

Interactive comment on “Natural vs. artificial groundwater recharge, quantification through inverse modeling” by H. Hashemi et al.

Anonymous Referee #1

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Review for the manuscript: Natural vs. artificial groundwater recharge, quantification through inverse modeling Authors: H. Hashemi, R. Berndtsson, M. Kompani-Zare, and M. Persson

The manuscript provides a model that was constructed to provide estimation of groundwater recharge of shallow alluvial aquifer by flood water spreading system in an arid zone. No doubt that proper estimation of groundwater recharge in arid lands is very important and merits every effort, and so is every attempt to develop means to increase recharge capacity of these aquifers. The modeling approach and its validation process presented in this manuscript are entirely based on analysis of groundwater level fluctuation in response to flood events and groundwater abstraction from pumping wells. If

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this manuscript was only an academic exercise on constructing a groundwater model, than I could state the manuscript presents a model that is well constructed, well written and follows the necessary path on the calibration process. Nevertheless, authors should be aware that once published, the results of such a well written manuscript are as good as gold to practitioners and decision makers. Therefore, in this review I would like to raise several concerns that in my point of view weaken the strength of the results and conclusions.

In page 9769 lines 6-11, the authors states that transmission losses in stream channels are inefficient with respect to recharge of the alluvial aquifers. This statement is not accurate. Several studies demonstrated that the capacity of the recharge from stream channels is very high and efficient. Moreover several other studies indicated inefficiency of spreading reservoirs to recharge ground water. In fact many flood water spreading zones in arid lands abandon after several years of operation due to acknowledgement of their mal functioning as ground water recharging mechanism. Therefore such statements as a starting point for the manuscript is miss leading and require a broader discussion on the this subject.

In the same page line 15 the authors state that underground storage is an important alternative to overcome seasonal water deficiency. Indeed it is a preferred solution in arid environments. Yet, flood water in arid environments is usually characterized with very high load of suspended material. Reduction in the stream water energy in the spreading zone derives accumulation of clay particles on the reservoir bottom. As such the infiltration capacity of reservoirs in arid environments is a known to be reduced dramatically. Practically the bottom of the reservoir is sealed off, and significant infiltration is very limited. Unfortunately Examples for such inefficient reservoirs in arid environments exist all over the world's arid countries. Moreover in many cases it has been proved that the infiltration reservoirs created sever damaged the groundwater due to reduction in natural infiltration in the stream channel.

Further on in line 18 of the same page the authors state "Artificial recharge is a method

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to balance and recover groundwater resources through floodwater spreading systems and injection wells". In most cases (of which I am familiar with) recharging reservoirs in arid environments are very shallow and spread over large area. As such, the ability to collect the stored water after sediment settling for direct injection through wells is very limited due to the very large surface area to depth ratio. Therefore only small fraction of the reservoir water may be diverted for recharge through well and the rest is left for intensive evaporation that ends up in salinization of the reservoir sediment. Throughout the entire introduction chapter and further through the results the manuscript almost completely ignores operational issues related to siltation on clogging of flood water reservoirs in arid environments. The only place where the author mentions the clogging phenomena of reservoirs is in a vague sentence the in chapter 3.2.2. as an explanation to observation on reduced recharge.

The objective of this study and its model are primarily addressed toward assessing infiltration issues. Nevertheless, the research approach is totally based on ground water modeling. As such the level of uncertainty regarding the actual process the take place through the vadose zone to ground water is extreme and so is the sensitivity to recharging values. Technically, using groundwater level fluctuation to estimate recharge is a common and valid approach. Nevertheless, results should have been validated (even conceptually in qualitative manner) through independent other parameters that are independent of the fluctuation in groundwater level. For instance, floodwater infiltration and groundwater recharge inherently impact the chemical composition of groundwater (or in a more simplistic way salinity or EC). Since those parameters are very easy to be measures I have a personal feeling that the model results regarding the recharge process could well be validated through simple independent parameter as variation groundwater EC during recharge events. This is only one option out of many independent ways to get a "better feeling" of the actual infiltration process that could have finally support the results. Somehow this work did only little to validate results on infiltration process.

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In page 9775 line 7, the authors explain reduction in groundwater level by over exploitation by pumping. On one hand this may be a viable explanation. On the other hand it could well be aggravated by a decreased recharge due to reduced infiltration from the spreading zones. This phenomenon has been observed in many infiltration reservoirs in arid zones.

In page 9775 line 18, the authors state that 10% of the irrigation water is assumed to be back infiltrated (as agricultural return flow). It is a vague number that require better be explanation, or at least some discussion. For drip irrigation this value is reasonable, on the other hand if farrow irrigation is practices than return flow may exceed 50%. This is a significant difference that requires elaboration. Moreover, if 10% is a solid value than the authors should be concerned of an expected dramatic increase in solute concentration of the return flow. The return flow concentration may increase by 5-10 times fold of the concentration of the groundwater that is pumped and used for irrigation. This may be resulted in dramatic deterioration of ground water quality. Examples for that process may be found in all arid countries. Though this is not the main subject and objective of this manuscript in my view the authors should discuss this issue, even in brief.

In page 9784, lines 9-13, the authors state that "the river channel recharge estimation represents relatively more uncertainty, which can be due either to less model sensitivity for parameters of ER or to major influence of extreme flood events on the estimated recharge in the channel". To my experience it is obvious that the level of uncertainty under the river channel zone is much higher simply because infiltration rate and percolation velocities under the active channel are inherently higher compare to the unavoidable much low infiltration rate under the clogged flooding zones. There are many studies showing very quick response time of ground water to flooding events under stream channels. This is a localized phenomenon that is expected to act in short duration and therefore will be reflected as uncertainty.

My argument that artificial recharge of flood water in spreading zones in arid lands is

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"not as efficient" as planned (and presented in this manuscript), mainly due to clogging, is getting stronger upon analyzing the "Recharge contribution to groundwater" chapter 3.2.2. (page 9785,lines 2-25). Figure 10 shows clearly that the recharge rate through the early stages (years 1993-1996) was significantly more efficient compare the later years, though no significant change in rain pattern was recorded. The authors do not provide reasonable explanation to that and provide only vague explanation in page 9785 lines 20-25. Than in the next paragraph of this chapter the authors state that "in order to stabilize and increase infiltration rate eucalyptus trees were planted, ignoring the huge transpiration capacity of these trees. In fact in few places around the world these trees were planted in order to dry swamps. Transpiration factor of a dense Eocalyptus forest (as appear in figure 11) may have a significant impact on the total recharge as well as direct groundwater abstraction, especially from shallow groundwater.

In summary, I believe estimating recharge rate in such a complex area using a model that is totally based on groundwater level, with no validation through independent observation that provide insight to the infiltration-percolation-recharge process, is insufficient to derive conclusive estimation of the recharge rates.

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