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Supplementary Material

1. The Online Questionnaire used in surveying RECARE researchers across 15 case study sites can be found in the link here:

https://docs.google.com/forms/d/1mNIqmu7pW7TxGNR35p6t5iVJiJGmIVy3aa293asTDho/prefill

2. Table S1.
Tool combination – how it worked and the benefits across different sites

Some practice-based examples on: (i) how the combinations of tools worked in different sites; and (ii) the benefits tool combination had across different sites
In Crete [Greece] T1 provided an efficient way to collate and group information and test scenarios regarding the impact of each property group on ecosystem services (ES), taking into account the feasible ranges of each property. T3 and T4 (co-developed with stakeholders through interviews) revealed the financial feasibility of measures to tackle salinisation - the BBN developed in T3 provided information for a single timestep, while T4 better quantified financial indicators by working in multiple annual timesteps. Although the information provided by T4 was more accurate in terms of financial flows, T3 helped identify systems components and their interconnection better, thus providing a better view of agricultural inputs and yields with respect to changes in system variables (e.g. soil salinity). T5 provided feedback about the barriers and opportunities of adoption, as well as who the bearers of the cost of technology application should be. The experience gained from all previously applied tools was very helpful for the application of T2. The highlight of T2 was that it succeeded in reframing the context of the soil threats both in space and time (wider area vs farm scale; and long-term vs short term). T2 had a high degree of novelty and complication (for both stakeholders and moderators), also uncovering opportunities for better collaboration between stakeholders. Combinations of tools enabled collaborative working between case study researchers, experts and stakeholders, supporting efficient ecological, economic and social assessment of measures to tackle soil salinization.
In Guadiamar [Spain] the combinations of T1, T2, T4 and T5 worked to improve communication with stakeholders in ways that enabled comprehensive evaluation of soil measures. Tools' outcomes helped in selecting strategies for soil remediation that were more acceptable to stakeholders. Ecosystem services (ES) valuation (using T1 and T2) for soil amendments and phytoremediation measures showed the importance of 'stabilisation of contamination' and 'recreational activities' as the most important ES.
In Myjava Catchment [Slovakia] T1 and T2 were applied in sequence to enable identification of complementary measures (e.g. use of small wooden check dams, contour ploughing and green buffer strips) for tackling mud floods and soil erosion. Although T5 flagged up adoption barriers (e.g. lack of subsidies and agencies to support implementation), application of T3 and T4 faced data constraints due to the peculiarity of the soil improvement measures trialled for the region. T1 and T2 in particular fostered stakeholder cooperation which led to identification of measures to exclude (e.g. production of row crops) in order to maintain soil fertility in the region.
In Peristerona Watershed [Cyprus] the combination of tools worked well - tools were applied consecutively and they complemented each other. For instance, regarding T1 and T2, although 'ecosystem services' was a new term to almost all stakeholders attending the third workshop in Cyprus, the flow of exercises and the necessary simplification helped

them to see benefits that were previously not so obvious, e.g. regarding cultural heritage, or soil formation. In addition, the cost-effectiveness tool (T4), provides more objective results; ultimately, land users are interested in becoming more economically efficient, thus any investment in improving soil management should be worth it in monetary terms. The last tool (barriers and opportunities – T5) was also very helpful and with hindsight, could usefully have been undertaken at earlier periods of time, e.g. at the beginning of the project.

In Frienisberg [Switzerland] T1 and T2 were used in combination as T2 builds on the results of T1. This combination worked well and triggered interesting discussions in the stakeholder workshop, where the stakeholder valuation brought to the light the different perceptions/priorities that the different stakeholders have in regard to ecosystem services. In the same workshop T5 was applied, which was also a success. It was very helpful to have the different stakeholders there, because in the discussion, the main barriers could be identified and clarified to an extent that would not have been possible without the face-to-face interaction of the different stakeholders. Overall, a number of possibilities to support the adoption of the tested technology were jointly identified. In addition, it was ideal to include T5 in the stakeholder workshop as it would have been very difficult to organize an additional face-to-face event with the stakeholders.

T3 was only used as a stand-alone tool within the research team and only in a basic version. It helped to sharpen understanding of the connections between different elements of the system, and the impact chains. However, the feeling people had was that it is not a very 'stakeholder-friendly' tool and is too complicated to be used with stakeholders. In addition, the timing of T3 was not ideal. Researchers felt T3 was applied somehow 'isolated' – they did not clearly see a link to the other tools.

T4 was a bit 'isolated' and not clearly linked with the other tools. Researchers used it within their team, and in consultation with the farmers who tested the measure. However, if it would have been applied earlier in the project period, stakeholders could have been better involved. Only one measure was tested and the outcomes were highly variable because they strongly depended on factors such as topography and timing, and amount of rainfall events. Therefore, it was quite easy to assess the costs, but very difficult to assess the monetary benefits of the measure.

In general, researchers felt that the combination of the different tools during the entire project period (both time and content wise) was not always clear.

In Wroclaw & Poznan [Poland] T2, T4 and T5 were applied in the context of soil sealing case studies. T4 and T5 in particular appeared to be complementary. Building problem trees in T5 revealed financial limitations for improved spatial planning based on soil data. The raised limitations were, for example, cost of data, software and new staff needed for mapping and spatial GIS analysis. T4 helped to express the cost in numbers and to verify whether the cost barrier is real or perceived.

In Veneto region [Italy] the T5 problem-solution tree was performed at the same workshop as the valuation of ecosystem services (T2). T5 was performed for conservation agriculture (CA) only, however it was an interesting way to combine different approaches to evaluate sustainable land management (SLM) practices that aim at mitigating SOM decline in mineral soils. Results from T2 and T5 showed they were complementary: T2 focused mainly on biophysical aspects of selected and tested measures (environmental impacts); T5 mainly handled socio-cultural and technological aspects (e.g. reasons on why measures were not adopted in the past). Combining T2 and T5 addressed methodological weaknesses relating to each single tool. In fact, different tools had assessed different dimensions and values, and therefore their implementation directed stakeholders towards different issues.

Interestingly also with T2, stakeholders highlighted some technological issues, even if the tool was mainly related to biophysical aspects. In particular, stakeholders identified low

expertise and lack of field training (technical aspects) as bottlenecks for the correct implementation of trialled measures and the occurrence of biophysical drawbacks (e.g. potential increase in pesticide use with conservation agriculture; worsening of water cycle management in practicing cover crops). As a result, “cause-and-effect” relationships were suggested that linked biophysical aspects to barriers hindering adoption of SLM practices. Discussions among stakeholders did not raise any historical, socio-cultural, political, administrative/bureaucratic, or individual reasons related to incorrect implementation of the measure and, consequently, to biophysical drawbacks. However, T2 did not provide evidence of being able (as a single tool) to overcome identified barriers towards possible (implementing) solutions. On the contrary, problem-solution trees in T5 highlighted institutional barriers (poor knowledge transfer to users, limited education, and bureaucratic bottlenecks) as well as solutions that could be likely connected by stakeholders to impact assessment on ecosystem services and valuation. Combining different tools was also useful to identify: 1) to what extent biophysical aspects were affected by the correct/incorrect application of selected measures (e.g. incorrect implementation of CA practice causes soil degradation through compaction); 2) which biophysical drawbacks have been likely pivotal and hindered application of specific measures (e.g. in the past, low crop productivity hindered CA application). Effectiveness of using a combination of different tools may increase whether identified benefits – and drawbacks – from impact assessment are used in the process of developing problem – and solution – trees. Therefore, data, results and concepts from T2 may be directly integrated into T5. Even in the case biophysical aspects are not identified as relevant in any problem-solution tree, this can be an way to explore alternative problems and solutions.
In Caramulo [Portugal] the combination of T2 and T5 was extremely insightful in the sense that it allowed us to understand that: (i) private land owners will not readily engage in post-fire land management practices that specifically target erosion control, unless duly compensated; and (ii) they may consider changing existing practices to minimize their impacts on soil erosion, provided possible additional efforts and costs are acceptable. Including cost considerations in workshops would not have changed the conclusions of the private stakeholders but would have been of considerable importance for informing the organisations directly involved in operational post-fire emergency stabilisation. All the same, the main message from the cost-effectiveness assessment of post-fire mulching – i.e. timing is the key – has been conveyed at several occasions after the last workshop researchers held in the region.
In Broddbo [Sweden] researchers tested all tools T1 - T5 with varying success. There is no “tool fits all”. Depending on what you want to achieve you use the tool you want. There was no obvious benefit from combining the different tools except that T1 and T2 had to be combined if you wanted to use T2. Researchers think it should be emphasised that you cannot use T2 unless you have completed T1. The stakeholder valuation of ecosystem services (T2) is not a stand-alone tool, but builds on the outcomes of T1, which is an expert assessment of the impacts of the different remediation options on ecosystem services at the study sites. In general T5 was the tool that researchers at this study site appreciated the most. The construction of problem and solution trees was quite appreciated by both researchers and stakeholders as it created interesting discussions and new insights.
In Vansjø-Hobøl Catchment [Norway] researchers had positive experiences with all the tools. The combination of tools brought the benefit of placing single measures (retention pond and vegetative buffer zones) in the wider perspective (social, economic, etc.). Moreover, it allowed for better visual presentation of the complex issues and gave room for

translation from the experiments of the study sites into useful information understandable by all stakeholders.

Table S2
Reflections from those who developed each tool (i.e. tool developers)

T1: The tool generally worked well for most of the case study sites. Although methodological challenges remain, the ES assessment was shown to be a comprehensive evaluation of the impacts of the trialled measures, and also served as an input to a stakeholder valuation of ecosystem services at local and sub-national levels (T2). The ES assessment provided the opportunity to compare monitoring results across the case study sites. Through the assignment of magnitudes of change, the monitoring data became directly comparable and independent of the parameter used or the unit of measurement applied. Additionally, the request to estimate changes, even if no measured data were available, enhanced the comprehensiveness of the assessment, taking into account drawbacks relating to its accuracy and reliability. However, some researchers were more hesitant in estimating impacts than others.
T2: We noticed that many stakeholders found the concept of ES difficult to understand or work with. While the provisioning services are easy to understand due to their immediate use value or benefit to people, the regulating services are more difficult to perceive, as they frequently involve processes that show their positive or negative effects only in the long term and/or in a bigger context, meaning they are therefore often overlooked. The same holds true for the cultural services, which are less tangible and often go unnoticed. Nevertheless, in a number of case studies, the ES valuation workshops specifically uncovered some of these previously overlooked (by the researchers) cultural services. In most cases, T2 drew out differences between stakeholder categories in terms of valuation of ES. The valuation process also helped to evaluate whether the trialled measure(s) contributed to the benefits that different stakeholders desired. It was found difficult to discuss trade-offs between ecosystem services, which we presume is due to the fact that many of the trialled measures are new to the specific case study contexts, and therefore long-term results are not available. In many cases, stakeholders found it too difficult to imagine / estimate the potential long-term effects on specific ES. The combination with T5 was demanding for the workshop organisers, but rewarding in most cases.
T3: While Bayesian Belief Networks (BBNs) have been designed to enable participatory model building with stakeholders, the reality was that to do that effectively required development of significant expertise on the part of researchers. Time demands were also substantial - on the part of researchers and stakeholders for all the steps in the model building process and to enable stakeholders to engage effectively. This is not an insignificant undertaking, particularly in combination with other tools. BBNs also require substantial data, or time to elicit stakeholder knowledge, to be able to operationalise the relationships captured in the models. Where BBNs were used they tended to be constructed using knowledge from within research teams rather than through a process with stakeholders, and fully functioning models were only constructed where data were already available. However, where the tool was used it did enable evaluation and recommendation of management strategies to reduce soil degradation (Dal Ferro *et al.*, 2018).
T4: The tool (both CEA and CBA) is in principle easy to understand and apply. One of the key challenges encountered was that most soil improvement measures trialled in RECARE are new and only applied in experimental settings, so there is not yet a wider uptake of the measures. This poses two difficulties: a) a translation of costs of the measure from an

experimental to real-life situation, and b) the need for a projection of effects, benefits and costs beyond the lifetime of the experiment. Costs were relatively easy to come up with, and many case studies had meaningful interactions with stakeholders to estimate these, as return on investment and cost-effectiveness are important indicators for potential adopters of the measures. The long-term benefits were however highly uncertain and their quantification was hampered by a lack of data on monetization of many benefits (cf. T1 and T2). Despite this, in several cases the tool helped to reach conclusions on the feasibility and cost-effectiveness of measures, and was considered objective; other tools produced 'softer' and more contested outcomes. An easy lesson learnt was that due to the many assumptions that need to be made, it is not necessary to wait for experimental data to start developing the CEA/CBA of measures, and earlier deployment of the tool may enable more stakeholder engagement.
T5: The tool included several components which incorporated both structured and more participatory, free-flowing interactions that enabled stakeholders to put forward their perspectives, learn from one another, while allowing researchers to get a more in-depth understanding of local perceptions and understandings of barriers and opportunities. It also provided a space for stakeholders to air wider concerns about responsibilities (e.g. who pays for soil conservation measures?) and tackle questions about scale (e.g. at what scales do we need to be working?). In RECARE, the tool was applied in the latter part of the project, by which time stakeholders had already been engaged through the use of several of the other appraisal tools. Stakeholder fatigue was therefore a challenge in some case studies. Most case study sites relied on the guidelines provided by the tool developers, adapting them to their contexts as needed. This resulted in the problem and solution trees taking quite different forms across the case studies and the tool yielded different levels of detail from different places and in relation to the different soil threats. Despite the tailoring of the approach, it was easy to compare across the different cases and draw out commonalities and differences in the kinds of barriers faced.