

Dear editor, dear reviewers,

since the revisions described here are based on our comments already made in the discussion forum, here we only provide concise descriptions of what and where we changed in the manuscript to accommodate the reviewers' comments. Note that we also slightly rephrased Q1 and Q3 in section 2.1 on target adequacy, in order to improve their applicability and so that they fit better their application in section 3.2.

Comment	Response
Reviewer 1	
<p>The subject is interesting and the various aspects of soil protection are covered. However, the paper fails to address one major problem of all legislative attempts to apply a soil protection law which is the lack of data. It is not very useful to invoke to "explicitly and directly address all soil functions and the interactions between them" when science is far from attain such a target or even defining it.</p> <p>More space should be given to the root problem of the scarcity and quality of data which is, after all, the very reason why soil is neglected in the legislations. The difficulties in obtaining the data and their variability should be taken into account and duly commented upon.</p>	<p>We addressed the issue of data availability in section 3.2.1 on target adequacy by adding the following passage: "These gaps may be a reflection of data (non-)availability as an important constraint of environmental policy, though the recently launched EU Soil Observatory has the potential to improve the situation significantly (Montanarella and Panagos, 2021). In this sense, soil policy can be considered an art of making decisions and creating instruments in the absence of perfect knowledge and in a way that allows to adapt to new knowledge." (lines 193–7 in the revised, track-change document)</p> <p>Also, in section 3.2.4, we again address the more specific context of result-based payments: "However, this [lack of result-based soil schemes] may reflect the challenges in terms of monitoring 'results' such as soil functions (Jeffery and Verheijen, 2020; Vogel et al., 2019), whereas innovative, e.g. model-based payment schemes might be a promising alternative (Bartkowski, 2021; Bartkowski et al., 2021)." (lines 302–4)</p>
Reviewer 2	
<p>The article is based on very specific theoretical concepts (difficult to grasp for non-specialists) and a proper understanding of these concepts would require reading also the numerous publications cited (e.g. p. 111 so-called Tinbergen rule, p. 203-206 even if consulting the cited literature, it is not clear why organic fertilization may be detrimental to water quality). A more tangible approach, with examples, would increase the impact of the article.</p>	<p>We deleted the (unnecessary) reference to the Tinbergen rule and simplified the point made (lines 111–2 in the revised, track-change document). Also, we specified the organic fertilizer point by adding the following half-sentence: "as exemplified by the high spatial correlation of livestock production (and thus local availability of organic fertilizer) and nitrate pollution in North-Western Germany" (lines 211–12)</p>
<p>From a pragmatic policy making point of view, the conclusions of the article (4. Lesson learned) do not</p>	<p>In addition to the small insertion on the importance of communication for uptake of AECM in section 3.2.4 (see below), we added the following to section</p>

sufficiently reflect the importance of the analysis performed and the recommendations lack relevance or are a little bit weak (“urgent need for more research”).

A proposal would be to develop reflection/recommendations on how to include the following topics in policy frameworks, possibly with prioritization:

1. **Monitoring.** The first question (target adequacy; specific environmental objectives, concrete indicators) clearly suggests the importance of setting targets and measuring their achievement. Even if this point is obvious, it should be mentioned here.
2. **Behavioural changes.** The original aspect of the GDF is to raise the importance of individual and societal behaviours for the implementation of conservation/protection measures of natural resources. This is now widely accepted in economics (behavioral economics), but has not been sufficiently taken into account in policy designing.
3. **Communication.** The issue of (lack of) communication is well known, and also underlined by the authors (p. 387). The transfer of knowledge (i.e. of appropriate and comprehensible information between different levels and stakeholders) constitutes a major challenge and a critical phase in soil protection and policy design. It might be argued that this point is not

4.1 (lines 422–31): “Against this background, two major practical consequences for soil policy appear particularly salient: first, effective soil policy requires clearly and realistically formulated targets that take into account the current understanding of underlying mechanisms and availability of data for monitoring the success of policy interventions. Second, much knowledge is available about behavioural factors that affect the effectiveness of environmental policies, including soil-related management (Bartkowski and Bartke, 2018). However, the (implicit) assumptions reflected in conventional policy design are rather simplistic (Brown et al., 2021). This calls for more consideration of behavioural factors in soil policy design. In addition to these two issues, and given that soil policy is covered at various governance levels (from EU to federal states and further down), while being implemented ‘on the ground’ by farmers, communication (of and about soil policy targets, sustainable management practices, legal competencies, administrative rules etc.) across governance levels and among stakeholders is crucial for successful soil protection.”

Furthermore, in section 4.2, we expanded the final statement, which now reads as follows: “One may say that in this respect, the GDF reflects the challenges of the policy arena we have applied it to, where communication across levels is essential (see above). At the same time, the GDF has proven quite useful in facilitating the structured identification of research gaps relevant to a comprehensive analysis of natural resource governance. Following this exploratory application, the GDF can now be tailored to more specific aims and contexts, in order to illuminate particular aspects of the natural resource governance. This may include pragmatic simplification to facilitate GDF’s use as an analysis tool for policy makers.” (lines 454–9)

sufficiently and explicitly addressed in the GDF.	
Finally, an adaptation (and simplification) of the GDF to the field of soil legislation would be a valuable tool in the policymaking.	Regarding the adaptation of the GDF to the realities of soil legislation processes, we concur that this could be helpful – our paper’s aim has been to demonstrate how the GDF in its “complex” form can be applied, and simplifying it for specific purposes would be a next step. We added this to the conclusion section (see above).
p. 192-193 SDG indicators: 15.3.1 Proportion of land that is degraded over total land area includes explicitly the soil organic carbon stock.	Corrected (lines 192–3).
table 3 Possibly revise the table: cover crops (may) have an effect on CS, herbicides on BD	We added the reviews by Rose et al (2016) and Gunstone et al (2021) and revised the herbicide effect on BD in Table 3.
p. 359-361 As the § addresses the behavioural adequacy, “other motivational factors” should be more detailed.	<p>We added the following sentence in lines 372–4: “For instance, Bartkowski and Bartke (2018) show that, depending on the specific context, factors such as general pro-environmental attitudes or problem perception can play an important role in soil-related decisions.”</p> <p>Also, in lines 378–80, “Also, it has been shown in other contexts that transparent communication of AECM goals, administrative rules and responsibilities as well as perceived administrative effort associated with participation are important for uptake (Brouwer et al., 2015; Mack et al., 2020, 2019).“ (addressing the communication point from above)</p>