

## ***Interactive comment on “Assessing biogeochemical and human-induced drivers of soil organic carbon to inform restoration activities in Rwanda” by Leigh Ann Winowiecki et al.***

### **Anonymous Referee #2**

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In this manuscript, the authors utilize the Land Degradation Surveillance Framework (LDSF, Vagen et al., 2016, Vagen and Winowiecki, 2020) to assess the variability of vegetation structure and diversity, soil carbon (total organic carbon and  $^{13}\text{C}$ ) and other soil properties (texture, pH, exchangeable bases, and saturated hydraulic conductivity) in response to land use/vegetation type across two sites in eastern Rwanda (Nyagatare and Kayonza). The biophysical data from these LDSF sites was also used to generate spatial predictions of soil organic carbon and soil erosion prevalence across eastern Rwanda through the use of Landsat 8 imagery. This work is important and could be quite useful to managers and policy-makers, particularly in Rwanda, where restoration goals are uniquely ambitious. Therefore, the authors should be encouraged that this

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manuscript is deserving of eventual publication. However, I have concerns with the manuscript in the current state that together amount to a significant revision of the manuscript and writing. My major comments are listed first followed by minor/editorial comments.

1. The title is compelling and the introduction nicely frames the importance of this work in the context of national and international policy goals. However, the results and discussion can be bolstered and better aligned with the title and objectives of the manuscript. The discussion is currently the weakest part of the manuscript and is poorly referenced. One suggestion for better aligning the discussion text with the title and objectives might be to create sections within the discussion section that align with the stated objectives of the study in the last paragraph of the introduction. This would provide focus for introducing more context to the data in this study. For example, the first objective is to assess soil and land health parameters across sites. Here perhaps the discussion could focus on why significant differences may or may not occur between the LDSF sites or vegetation classes investigated here (for example, what factors contribute to lower SOC in Nyagatare specifically? is one of the main drivers climate? or soil texture, geomorphology, etc...how does this relate to Kfs and what are the management implications of that?), and how the range of values compares to other landscapes in sub-Saharan Africa. The second objective is to understand the drivers of SOC dynamics. Given the dataset, the major drivers that could be assessed are geomorphic (slope - slope is mentioned twice, but never quantitatively explored as a driver - why?), climatic (rainfall?), erosion prevalence, land use, soil texture, and (maybe?) pH - although whether pH drives SOC accumulation (possible in some soil systems) or vice versa (SOC drives pH) may depend on the system. Which of these appears to be most important? What does that means for managers and policy-makers? The third objective is to develop hot-spot maps of soil erosion and soil organic carbon for targeting interventions - in the discussion more context regarding the major insights provided by these maps would be very helpful. How does the variability of these spatial predictions compare to other LDSF landscapes for example? Does that have any

impact on the importance of these spatial predictions for management?

2. I'm wondering if it might be possible to provide some tests of statistical significance between groups for the measured properties. This would help bolster the results, and allow the reader to better interpret the stated differences in means between sites and vegetation classes. For example, is topsoil SOC in Kayonza significantly higher than in Nyagatare? Or is it just numerically higher, given the variability. There should also be a portion of the methods that describes the statistical approaches utilized.

3. I do believe it is important not to ask readers to mine too many references when uncovering the methodology utilized. The LDSF methodology is well documented, but nevertheless there could be a more specific overview of soil sampling methods and geospatial techniques in the methods. These don't need to be pages worth of information, but a more full description of the methods employed here (even if they are published elsewhere) would be important for readers, particularly when it comes to cross-journal accessibility issues for international audiences. Yes readers can request documents from the author if necessary, but that places an undue burden on the reader.

4. What do the differences in soil properties between vegetation classes within sites tell us? Kayonza district, on average, appears to be wetter. Is there an interaction between climate, vegetation class, and SOC?

5. Several other things could be added to the methods: 1) it would be helpful to have a general description of the soils/soil parent materials across the region (and specifically within the sites), to include general soil types per FAO WRB system for international audience. 2) I'm wondering what the authors think about placing the vegetation structure and diversity section of the results (Section 3.1) in the methods? Given that much of this is background and that vegetation classes are utilized as potential drivers of OC in the interpretation of the data it seems like it may be more appropriate there. I'm also not sure that Figure 2 is necessary as a plot given that after the first 5 or so most fre-

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quent species it is difficult to tell any differences between other species on the list. This might be more meaningful and useful as a list of species and frequencies (perhaps also broken up by land use?) in the supplementary material.

6. The MIR predictions perform very well. However,  $\delta^{13}\text{C}$  performance is more likely due to correlations (what does a plot of  $\delta^{13}\text{C}$  vs organic C look like?) than a reflection of MIR detecting isotopic differences in OC. Therefore, I'm wondering if the authors might use "estimated" before  $\delta^{13}\text{C}$  just to indicate that these are estimated from MIR and not directly measured. I do understand that the other properties are also estimated in the same way, but I don't think it is as critical to make that distinction for the reader for those because MIR is much more likely to be giving more direct measures of the other soil properties.

MINOR COMMENTS: 7. The introduction could be re-arranged to improve readability. For example, paragraphs starting at lines 70 and 93 are both about soil erosion but separated by a paragraph on management strategies and agroforestry.

8. Ensure  $\delta^{13}\text{C}$  notation and symbology is correct.

9. I do not believe that figures 4 and 8 are referenced in the text

10. Line 28 and Line 330: "compaction" is mentioned in the text here, but nowhere else in the manuscript. The way that it is mentioned in lines 28 and 330 appears to indicate that compaction was a measured variable and also that it had a direct impact on Kfs. However, I can't find reference to the compaction data or any correlation, plot or values for compaction in the reported numbers. Nor can I find a method for measuring compaction (cone penetrometer?). Compaction data should either be added to the manuscript or the word compaction should be removed from the text.

11. Line 39: Replace "In other words" with "Therefore"

12. Line 72 replace "execrated" with "exacerbated"

13. Line 84: insert "that" between "effects and "intensive"

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14. Line 86: insert "to" between "access" and "labour"
15. Lines 89-90: replace "tree-based ecosystem" with "agroforestry"?
16. Line 124: replace "scale scale" with "spatial scale"
17. Line 147 and 155: deforestation rate percentages are mentioned. what are these rates describing: deforestation of total forested lands? more context to the meaning of the numbers would be good.
18. Line 151: there should be a reference at the end of this sentence.
19. Lines 176-177: more detail on the scoring of erosion prevalence would be extremely important. See comment 3, above.
20. Lines 210-220: information about laboratory soil particle size analysis for validation set should be provided here.
21. Lines 301-303. This would be an excellent sentence to include in a re-written discussion section.
22. Line 382: replace "religiously" with "systematically".

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