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Hydrology and Earth System Sciences Discussions

Interactive comment on "Relating trends in streamflow to anthropogenic influences: a case study of Himayat Sagar catchment, India" *by* R. Nune et al.

R. Nune et al.

rajeshnune@gmail.com

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We thank the referee for their thoughtful comments on our paper and respond to each in turn as follows.

Referee 2: The authors have made a good attempt to quantify the impacts of anthropogenic changes on streamflow trends in their study area. The manuscript quality can be improve if the following suggestions are implemented Discussion about the data should be reduced (3-3.3 one paragraph, 3.4-3.5 in second and 3.6 in the third paragraph)

We have merged sections 3.1 and 3.2 as they both deal with hydrometric data and we also merged sections 3.4 and 3.5 as they both deal with groundwater data. We have kept the remained of section 3.3 as a separate section as it deals with land use. Overall, this combines similar data together.

Referee 2: what does GL refer in equation 1?

GL refers to Giga litres and it is now defined in the explanation following Eq(1).

Referee 2: Page no 9308 line 5 - what is prime factor for the reduced runoff even though rainfall in years from 1995-99 being high?

It is difficult to attribute this fluctuation in the five-year averages to any particular cause, given the short averaging periods and available data. Therefore we have not sought to interpret these fluctuations in detail. In general, it is likely to be primarily a result of the overall trend to reducing streamflow in combination with the particular patterns of rainfall over that period.

Referee 2:. Page no 9309 - i did not see storage in fig 7.0. what is dm in fig 7.0 - decimetres? why the abnormal change in groundwater abstraction between well census data and as per irrigation any reason? Please check fig 7.7 and the related text.

Figure 7 has been amended as requested.

Groundwater abstractions were estimated using two methods as we don't have measurements of groundwater pumping volumes for this region. We have added the following sentences to explain possible causes of this discrepancy.

"The well based approach leads to lower overall extraction volumes and there are two possible causes of this. It is likely that the number of wells in the region is underreported as farmers make use of private drillers for installing wells and it is probable that not all wells are recorded. It is also possible that some farmers practice deficit irrigation and the land use based estimates assumed that the crop water demand was full met."

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Referee 2:. Page no 9312, line 20 - it is not clear how a reduction in base flows to the river can help to increase the recharge?

We are not arguing this and have expanded this section to clarify what we mean in the amended paper as follows.

"Nevertheless, large changes in groundwater levels have not been observed despite increased pumping. Two effects on the overall groundwater balance could influence this outcome. Recharge might have increased due to increased recharge from irrigation and additional watershed structures. Also, with declining groundwater heads, discharge from the groundwater to stream may have decreased. Both of these would partially offset the additional pumping from a groundwater balance perspective."

Referee 2:. Page no 9312 through to 9314 - the author claim on page no 9312 that WSD contributes negligibly to recharge and on page 9314 that application of water irrigation is also a negligible contribution to recharge. if it is true what is benefit of WSD? previous studies in India generally suggest that river flows are reduced due to WSD and have reported significant irrigation return flows as well. Hence, if there is no significant trend in rainfall but stream flows are reduced due to WSD (anthropogenic) then what is happening with stored water/applied water? Some explanation of these apparent contradictions is required.

We show that the additional amount of recharge due to hydrologic structures is likely to be relatively small, as argued in the paper. Contrary to what the reviewer states, we do not claim that irrigation leads to negligible recharge, we just note on page 9314 that "equating groundwater withdrawals and irrigation volumes to evapotranspiration assumes negligible recharge from irrigation applications, thus these two estimates of dE/dt should be treated as upper bound estimates." The overall trends in streamflow and evapotranspiration measurements with steady rainfall can be explained by small declines in groundwater as argued in the paper. We do not see any contradictions in the data presented but we do suspect that the groundwater based estimates either

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overestimate applied water or there is significant recharge occurring under the irrigation areas. We have added the following sentence following that quoted above to further expand on this point.

"Indeed, it is likely that there is significant recharge under irrigation areas and this might explain the differences between the groundwater/irrigation based estimates and the remote sensing estimate."

Referee 2:. Page no 9309 - groundwater storage is declining at the rate of 6.1 mm/yr and in page no 9314 the change in storage is contradicting to this. please explain ?

We have simplified the description and it is now clearer that the same rates (6mm/y) are provided in both these places.

Referee 2:. Were there any significant temperature trends in relation to ET?

There were no significant trends in temperature leading to changes in ET.

Referee 2:. Equation 6 to 11 should be discussed in the methodology section rather than being included in the discussion.

We have relocated Equation 6 to 11 as suggested.

Referee 2:. The discussion could be improved by examining the interactions and inter-linking of the different water fluxes' in discussion and results since the discussion is too constrained to individual components

We have added a paragraph at the end of the discussion covering the overall relativities between these effects.

Referee 2:. Too many figures and tables are used which are not necessary. Table 3 and 4 can be combined into one table.

This has been done. Table 1 has also been removed.

Referee 2:: Table 2. could be removed and the observation wells shown the in the

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location map

This has been done.

Referee 2:: Remove Tables 8 and 10 and discuss the main points from these tables within the text at the appropriate place.

We have retained both of these tables (8 becomes 6 and 10 becomes 8) as we feel they provide a convenient summary to the reader.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 9295, 2012.