

Interactive comment on “Sustainable soil management requires a systemic approach” by Hans-Jörg Vogel et al.

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We thank Johan Bouma for his valuable comments which we are glad to include in our paper. Here some comments on how we intend to do this.

General comments:

- 1) Clear Storyline: We will summarize the major goals, related problems and proposed avenue to proceed into a more coherent story line at the end of the introduction.
- 2) The paper is strongly soil-focused, while more inter- and transdisciplinarity is also needed: We definitely agree and made this point in the introduction - but it is fully intentional to focus this paper on what actual science can contribute. We feel that this question was actually somewhat underexposed in the current discussion on soil

C1

functions, ecosystem services and SDGs. Yet, we emphasize that a transdisciplinary approach is highly required for sustainable soil management. Another paper is actually in review where the focus is on the transdisciplinary aspect (Helming et al: Managing soil functions for a sustainable bioeconomy – assessment framework and state of the art, submitted to LDD)

- 3) Include some specific examples to increase transparency: We will extend the presentation of this case study in an additional section (2.3) to better illustrate how the model can be applied and what input is actually required.
- 4) There should be a way in between modeling soil in full complexity and using simple indicators: We agree - but in fact the proposed focus on "functional characteristics" and their interactions is meant to be such an intermediate approach. We will make this more clear in section 2.2.

Specific comments:

- 1) We absolutely agree that dynamic simulation models are very important also for stakeholder interaction and just want to stress the special challenge for (natural) soil science in this framework (see general comment 2). We of course also agree that the representation of soil in soil-water-plant-atmosphere models is typically too simple and will emphasize this more clearly. In fact this justifies the more elaborate model concept we suggest here.
- 2) Pro-active approaches by soil scientist to engage stakeholders: This is a very important point and we will emphasize the potential of process-based soil models (including the one which is presented here) to demonstrate the sensitivity of soil functions with respect to external perturbation. In this context we are happy to include the suggested references.
- 3) We agree and change the wording from "services that soil provide" to "the contribution of soil functions to ecosystem services"

C2

4) The link between social and natural sciences: Fig.1 is rather simplistic but we hope it describes the two essential interfaces between the societal and the natural systems which should in principle be pretty general and valid also for developing countries. We will extend the explanations for Fig.1 as also asked for by reviewer #2.

5) The big jump from complex process interactions to simple indicators: In section 2.1. we contrast the two extreme approaches for evaluating soil functions: Modeling complex process interactions starting from the molecular scale and just using simple indicators. As a conclusion we actually suggest an intermediate possibility: identifying these "functional characteristics" providing integral information on soil processes and attempting to model their dynamic interactions in response to external forcing. The suggestion to profit from some known history of soil management obtained by questioning farmers is very good! This is especially valuable as an addition to analyzing long term field experiments - so we will add this idea to section 2.2 as an additional option to verify and further develop the proposed model approach.

6) We will emphasize the concept of soil health and will add the reference to Moebius-Clune et al. 2017

7) We agree that field observations are absolutely essential to identify process interactions and especially tipping points (or threshold values). This is why the model development and the formulation of the required interactions need to be based on exactly such observations and focused experimental studies. This is our motivation to set up a structured library for published observations as another activity of the BonaRes project - this will be subject of a forthcoming paper. Here we will add the suggested idea to look for cooperating farmers who are willing to share the history of soil management which can be evaluated and connected to the present state of soil properties as an additional observational tool. We also agree - and actually tried to make this point very clear - that the assessment of soil functions and herewith also tipping points need to be site specific.

C3

8) We agree that the importance of soil types needs to be mentioned earlier and will do so already in the introduction (where it has been mentioned only in passing).

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C4