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Hydrology and Earth System Sciences Discussions

Interactive comment on "Using an inverse modelling approach to evaluate the water retention in a simple water harvesting technique" *by* K. Verbist et al.

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Anonymous Referee #1

General The article is of great interest particularly, as the authors rightly say, few efforts have been made to quantify and publish the hydrological significance of improvements in small-scale agriculture. This is also partly evidenced by few very recent cited articles in the manuscript. The HYDRUS model is indeed an appropriate tool to explore this area of science. The article is well written which makes it very easy to follow. There are, however, some areas which, in my view, require attention for further improvement:

1. Page 4269 line 22: Explain clearly the spacing between these trenches and what influences the spacing between them. When read in conjunction with Fig 2 it would appear as if there is an interval of at least 60m between the trenches for slopes as steep as 30%.

AC-The authors agree with the reviewer that information on spacing between trenches can be important for the reader, so this was added to Table 1 and mentioned in the paper. Additionally, the graphical representation in Fig.1 was changed with a Digital Terrain Model of the hillslope, with indication of the infiltration trenches as measured by topographic triangulation. The average distance between trenches along the slope was 5.14$\pm$0.82 m, whereas horizontal spacing was 1.26$\pm$0.35 m. A distance of 5 m was observed between the trench under study and the upper lying trenches, creating an impluvium of 10 m2. The slope was also added to the text and was 23%.

2. Page 4270 line 18: Twenty-two TDR probes on a 6mx2m plot sounds like a very high density especially when it is noted that (page 4271, line 16) a further 25 undisturbed samples are taken after a rainfall event. There is a strong chance that samples are taken too close to the probes thus affecting readings. More repetitions with less density of probes could have served better to confirm findings.

AC-The objective of the study was to evaluate the water balance of the trench, without prior knowledge on the effect this trench would produce on the soil moisture distribution inside the profile. Therefore, we chose to intensify the measurements of the moisture content during and after the experiment. After the experiment was finished, 5 days after the rainfall event, the soil moisture measurements were stopped and soil samples were taken, as well as measurements performed to determine the hydraulic conductivity of the field plot. In such a way there was no influence of sampling on TDR readings since they were done during different time periods.

3. Page 4271, line 13: What is significance of 61 minutes for observing infiltration? Factors of 15 minutes are more common in infiltration analyses.

AC-The observation interval was 5 minutes, as indicated in the text, but the exact time when the trench overflowed as well as the time at which all accumulated water had infiltrated was recorded and given as additional information.

4. Page 4282, line 17: the interval 60min-5800min is too large. It is possible to show more pictures in between to highlight, in more detail, the advancement of the wetting face and its recession around the trench as a result of the rainfall event.

AC-Additional frames were added to Fig.11 that represent intermediate timesteps at 150, 800 and 3000 min.

5. Page 4283, line 2: Indeed the trench is a zone of moisture concentration hence better crop performance is guaranteed. With no information on the density of trenches within the field, it is difficult to visualise the practical significance of the trenches e.g. can crops downstream of the trench benefit from this technique or not? If so up to what distance after a typical rainfall event?

AC-The questions here posted are the true motivation for this kind of studies and should be answered eventually. Nevertheless, some methodological limitations did not allow to extrapolate our findings to larger areas and natural rainfall events. Both are related to the lack of surface runoff modeling in HYDRUS-2D, which limits its use outside the simulated rainfall event. It was therefore recommended in the conclusions (Page 4284 Line 19) to use fully distributed surface-subsurface models for this purpose, a work which is currently under progress.

6. Dry areas like the study site are usually characterised by shallow depths of soil. A free drainage boundary condition used in the simulation may not best represent reality. Application of other boundary conditions may see more moisture retention in the area between the trenches. Have these been explored?

AC-During soil sampling, a soil profile pit was dug up to 1 m deep that did not show any physical boundary to free drainage. Additionally, the soil moisture contents measured

by the TDR probes at greater depths did not show any increase in soil moisture due to accumulation, suggesting such a free drainage boundary. For these reasons, a free drainage boundary condition was chosen and inserting a layer with limited or no permeability was never considered.

7. The degree of slope is not mentioned. But if fig 2 is to scale, then the study has been conducted in very steep slopes. This could also partly explain why there is no evidence of infiltration after the rainfall event but only lateral sub-surface drainage in the top soil towards the trench. Is it the case then that closer spacing of the trenches may result in more zones of moisture concentration hence more benefit to cropping?

AC-The degree of slope (23%) was unintentionally omitted from the manuscript and has been added to the new version. The water harvesting technique is indeed applied on very steep slopes up to 30% and more, and is therefore used for reforestation purposes. This is now clarified more in the introductory part of the paper. The determination of correct spacing of the trenches would indeed be a further objective in this study, for which modeling tools such as the one described in this manuscript is especially helpful. This was also added to the conclusions.

8. Is it the case that, away from the trenches, infiltration does not occur to significantly affect the root zone?

AC-Based on our simulation results and confirmed by individual TDR measurements downstream of the trench, the effect of the trench is very limited spatially and was as such mentioned in the paper on line 1-2, page 4283.

Furthermore, it would be interesting if there is discussion on the likely impacts of up-scaling this experiment to whole field scale and possibly beyond. For example, trenches fill up with soil after some time,depending on effectiveness of upstream soil conservation structures. What management recommendations are to be advanced to maintain sufficient depths of the trenches so as to keep this technique hydrologically viable? What could be recommended to reduce loss to runoff given that the storage of

the trenches is fairly small?

AC-Upscaling would definitely be advisable for further studies, and was as a recommendation added to the manuscript. In our view, erosion and sedimentation in the trenches is a distinct topic which was not considered in this study. It should also be mentioned that sediment transport on slopes can only be modeled when the model used allows surface runoff routing, which is not the case for the model in our study.

Also, in practice, farmers do not cover soil surfaces (sufficiently) to prevent soil evaporation. What is the expected alteration to the water balance when more soil evaporation is occurs?

AC-Evapotranspiration was not considered in the present model, since the field plot was covered with a plastic cloth after the rainfall event, to reduce the amount of parameters needed to optimize and thus to reduce the risk of ill-posedness of the inverse model (overparametrization, parameter correlation and parameter insensitivity). When upscaling is performed, and longer time periods are considered, evapotranspiration will have to be taken into account. It should however be noted that these hillslopes are only used for extensive pastoralism, with few direct influence of farmers on the water balance.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 4265, 2009.