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Hydrology and Earth System Sciences Discussions

HESSD

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Interactive Comment

Interactive comment on "Surface and subsurface flow effect on permanent gully formation and upland erosion near Lake Tana in the Northern Highlands of Ethiopia" *by* T. Y. Tebebu et al.

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Reviewer 2

General comments: The paper describes the surface and subsurface flow effect on gully formation and development and compared the rate of erosion on upland and gully. This study may have significant contribution for the advancement of the science of gully formation and development. Each part of the paper was written reasonably but it needs more clarification on some of the parts.

Response: we would like to thank the reviewer for the helpful comments, most of which were incorporated directly into the manuscript, helping to improve the manuscript

Comment: 1. the research method for the upland erosion study was not clear and it is better to describe the size (length and width), design and set up of the erosion/runoff plots and the data collection method you followed on the plots. Especially the method you followed to measure interrill erosion was not clear.

Response: We have added detail to the section: "For determining rill erosion, 15 fields were selected in the contributing area, representing a cumulative area of 3.56 ha. These fields were classified into three slope positions: upslope, mid-slope, and toe-slope. A series of cross-slope transects were established with an average distance of 10 m between two transects; positioned one above another to minimize interference between transects (Hudson, 1993). During the rainy season, each field was visited immediately after rainfall events in July and August when the greatest rainfall amounts occur. During these visits the length, width and depth of the rills were measured along two successive transects. The length of a rill was measured from its upslope starting point down to where the eroded soil was deposited. Widths were measured at several points along a rill and averaged over the rill length (Herweg, 1996). From these measurements, different magnitudes of rill erosion were determined, including rill volumes, rates of erosion, density of rills, area impacted by the rills, and the percentage of area covered by the rills in relation to the total area of surveyed fields (Herweg, 1996, Hagmann, 1996, Bewket and Sterk, 2003). The percentage crop canopy coverage was estimated whenever rill measurements were taken."

Comment: It would be good to add more literature review on rill and interrill erosion on the Lake Tana watershed as well as on the Nile Basin

Response: We have added references to the section.

Comment: From your research setups, farmer interviews and the data; one may conclude about surface as well as subsurface flow impact on gully development but may not be necessarily on gully formation and/or initiation. Thus your results as well as conclusion may need to be interpreted with caution.

Response: This comment is to some extent correct, we could not collect data on gully initiation, and on the different processes that may control gully initiation. The only information that we have is from interviews. .

Comment: The average bulk density that you used to calculate gully erosion losses on Table 1, page 5255 may need to be indicated somewhere in the paper

Response: We have added this “Based on the estimates of the gully size and an average soil bulk density (1.24 kg m-3) the average gully erosion rate from the incision period of 1981 to 2008 was equivalent to 31 t ha-1 per year in the contributing watershed.”

Comment: The gully erosion losses from the main branches in Table 1, page 5255 for the year 1980 to 2007 was 356.4 ton ha-1 (13.2 ton ha-1yr-1$\times$ 27 years) which was less than the 2007- 2008 gully erosion loss (530 ton ha-1), this may need justification.

Response: We have added text to the discussion to address this comment.

Comment: On Page 5257, Table 3, column 4, 5 and 6: how did you measure deposition on upland erosion? What would be the reason for high deposition rate to be observed on teff plots?

Response: Deposition was estimated from the decrease in rill dimensions, especially the rill depths and lengths at the end of the rainy season. In addition deposition and inter-rill erosion in the fields were estimated using the Universal Soil Loss Equation (USLE) with parameters derived for the Ethiopian Highlands by Hurni (1988).The reason for the high deposition in the teff is that “once plant cover was established teff actually had greater sediment depositions rates than the other crops due to the dense root and ground cover slowing runoff and allowing sediment to settle out”

Comment: A GPS with 2 m accuracy may have impact on such type of study and may need to be justified.

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Response: We have added more detail to the materials and methods: "On July 1 and October 1, 2008, the volume and surface area of the entire gully system was estimated through measurements of width, depth, and length of several cross-sectional and length profiles using a 50 m long measuring tape. We labeled 43 gully cross-sections based on homogeneity of a gully profile and proximity to a piezometer. For each gully cross-section, two or more widths and three or more depths were measured at locations where the cross section changed abruptly. The surface area of the entire gully system digitized using GPS points was cross-check with the estimated measurement of surface area using the physical measurements made with the surveyor tape."

Minor comments: Comment: Line 9 of Page 5238: delete the word "and"

Response: We have made a change

Comment: Line 19-21 of page 5238, the definition of gully erosion may need to be cited

Response: We have added a definition in the introduction "Gully erosion is defined as the erosion process whereby runoff water accumulates in narrow channels and removes considerable amount of soil from this narrow channel over a short time period. A working definition of gullies in agricultural land is defined in terms of channels too deep to easily pass over with ordinary farm tillage equipment, typically anything deeper than 0.5m (Poesen et al., 2003; Soil Science Society of America, 2010)."

Comment: The sentence on Line 19-21 of page 5239 "The main effect of gully ..." may need to be cited

Response: We have added "The main effect of gully formation on the hydrology is that gully incision lowers the ground water levels by providing a shorter drainage path to the outlet for the same difference in elevation (Hagberg, 1997; Poesen et al., 2003)."

Comment: Line 13-16 page 5239: what is meant by gully formation results directly from land management practice? How land management practice without interacting with the hydrology (rainfall and/or runoff) leads to gully erosion.

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Response: The reviewer brings up a good point, and while operationally it is very difficult to distinguish between hydrological and land management, in our work presented here the landscape was essentially treated the same across the gully study area, thus allowing us to focus on the impacts of hydrology on gully formation and vice versa.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 5235, 2010.