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Interactive comment on "Particulate macronutrient exports from tropical African montane catchments point to the impoverishment of agricultural soils" *by* Jaqueline Stenfert Kroese et al.

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We would like to thank Reviewer #1 for the feedback provided to our manuscript. We will take their comments into account when revising the manuscript. Please find below the responses.

Anonymous Referee #1 Received and published: 16 December 2020 This study investigates suspended sediment and particle-bound nutrient fluxes from three catchments (with surfaces of _30 km2) covered with different land uses in Kenya, East Africa. Hydro-sedimentary monitoring was conducted at the outlet during 2 years. This manuscript is very well written, documented and illustrated (figures and tables

are very well done), and the research topic fits with the scope of SOIL journal. In my opinion, minor to moderate revisions should be required before the final acceptance of the manuscript. Detailed comments are provided below.

Abstract The quality of the abstract writing could be improved in my opinion (the quality of this section is not as good as the rest of the manuscript).

L. 14 "catchments generate high concentrations of suspended sediment" should be rephrased

01 Response: We amended the sentence to 'Agricultural catchments in the tropics often generate high concentrations of suspended sediments following the conversion of natural ecosystems' We will revisit the rest of the abstract and sharpen up the English.

L.17 "tightly connected to processes" unclear, please rephrase

02 Response: We amended to 'tightly connected to an increase in riverine particulate carbon and nutrient export'.

L.19 "with widespread land conversion" maybe specify the type of conversion of interest here

03 Response: We included 'with widespread land conversion from forests to agriculture'.

L.21 unclear what you mean with the "knowledge base" here

04 Response: We amended to 'In this study, we assess the effect of land use on particulate TC, TN and TP concentrations.'

LL.23-24 maybe add the corresponding catchment surface areas here

05 Response: We included the catchment areas: 'a natural montane forest (35.9 km2), a tea tree plantation (33.3 km2) and a smallholder agriculture (27.2 km2) catchment' (L. 23-24).

L.27 not sure “tighter” is the right term to use here?

06 Response: We believe that the term ‘tighter nutrient cycle’ is used in an appropriate way due to a fast mineralization and decomposition of organic matter and the input of fresh organic matter through a high and diverse aboveground biomass in natural forest ecosystems with little loss of nutrients from the system.

Introduction L.34 could you specify what you refer to as “high” here?

07 Response: To be more accurate we included ‘These sediment concentrations can be particularly high (up to 8,387 t km-2 yr-1) in the steep highlands of East Africa . . .’ and we amended the reference to ‘Stenfert Kroese et al., 2020b; Vanmaercke et al., 2014)’.

L.63 “sediment-associated nutrients” Âż which exact parameter are you referring to here?

08 Response: We refer here to N and P we amended the sentence accordingly ‘Sediment-associated nutrients (N and P) . . .’.

LL.65-67 were these different interpretations obtained in different contexts/environments?

09 Response: These interpretations were obtained from studies in temperate and tropical regions. We included ‘Other studies in temperate and tropical regions . . .’ and ‘Walling et al. (1997) and Bender et al. (2018) observed that P loads mainly occur in particulate form in temperate and subtropical catchments, while N is mainly transported in dissolved form in a temperate catchment in China (Wang et al., 2015)’.

Materials and Methods L.89 converted into. . .?

10 Response: We corrected to ‘converted into . . .’.

L.95 I guess that based on this statement and the characteristics shown in Table 1, these 3 catchments are hypothesized to be similar in terms of slope, surface, soil type,.

. . characteristics? Maybe state this explicitly?

11 Response: We amended the sentence to ‘The study catchments were chosen based on the criteria of different land use: (1) natural forest (NF; 35.9 km2), (2) tea tree plantations (TTP; 33.3 km2) and (3) smallholder agriculture (SHA; 27.2 km2) and comparability between the catchment characteristics, such as surface area, morphology, geology, pedology, slope and climate (Figure 1 & Table 1)’.

L.106 what do you consider to be “moderate to high amounts of organic matter”?

12 Response: We included the percentage of organic matter: ‘. . . with moderate (15-30%) to high (>30%) amounts of organic matter’.

Table 1: maybe add a category of characteristics to compare “signs/types of erosion” observed in the three catchments? For instance, on L. 134 in the text, you mention the occurrence of gullies. Are there other signs/types of erosion in the study areas?

13 Response: Included a category ‘Types of erosion’ in Table 1.

L.179 “long rainy season”Âż could you contextualize this better? Is it normal or not in this part of Kenya? What is “long”?

14 Response: Kenya has a bimodal rainfall pattern with a long rainy season usually covering the months between March and June and a short rainy season from October to December. The rainfall pattern and the different seasons are already introduced in L. 100-103 in section 2.1 Catchment characteristics. ‘The region has a bimodal rainfall pattern with a long rainy season (March June) and a short rainy season (October December) with a continued intermediate rainy season between the two wet seasons (July September). The driest months are in January and February.’

Results The text is really straight-to-the point and easy to read and to follow. It is clear that sediment fluxes are the highest from the agricultural catchment, although when I read the abstract, I had an opposite impression. Could you double-check that the text is not misleading on this point?

15 Response: When comparing the macronutrient concentrations between the catchments the natural forest catchment had the highest concentrations. However, because of higher sediment loads from the smallholder agriculture catchment, the total sediment-associated loads of the nutrients and carbon were higher compared to the natural forest catchment. We included a sentence in the abstract: 'Particulate carbon and nutrient concentrations were up to three fold higher ($p<0.05$) in the natural forest catchment compared to fertilized agricultural catchments. However, because of higher sediment loads from the smallholder agriculture catchment the total sediment associated loads of TC, TN and TP were higher compared to the natural forest and the tea-tree plantation catchment.'

Then, your results show that particle-bound nutrient concentrations are depleted in the agricultural catchment compared to the other catchments (in particular the forest catchment). Still, the nutrient fluxes from the agricultural catchment remain high (even higher than those from the other catchments, at least during the wet year, i.e. 2018; Table 5). Maybe it would be helpful to mention in the text (in % or in number of times) how higher/lower are the fluxes (either of sediment or of nutrients) when you compare the sites/years to contextualise this better.

16 Response: We amended the paragraph and included the number of times the smallholder agriculture catchment is higher compared to the natural forest and tea-tree plantations.

Regarding this topic, you focus in the text on the surface erosion processes, but what about the occurrence of subsurface erosion processes in the investigated catchments? You mention the occurrence of gullies in the text, what about the potential contribution of landslide or channel bank erosion to sediment transiting these rivers? This subsoil material should be depleted in C/N/P, which may impact the fluxes exported from the catchments and your conclusions regarding management options.

17 Response: Thank you for this comment. Sediment sources in the smallholder agri-

culture catchment are more diverse and originate with the greatest contribution from agricultural land but also from subsurface sources such as deeply incised unpaved tracks, gullies or channel banks as shown in a sediment fingerprinting study by Stenfert Kroese et al. 2020a (L. 354). Subsoil material is observed to be depleted in macronutrient concentrations. We therefore included a paragraph to highlight the occurrence of subsurface sources and their impact on depleted macronutrient concentrations: 'In the smallholder agriculture catchment, the lowered concentrations of sediment TC, TN and TP can be explained by sediment originating from the subsurface where nutrient concentrations are lower (Russell et al. 2001; Gellis et al. 2009; Wanyama et al. 2018). This was demonstrated by Stenfert Kroese et al. (2020a), in a sediment fingerprinting study, that the subsoil sources are of increased importance in the smallholder agriculture compared to the natural forest and the tea-tree plantation catchment due to exposure of subsoil to erosion processes.'

Discussion L.339: "land use is a key control" is it land use or land cover/management? Or both?

18 Response: We use the term 'land use' due to consistency throughout our study as we compared three catchments under distinct land use. However, the management of soil cover is certainly important and we no acknowledge this in 'this study shows that land use and management is a key control . . .'.

LL.369-372: about the discrimination between mineral and organic origins: is there really such a dichotomy or can it be nuanced through the mobilization/transport/deposition of organo-mineral complexes?

19 Response: We removed the sentence 'The suspended sediment is of mineral origin in the agricultural catchments and of organic origin in the natural forest catchment, which is reflected in the differences in organic matter and the C concentrations in suspended sediment (Table 4)'. We agree it is difficult to discriminate strictly that suspended sediment is of mineral origin in the agricultural catchments, but rather a mix-

ture of organo-mineral complexes as already mentioned in L. 348-352. 'These results suggest that the sediment from the forest catchment is comprised of organic material with a high C:N:P ratio either originating from the forest floor or falling directly into the river. In contrast, sediments from the agricultural catchments are a mix of mineral and organic matter and fertilizer additions do not balance with the loss of carbon, nitrogen and phosphorus from the system.'

LL.395-400: nice to have compiled all the data shown in Table 6; of course, it is really valuable to compare your results with those found in similar/tropical environments. Just a random question: is it meaningful to compare these results with those found in Spain, for instance? Are these environments /land management modes comparable?

20 Response: Thanks for this. We believe it is meaningful to make a global comparison of our results with those outside the tropics, especially when comparing our results of low-input systems with highly intensified agricultural systems from temperate regions.

L.424 : again, you refer explicitly to "surface erosion processes", but how can you convince the readers that subsurface erosion is negligible in these steep catchments?

21 Response: Please see earlier response. We included a paragraph in L. 379-385. 'In the smallholder agriculture catchment, the lowered concentrations of sediment TC, TN and TP can be explained by sediment originating from the subsurface where nutrient concentrations are lower (Russell et al. 2001; Gellis et al. 2009; Wanyama et al. 2018). This was demonstrated by Stenfert Kroese et al. (2020a), in a sediment fingerprinting study, that the subsoil sources are of increased importance in the smallholder agriculture compared to the natural forest and the tea-tree plantation catchment due to exposure of subsoil to erosion processes.'

We are reporting the work of others in this section and not commenting on our own catchments. To make this clearer we have modified the position of the citations. 'Similar soil nutrient losses have been observed in other densely populated tropical agricultural regions cultivated on steep hillslopes in Uganda, Tigray (Ethiopia), Kisii District

(western Kenya) through nutrient losses, caused in particular by surface erosion and insufficient use of fertilizer application (Lederer et al., 2015, Girmay et al., 2009, Smaling et al., 1993).

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