These differences should be considered before attributing their contrasting drainage-network changes primarily to SWC practices.*

The Maggia River watershed represents a single hydrological unit, and the reviewer well understood that the upstream and downstream parts are considered as two different units with different land use and land cover pathways. These pathways are described in figures 9 a, b (upstream) and d, e (downstream) and indeed, show similar or different trends as a function of time (similar trends for the 1950s-1970s, different trends for the 1980s-2020s). Although there are some differences in terms of slopes, hydraulic gradients (both described in details in § 2.1 « study area ») these differences do not impact processes: the whole basin is, from a geological point of view, a sedimentary one (cf. Fig. 2) and the outcropping unit is made up of tertiary sandstones for the plateaus and slopes, where the drainage network was shown to changes through time (cf Fig. 5). Both in the upstream and downstream parts, surface water –groundwater fluxes are mostly indirect (focused recharge ; e.g. as shown in Fig. 6 of Chaweye et al., 2026, reference cited), with surface water feeding the unconfined aquifer; we propose to add a new figure showing surface water – groundwater relationships, based on previous detailed reports (Sauvel, 1966) and more recent (Chaweye et al., 2026) descriptions. In the revised manuscript, we will expand the description to better describe the continuous outcropping geology (§2.1, LL 122-126), and make more explicit reference to the recently published description of the aquifer (Chaweye et al., 2026) that shows (Fig 2): i) continuity of the Continental terminal outcrops over the whole MRW for the plateaus ii) continuity of the quaternary alluvium through the whole watershed iii) hydraulic connection between Continental terminal and quaternary alluvium aquifers. In addition, we will detail more in depth the dynamics of dam and subsequent irrigation development through the upstream part and compare it to the downstream part.

4. *Section 3.3.2 and Figure 8: The uncertainty in the estimated groundwater decline rates needs to be quantified in this study.*

We agree that the estimated uncertainty would benefit from being described more in details. In §2.5, we will indicate that the accuracy is of ± 0.01 m for measurements in regular surveys (e.g. Fig 7a, irrespective of the time period considered). Additional measurements from the 1980s (currently LL 301-303) were reported with an accuracy of ± 0.1 m ; and this piece of information will be added in the text. Connecting older, sparser measurements with more recent ones or recent surveys (as shown for instance in Figure 7) has been discussed in details in numerous previous papers that showed consistency in the resulting dataset (Favreau et al., 2000 ; Leduc et al., 2001 ; Leblanc et al., 2008 ; Favreau et al., 2009 ; Nazoumou et al., 2016).

□ *Introduction: Yan et al. (2025) is cited to support the effects of reforestation on evapotranspiration, moisture transport, and regional water availability. However, the cited paper concerns urban flood hazard assessment and does not support this statement. The appropriate reference should be identified and cited.*

We wish to thank the reviewer for his careful reading and the appropriate reference will be included : Yan, W., Li, F., Wei, X., and Zhao, Y.: Observational Evidences in the Effects of Large-Scale Reforestation on Precipitation, Water Resour. Res., 61, <https://doi.org/10.1029/2025WR040446>, 2025.

5. *Figure 9: The caption appears to contain a panel-label error: annual rainfall and river flow correspond to panel (f) rather than panel (e).*

We do agree and correction will be made.

6. *Table 1/Section 2.2: The text states that 62 photographs from 1956 covered the study area, whereas Table 1 lists 67 IGN and 25 IGNN photographs for the AOF 1955/1956 mission.*

We do agree and correction will be made.

7. *References: The DOI assigned to SOGREAH (1982), 10.1787/601276CD-EN, is incorrect.*

We do agree and correction will be made. Indeed, the reference list would have deserved a better check and we collectively apologize for this.

8. *References: Several entries contain incomplete or incorrect bibliographic information. For example, Peugeot et al. (2026) is listed as "nature.com" rather than Nature Communications.*

We do agree and correction will be made. Exact reference should be "Nat. Commun.". The whole references list will be checked through an official Journal Title Abbreviations

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