Learning from farmers´ experiences with participatory monitoring and evaluation of Regenerative Agriculture based on visual soil assessment

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ABSTRACT

Participatory action research involving farmers and researchers is crucial to enhance the adoption of farming innovations and ensure the long term sustainability of agroecosystem restoration. However, the factors for successful participatory research for agroecosystem restoration are not always clear and have been rarely evaluated from the perspective of the subjects from whom change is expected. Despite the increasing call for agroecosystem Living Labs, farmers are still seldom involved in structured and shared co-monitoring and co-evaluation of farming innovations as part of participatory monitoring programs. Therefore, we developed a participatory monitoring and evaluation project to evaluate the impacts of regenerative agriculture between farmers and researchers in the Mediterranean drylands of Spain. Here we present and evaluate the project outcomes by reporting farmers´ monitoring results using a co-developed visual soil assessment (VSA) manual, and by documenting farmers´ evaluation of the VSA and other key aspects of the participatory monitoring and evaluation in the third year since the beginning of the project. Farmers´ VSA results pointed out regenerative agriculture as a promising solution to restore degraded agroecosystems in Mediterranean drylands with insights that are complementary to the scientific monitoring. Farmers´ evaluation of the participatory monitoring process revealed the need to enhance farmers´ support for implementation of VSA tools in initial stages, and to include farmers in the design of VSA tools to adjust them to farmers´ priorities, possibilities and needs. Farmers highlighted the importance of the participatory monitoring and evaluation process to enhance knowledge exchange, learning, and capacity building regarding soil quality management to adapt and adopt regenerative agriculture. Our results confirm that including farmers in the design, decision-making and evaluation of research projects for agroecosystem restoration is imperative to enhance efficient, sound and inclusive transitions towards long term sustainable agroecosystems.

Keywords: participatory action research, agroecology, almond farming, drylands, Spain

1 INTRODUCTION

Agroecosystem restoration is essential to support the livelihoods of millions of people worldwide, protect biodiversity, and contribute to adaptation and mitigation of climate change characterized by more extreme weather events (Cherlet et al., 2018; Dubey et al., 2021; Sanz et al., 2017). Increasingly promoted farming approaches for agroecosystem restoration, following the concepts of Agroecology and conservation agriculture, focus on the restoration of soil quality as a basis to enhance the delivery of multiple ecosystem services (Altieri et al., 2015; FAO, 2019; Kassam et al., 2019). Likewise, regenerative agriculture (RA) has recently gained increasing recognition as a plausible solution to restore degraded agroecosystems worldwide (Giller et al., 2021). RA is a farming approach foreseen to reverse land degradation, increase biodiversity, boost production and enhance the delivery of multiple ecosystem services (Rhodes, 2017, 2013) through the adoption of a variety of soil quality restoration practices under 4 main principles: 1) minimize soil disturbance, 2) enhance soil fertility, 3) reduce spatial-temporal events of bare soil, and 4) diversify cropping systems with integration of livestock (Elevitch et al., 2018; LaCanne and Lundgren, 2018; Rhodes, 2017). Despite the promising benefits of RA (De Leijster et al., 2019; Luján Soto et al., 2021), this farming approach has shown limited adoption in semiarid regions. Major reasons explaining this seemingly incongruous mismatch are the scarce and contrasting empirical data proving RA effectiveness (Lee et al., 2019; Palm et al., 2014), the lack of farmer involvement in agroecosystem restoration projects and decision-making (Chinseu et al., 2019), and the generally slow response of soils to management changes in semiarid regions, which may delay the appearance of visible results discouraging farmers from adopting RA.

Participatory action research (PAR) involving farmers and researchers for agroecosystem restoration can potentially overcome RA adoption barriers and ensure the long term sustainability of agroecosystems (Cuéllar-Padilla and Calle-Collado, 2011; Guzmán et al., 2013; Mapfumo et al., 2013; Pimbert, 2018; Stoate et al., 2019). PAR emerged in the 1970´s as an alternative to technocratic top-down research approaches that have failed to involve farming communities into sustainable land management (Cuéllar-Padilla and Calle-Collado 2011, Fals-Borda and Rahman 1991; Guzmán et al., 2013; Mendez et al., 2017). PAR encourages horizontal modes of relations between farmers and researchers, active participation, experimentation, joint reflection and the collective development of findings and conclusions to better understand and resolve an issue of interest to all parties involved (Cuéllar-Padilla and Calle-Collado 2011, Guzman et al., 2013, Mendez et al., 2017). Within PAR, participatory monitoring and evaluation (PM&E) of the impacts of innovative farming approaches plays a central role to support adoption of innovations in several ways. Most importantly, well designed PM&E processes can enhance farmers access to scientific and local knowledge from different RA experiences, increase the insights in impacts of agricultural innovation and progress towards restoration goals, and foster learning and the creation of relationships of support and trust among stakeholders (De Vente et al., 2016; Luján Soto et al., 2020; Reed et al., 2018; Stringer et al., 2013; Vernooy et al., 2006, Sol et al., 2013).

We understand PM&E as a continuous iterative learning and adaptation process that involves intensive local and scientific data gathering, testing, and facilitated joint discussion of results by farmers and researchers. PM&E implies making use of different participatory activities and tools to facilitate the involvement and interaction between participants in the whole research process, integrate different knowledge and experiences, reduce power imbalances and foster critical evaluation. Previous PM&E experiences have shown multiple benefits of improving both project processes and outcomes (Cardoso et al., 2001; Funder et al., 2013; Masset and Haddad, 2015; Vernooy et al., 2006). It is expected that involving farmers into PM&E of the impacts of RA would enable social learning (Masset and Haddad, 2015), support capacity building (Vernooy et al, 2006), enhance farmers´ sense of ownership of the PM&E project (Cardoso et al., 2001; Funder et al., 2013; Vernooy et al., 2006) and increase the confidence in the farming innovation leading to increased adoption and efficiency (Masset and Haddad, 2015). Especially in the case of innovations like RA in semiarid regions for which no immediate results are expected for crucial aspects like crop yield (Lujan Soto et al., 2021) PM&E can be particularly important to help identify and exchange experiences with other farmers regarding small changes in functionality of agroecosystems that help them see the return of their restoration efforts. Nonetheless, quite a few studies reporting PM&E experiences have warned that the results generated by PM&E are context dependent and might be influenced by multiple factors including the social-economic and political situation of the place where research takes place, the availability and access to resources, the local culture, the research design, and the attitudes, interests and abilities of the various stakeholders involved, including the researchers (Cardoso et al., 2001; Funder et al., 2013; Masset and Haddad, 2015; Vernooy et al 2006, Rahman 2019).

Despite the increasing call for agroecosystem Living Labs and transdisciplinary approaches involving farmers, researchers and other stakeholders in the co-design, co-monitoring and co-evaluation of agricultural practices to expedite the transition towards sustainable farming systems (FAO, 2019; McPhee et al., 2021; Veerman et al., 2020), farmers are still seldom and hazily involved in structured PM&E programs, undermining the potential success of restoration efforts. In PM&E, participants are the ones who track the progress of the project, analyze and discuss collected information, and identify constraints and potentialities in order to decide the appropriate actions needed to improve project outcomes (Estrella et al., 2001; Estrella and Gaventa, 1998; Luján Soto et al., 2020; Vernooy et al., 2006). Essential to this process is that farmers undertaking the innovative activities are the ones who decide on what should be monitored and evaluated, which data should be collected, and how this should be done and combined with possible monitoring performed by scientists (Cardoso et al., 2001; de Olde et al., 2016).

Visual soil assessment (VSA) tools have been broadly promoted to facilitate PM&E of the impacts of sustainable land management on soil quality by farmers (Ball et al., 2017; Milgroom et al., 2006; Nicholls et al., 2004; Shepherd et al., 2008; Shepherd, 2000). VSA tools are user-friendly tools destined to assess soil management effects and provide soil management recommendations to improve agroecosystem sustainability (Ball et al., 2017; Milgroom et al., 2007; Triste et al., 2014). VSA tools can be used to monitor soil quality, to identify constraints for soil functioning, to detect early stages of degradation and restoration (Ball et al., 2017; Luján Soto et al., 2020; McKenzie, 2013) and is a valuable addition to technical soil analyses (Ball et al., 2017; Luján Soto et al., 2020; McKenzie, 2013). Furthermore, VSA tools have been spotlighted as a mean of communication between stakeholders to exchange knowledge on soil and agroecosystem quality, since they allow systematizing a wide diversity of information into a simple, visual, and familiar language to most people (Ball et al., 2017; Luján Soto et al., 2020; Triste et al., 2014). Despite the multiple benefits from VSA tools, concerns about VSA tool adoption by intended users, and thus ensuring potential benefits, have recently arisen (Coteur et al., 2020; de Mey et al., 2011; de Olde et al., 2018, 2016; Gasparatos, 2010; Triste et al., 2014). Although the factors influencing VSA tool adoption are contextual and might vary from case to case, the development process of VSA tools explained the lack of adoption in previously developed tools (Coteur et al., 2020; de Mey et al., 2011; de Olde et al., 2018; Triste et al., 2014).

Both, experimentation of sustainable land management approaches by farming communities, and impact assessments of such approaches, including RA, lag significantly behind their promotion (Chaffin and Gosnell, 2015). In like a manner, evaluating the success of projects promoting adoption of SLM approaches have frequently responded to the needs of project implementers and donors, and rarely included the perceptions and experiences of those subjects from whom land management change is expected, and which can be of great help to decide appropriate actions to improve project outcomes (Cardoso et al., 2001; Veernoy et al., 2006; Stringer et al., 2014; Jemberu et al., 2018). In PM&E projects, agroecosystem restoration is considered successful when progress is made towards achieving agroecosystem restoration targets through a learning-based (adaptive) decision process (Chaffin and Gosnell, 2015). In particular, in PM&E for agroecosystem restoration, farmers´ own evaluation of progress provides crucial insights as part of a continuous iterative co-development process to increase the efficiency of restoration interventions.

The goal of this study is to present the outcomes of a PM&E project grounded in farmers´ VSA of RA impacts in the Mediterranean drylands of Spain, and evaluate the PM&E process itself based on farmers´ insights. By drawing on, and discussing, farmers' insights we further aim to: 1) improve the understanding of RA impacts to support its large-scale adoption, and 2) enhance the design of PM&E processes based on the VSA of farming innovations for the benefit of future restoration and farming innovation initiatives. To achieve these goals, we present farmers results on RA impacts based on VSA, discuss factors hampering and stimulating VSA tool adoption in the PM&E project, and provide recommendations for practitioners to improve PM&E outcomes.

2 MATERIALS AND METHODS

2.1 Study area

The high steppe plateau of the semiarid southeast of Spain has attracted increasing attention in recent years for its advanced state of degradation and vulnerability to climate change, and its high restoration potential (Commonland, 2020; Martín-Arroyo, 2019). Rainfed almond farming occupies the largest area destined for woody crops in the high steppe plateau (Cruz Pardo et al., 2010). Tillage intensification (Clar et al., 2018), removal of soil erosion barriers (Bellin et al., 2009), overexploitation of the limited existing water resources (Molina et al., 2009), the near to total disappearance of sheep farming (Toro-Mujica et al., 2015), and land use change from forest to cereal cropping and to woody crops (Cruz Pardo et al., 2010) are major human drivers causing land degradation in the region (García-Ruiz, 2010). The decreasing production potential of rainfed farming has resulted in land abandonment and loss of economic prosperity (van Leeuwen et al., 2019). Together with human activities, the climatic and biophysical conditions of the region play a major role exacerbating land degradation and related soil erosion processes. The climate is semiarid Mediterranean with long periods of drought of about 330 days per year, and average mean annual precipitation of 350 mm concentrated in few torrential events (Cruz Pardo et al., 2010). Predominant soils are Calcic Cambisols, Calcic Regosols and Leptosols (FAO classification) of highly erodible nature, covering about 82 percent of the study area (Cruz Pardo et al., 2010).

2.2 Study context

In 2015 substantial efforts to counter land degradation and return the sustainability of agroecosystems in the high steppe plateau began to materialize with the creation of the farmer association AlVelAl. Local farmers pioneering in implementing RA practices created the AlVelAl farmer association with the support of the Commonland foundation, business entrepreneurs, regional governments, and research institutions. The AlVelAl association aimed to foster a large-scale adoption of RA in the high steppe plateau for landscape restoration in a time frame of 20 years (Fewerda, 2015). Members of AlVelAl considered RA a promising farming approach to restore the soil quality and enhance the functionality of the agroecosystems in the region. However, the limited empirical information supporting RA effectiveness (Lee et al., 2019), the lack of reference examples in the region, and the slowness with which visible ecological restoration processes usually occur in semi-arid climates were considered major obstacles hindering RA adoption. To effectively address this knowledge gap, support farmers and expedite RA adoption required joining efforts between farmers and researchers, putting together local and scientific knowledge to improve the understanding of RA. Farmers´ visual soil assessment (VSA) of regenerative agriculture impacts was considered key to foster farmer self-evaluation and self-reflection on individual and community records and facilitate the exchange of information between farmers and researchers. The improved knowledge and experience would help farmers in the decision-making towards soil restoration and sustainable management objectives fit to their personal conditions, priorities and possibilities (Ball et al., 2017; Triste et al., 2014). This was expected to enhance farmer ownership and community empowerment to adopt and adapt RA, maximizing restoration success without the need of continual technical support. To this end, we initiated a participatory research collaboration with the AlVelAl association involving 12 pioneering farmers who were already implementing RA practices in the region and who showed their interest in engaging in a PM&E project at their farms (Figure 1) (Luján Soto et al., 2020).

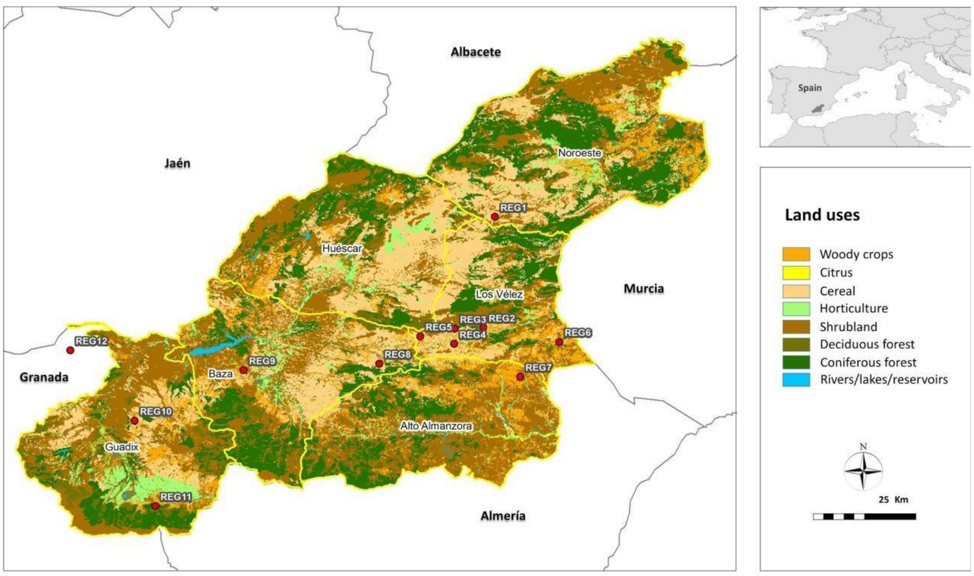

Figure 1 Map of the territory where the AlVelAl association operates. Yellow lines define county borders within the autonomous regions of Andalusia and Murcia; red dots represent the 12 farms of participating farmers involved in the participatory monitoring and evaluation research project.

2.3 Development of a participatory monitoring and evaluation project

To evaluate the impacts of RA on soil quality between farmers and researchers we developed a participatory monitoring and evaluation framework consisting in 7 phases (Luján Soto et al., 2020). The framework included various iterative feedback processes with participating farmers in order to detect, and modify, aspects that could hamper and improve the monitoring process, and to increase the effectiveness of the regenerative practices under evaluation (Luján Soto et al., 2020). Completion of all 7 phases building on farmers´ and researchers´ learnings and insights, gives rise to a new monitoring and evaluation cycle (Luján Soto et al., 2020)(Figure 2). The major goal of this iterative participatory monitoring and evaluation framework was to enhance knowledge exchange between farmers and researchers, to increase the understanding of RA impacts on soil quality and agroecosystem sustainability, and thereby foster the large-scale implementation of locally adapted RA practices. The 7 iterative participatory monitoring and evaluation phases structuring the framework are:

Phase 1) Definition of research and monitoring objectives

Phase 2) Identification, selection and prioritization of Technical Indicators of Soil Quality (TISQ)

Phase 3) Identification, selection and prioritization of Local Indicators of Soil Quality (LISQ)

Phase 4) Development of a VSA tool integrating LISQ

Phase 5) Testing and validation of the VSA tool

Phase 6) Monitoring and assessment of the impacts of RA by researchers and farmers based on TISQ and VSA results

Phase 7) Exchange of monitoring results between all involved participants, and joint evaluation of RA impacts

Phases 1 to 5 were addressed during the first year of the research project starting in 2017, and results were reported in Luján Soto et al., (2020)(Figure 2). Results included the complementary information provided by LISQ and TISQ for enhanced RA impact assessment, and the development of a VSA tool ("the farmer manual") integrating 16 LISQ that were identified, selected and validated by participating farmers in two participatory workshops (workshops 1 and 2)(Figure 2). Phase 6, corresponding to the researchers´ RA impact assessment using TISQ, was addressed and results reported in Luján Soto et al., (2021).

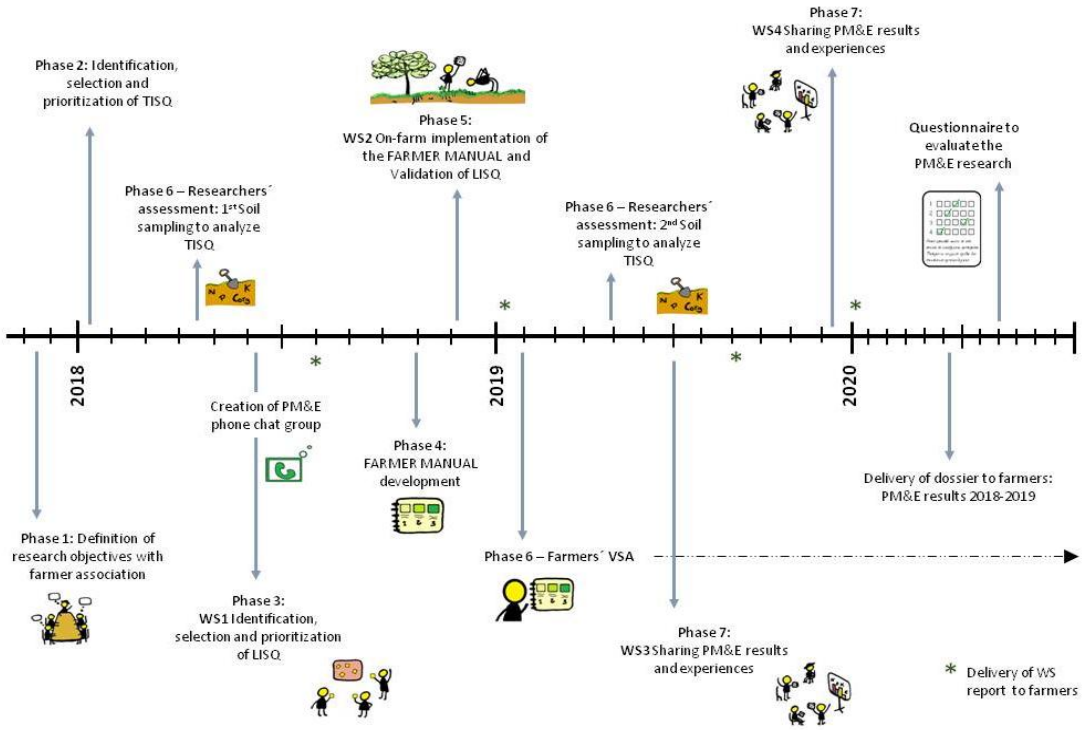

Figure 2 Process roadmap outline depicting PM&E phases. Figure adapted from Luján Soto et al., (2021b).

2.4 Evaluation of the participatory monitoring and evaluation project

In the present study we address the complementary part of Phase 6 corresponding to farmers´ monitoring of RA using the farmer manual and Phase 7, which includes: sharing results on RA impact assessment between farmers and researchers and, sharing farmers´ results on the evaluation of the VSA tool and the overall evaluation of the PM&E project after conclusion of all 7 phases (Figure 2). Phase 7 was designed to follow the restoration progress of participating farms, to verify whether selected indicators and our co-developed VSA tool were useful for farmers to provide evidence on RA impacts on soil quality and related ecosystem services, and to review and keep track of the PM&E process based on farmers´ and researchers´ observations. Therewith serving as a major dialogue and feedback phase for all participants to learn and implement changes, and enhance the consecution of intended goals.

Phase 6 was carried out by farmers´ assessment of RA impacts by comparing a regenerative field in their farms to a nearby conventionally managed field, used as control. To operationalize phase 7, we developed two participatory workshops (workshop 3 and 4) (Figure 2), which we entitled "Sharing monitoring experiences in regenerative agriculture" since both workshops aimed to achieve the same goals. To meet these goals in each workshop we performed a number of exercises, each exercise with their own specific objectives and methods (Table 1 and Table 2). Since the beginning of the PM&E project, in parallel to workshops, we developed multiple mechanisms to enhance support and knowledge exchange between participating farmers and researchers. These mechanisms included: a phone chat group, frequent email contact, the delivery of workshop and progress reports, farm visits, and formal and informal interviews (Luján Soto et al., 2020).

Workshops were designed in such a way that each exercise would serve as input to elaborate on the following one. Some exercises were exclusively designed to incite farmers to integrate and interpret TISQ with VSA observations. Other exercises focused on inducing farmers´ self-reflection and discussion on RA impacts based on TISQ and VSA results, and to collectively deliberate about possible actions to achieve farmers´ targets for improving their farming systems. Furthermore, we asked farmers to reflect on the VSA to track progress and identify advantages, difficulties and suggestions to improve the VSA tool. Workshop 3 and 4 took place in the farm of participating farmers during approximately 5 morning hours each, and were moderated by one of the scientists leading the research project. After conclusion of each workshop, a report with workshop results was sent by email to all participating farmers.

Table 1 Structure breakdown of workshop 3

Exercise	Objectives	Techniques
Presentation of participants and RA experiences	Introduce the participants involved in the participatory research and their experiences with RA, and create a pleasant and relaxed working atmosphere	In a circle each participant takes a few minutes to introduce her/himself and the RA practices she/he is implemented
Recap of the participatory monitoring and evaluation	Make an oral return of the phases that have been already covered, and highlight relevant aspects and goals achieved until the moment to update participants.	Narrated timeline by the facilitator

Most significant changes (MSC)	Share the most significant changes farmers observed in their farms through application of the farmer manual, the changes that are expected to be observed, and collectively generate ideas on how each farmer can achieve them.	MSC technique. Individual and group work to complete a table with guiding questions, and plenary discussion
Monitoring experiences using the farmer manual	Share farmers reflections about the farmer manual, including doubts on how to use it, usefulness and suggestions about modifications to better register most significant, and expected, changes.	Group work and plenary discussion
Introducing Technical Indicators of Soil Quality (TISQ)	Present TISQ to farmers as the complementary half of LISQ that completes the monitoring system of soil quality to enhance information exchange.	Explanation of each TISQ using inclusive language and making use of cards for graphical support
Return TISQ results from 2018 and link farm management, TISQ and LISQ results.	Enhance the exchange of information between farmers and researchers based on results obtained with TISQ from sampled soils and leaves in 2018, and LISQ in each farm, to better understand RA impacts.	Individual presentation of RA managements, results from LISQ and TISQ with the help of the researcher to facilitate indicators´ interpretation and discussion. Plenary discussion
Workshop closure and establishment of agreements	Recapitulate about obtained results; establish agreements on research commitments by farmers and researchers; briefly introduce following research steps to keep participants engaged	Plenary session and discussion

Table 2 Structure breakdown of workshop 4

Exercise	Objectives	Methods
Participatory research update: Refreshing main aims and process stage	Keep all participants informed on the research project. Introduce the aims of workshop 4	Plenary talk
Return of TISQ results from 2019 and contrast with LISQ	Provide farmers individual reports with TISQ results and detailed information to help the interpretation. Contrast LISQ results and further farmers´ observations with TISQ results, and co-	Refreshing TISQ. Collectively discuss TISQ results and contrast with LISQ, influencing causes, and how to improve them

	generate proposals between farmers and researchers for improving these results.	
Visit to regenerative plots in the farm	Visit the RA experience of the farmer hosting the workshop and value local knowledge. Develop a VSA in situ. Enhance discussion between participants on the impact of current and alternative managements. Understand the landscape and the impact of RA practices to favor or control different processes	Farm visit guided by the hosting farmer
Return of LISQ results from 2019 and establishment of future actions	Share monitoring experiences and observations from each farmer on their RA practices and management based on the farmers´ observations of LISQ. Enhance individual and collective reflection to discuss how to improve the effectiveness of implemented RA practices.	Individual and group work to elaborate on RA managements, remarkable observations, goals to achieve and suggestions on how to achieve these goals.
Enhancing VSA tool adoption	Share farmers´ difficulties to implement the Farmer manual. Add suggestions on content, structure and design, to improve it. Generate new ideas to enhance farmer adoption of VSA tools	Brainstorm and plenary discussion
Workshop closure and establishment of agreements	Establish objectives and future actions.	Plenary: stating stakeholder agreements

Once all 7 phases were completed, concluding one PM&E cycle - in the third year of research - we interviewed farmers to evaluate the PM&E project. We conducted an online semi-structured questionnaire asking farmers about the overall usefulness of the PM&E project, and specifically about 3 key aspects to confirm whether intended goals of the PM&E project were met. These 3 aspects were stated as follows: “Select to what extent this PM&E project has helped you to: i) relate with other farmers, ii) learn about RA practices, and iii) see and understand the regeneration effect in your farm”. To conclude with, we asked farmers to freely report aspects to highlight from their experiences being involved in the PM&E project.

3 RESULTS

3.1 Farmers´ Visual Soil Assessment of Regenerative Agriculture impacts

From the twelve participating farmers, six farmers reported VSA results on regenerative agriculture impacts compared to conventional farming (Appendix). From them, four farmers reported quarterly results from both regenerative and conventionally managed fields used as control, while the other two farmers just reported results from regenerative fields, and data from some seasons was missing. The amoeba diagram (Figure 3) shows the VSA average results reported by these six farmers on 14 local indicators of soil quality (LISQ) comprising the farmer manual. LISQ scores range from 1 point (low soil quality) to 3 points (high soil quality). Overall, regenerative agriculture performed better than conventional farming for all indicators but for leaf color that was slightly higher for conventional farming. The LISQ bioindicator plants, soil roots, erosion control, infiltration capacity, soil smell, and ladybugs, showed the highest improvements for regenerative agriculture, ranging on average from 0,5 to 0,7 points higher, compared to conventional farming. Average punctuation of all 14 LISQ was 1,8 points for regenerative agriculture and 1,5 points for conventional farming.

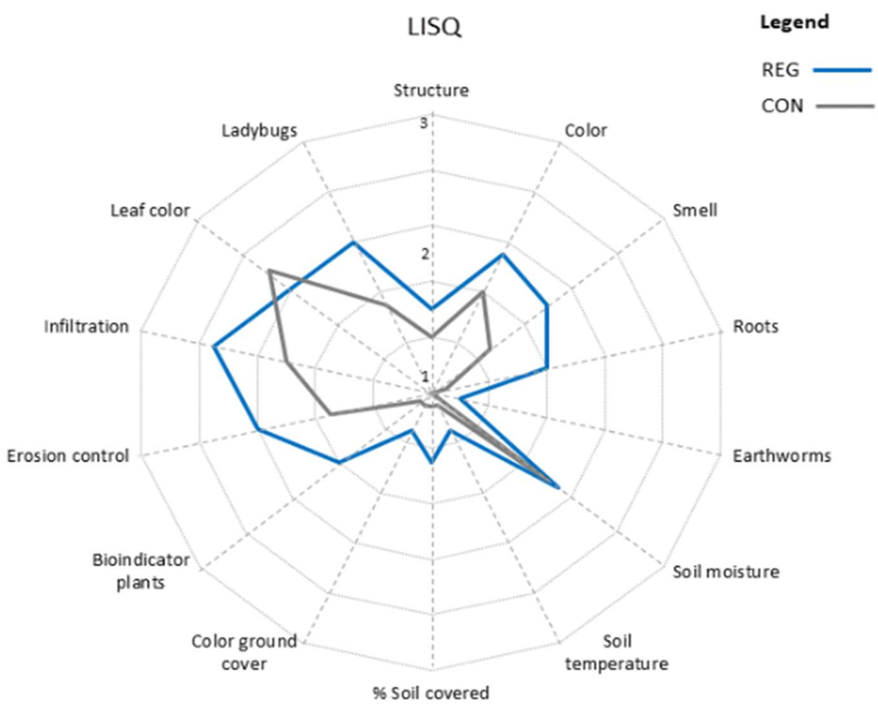

Figure 3 Amoeba diagram presenting farmers´ visual soil assessment results on regenerative agriculture and conventional farming impacts on 14 local indicators of soil quality (LISQ).

3.2 Participatory evaluation of RA integrating LISQ and TISQ

Workshops 3 and 4 were planned to integrate the information on RA gathered by farmers and researchers, stimulate farmer discussion about obtained results, and propose ideas to achieve desired restoration goals through modification of RA practices. Seven farmers attended each workshop (Appendix). From farmers´ integration and discussion of TISQ and VSA results during the two workshops, four main topics arose:

1) Indicator interconnectedness: Farmers highlighted that most TISQ and LISQ were directly or indirectly related to organic matter content, highlighting the central role of increasing organic matter levels to achieve restoration objectives. Furthermore, farmers draw attention to the relationship between soil quality improvements and almond production, identifying a variety of other factors, such as soil type, climate conditions and almond variety, which also influence crop production. Subsequently, farmers mentioned that regenerative management is key to enhance soil quality and as a long-term production "insurance".

2) *Regenerative practices and management:* Farmers discussed that in addition to the type and combination of regenerative practices applied (e.g. organic amendments, green manure, reduced or no tillage, etc.) the management of the regenerative practice is what determines its restoration "efficiency". For instance, a farmer (F10) commented: *"I do no-tillage, but no-tillage does not equal no management. I learnt about the perfect timing to stop tilling and favor natural ground covers with winter grasses and leguminous species, and to include complementary fertilization strategies to enhance soil fertility; thus adapted management is fundamental to make any RA practice work".* Another farmer (F2) commented *"I do green manure and use it as fodder for my sheep herd. My sheep graze the green manure once or twice before they leave to the mountain pastures when I incorporate it into the soil with the chisel plow. Thanks to the soil lab analyses, I realized that I should apply sheep manure or other organic amendments to keep a positive nutrient balance in grazed fields".*

3) *Visual Soil Assessment of RA*: Farmers pointed out that there were very large differences in the results between different regenerative farms on a number of LISQ. They discussed the importance of making comparisons "fair", thus between regenerative and neighboring conventionally managed fields, and not between regenerative farms because they were far from each other and the particular biophysical and

climatic conditions of each regenerative farm could be constraining or stimulating the effectiveness of the different RA practices.

4) *Future soil analysis using TISQ*: Farmers highlighted the importance of continuing doing physic-chemical and biological soil analysis in the longer term. For instance, a farmer (F11) pointed out that *"the results from some indicators were very different between 2018 and 2019, and only by continuing carrying out soil analysis, general trends could be identified"*.

Regarding farmers´ self-reflection and discussion on RA impacts in their farms, participating farmers (Appendix) provided a series of suggestions to help each other achieve their targets (Table 3).

Table 3 Farmers´ reflection on regenerative managements and visual soil assessment, desired goals and how to achieve them.

Farm	Management	Field manual observations	Improvement goals	¿How can we achieve them? Suggestions
Reg 1	Tilling 2-3 times/year Vegetation strips of 2 meters wide in between almond lines	Below vegetation strips there are more roots, the soil has better structure and is alive	Include ground covers with leguminous and cereals, and improve their management	By integrating sheep for grazing. By trial and test with different ground covers and farm implements (roller crimper, chisel plow, mower...)
Reg 2	Tilling twice per year. Green manure managed with sheep and incorporated in the soil. Compost addition every 2 years	In the regenerative parcel soil temperature is lower, humidity is higher and trees look better. In the conventional parcel, there is more runoff, more gullies and lot of tumbleweeds	Increase nutrients, improve crop performance and prevent erosion. Try to apply ground covers	Applying compost or organic fertilizer annually. Increasing soil coverage. Testing no-tillage in September in a parcel and bringing sheep to enrich the seed bank of autochthonous plants
Reg 3	Tilling twice per year. Addition of compost	At first glance, the regenerative parcel looks better, but I have to check it with the field manual	Apply a bit more quantity of compost. Trim pruning in November to use it as mulch	Time is needed for making observations and to get more soil analysis results to see how regenerative parcels are evolving
Reg 4	Tilling twice per year. Green manure mix of vetch, lentil vetch and barley. Addition of organic fertilizers	During summer trees look weak due to lack of water. There are soil patches where grass never grows	Improve soil structure, soil porosity and increase soil organic matter	Slash and mulch green manure to continuously reduce tillage in time. Try to establish permanent natural covers.
Reg 6	Tilling 1-2 times/year. Annual addition of compost and pruning. Guara almond variety	Overall, soil quality results are a little better than in the conventional parcel. Visually my almond trees look better	To keep more humidity in the soil and till just once per year. Prevent	Using soil terraces. Continue adding compost and green manure

			erosion.	
Reg 8	Tilling twice per year. Trimmed prunings and composts added to the soil biannually	We have improved a bit, but we need more organic matter to make nutrients available for our almond trees	Keep on applying various RA practices to get to know which one works better	Wait for future results and observations
Reg 10	No tillage and permanent ground covers	Soil temperature is still too high in regenerative fields. There is a lack of soil nutrients	Lower soil temperature and increase soil fertility	Adding compost and spreading it with a disc. Keeping the whole soil surface covered

3.3 Farmers´ evaluation of "the farmer manual" (VSA tool)

To enhance the PM&E process through the VSA of RA impacts, during workshops 3 and 4 farmers discussed, and provided feedback, regarding the design and usefulness of the VSA tool. Farmers identified usefulness and difficulties they encountered during the operationalization of the VSA tool, and provided suggestions for how to improve it. The main usefulness, difficulties and suggestions for improving the VSA of RA impacts are listed in Table 4.

Table 4 Farmers´ evaluation of the Farmer Manual

Usefulness	Difficulties	Suggestions to enhance farmers´ VSA
• U.1) It allows us to see the soil in a different way and pay attention to parameters we did not pay attention to before • U.2) It allows us to collect and systematize information • U.3) It is easy to use because it resembles the indicators we observe on a daily basis in the field • U.4) We have used it to show the quality of the soil to visitors and students visiting our farms	• D.1) Sometimes it is tedious to bring it to the field and take notes while farming • D.2) We forget many times to take it to the field • D.3) To adopt a VSA tool because we do monitor our farming practices with our own methods • D.4) Some indicators change their value from one day to another, while others take really long time to change, which is sometimes difficult to interpret (reliability)	• S.1) Receiving a reminder every time we have to do the visual soil assessment • S.2) Develop a mobile app that allows farmers to record changes directly on the phone • S.3) An app where we could mark on a map the place where the soil diagnosis was made • S.4) Add a final section with recommendations on RA practices and management to help us improving restoration results

3.4 Farmers´ evaluation of the PM&E project

All twelve participating farmers answered the questionnaire to evaluate the PM&E project. Table 5 shows farmers´ answers on requested key aspects.

Table 5 Farmers evaluation of the PM&E project

A. How useful was it for you to participate in the PM&E Project?					
	Very	Notably	Moderate	Slightly	Not
	F2, F3, F4, F6, F7, F9, F10	F5	F1, F8, F12	F11	
B. Select to what extent this PM&E project has helped you to:					
	Much	Notably	Moderate	Slightly	Not
Relate with other farmers	F2, F3, F4, F6, F10	F5, F7	F8, F12	F1, F9, F11	
Learn about RA practices	F2, F3, F4, F6, F7, F9	F5	F8, F12	F1, F10, F11	
See and understand the regeneration effect in your farm	F2, F3, F4, F6, F7, F9	F5	F8, F12	F1, F10, F11	
C. What would you highlight?					

F1. I have realized that theory and practice, or in other words, what is told about RA and what we´ve seen in our farms, does not always match. It would be nice to continue researching different types of ground covers and different types of management to see what performs best.

F2. It has helped me to dare implement new RA practices. Activities are increasingly going online, and if it were not for this participatory research, I would not have met many farmers and their farms, and I would not have dared to implement innovative practices such as no tillage.

F3. I liked from this research the spirit of sharing information, and feeling integrated into a group doing something positive to achieve AlVelAl's goals. I couldn´t participate as much as I wanted but I see participatory research projects crucial to engage farmers into agroecosystem sustainability.

F4. It has been a very educational process. I liked the importance given to farmers. I really liked the workshop's format. It would be nice to have public policy incentives to help us implement regenerative agriculture practices for the longer term.

F5. I have learned how to interpret soil analysis and how to act upon them. I would like to learn more about plants to prevent soil erosion, natural ground covers, and how to minimize costs while maximizing environmental benefits.

F6. It has helped me to delve into soil analysis and to interpret soil parameters and the role they play (chemical parameters, organic matter, texture). For future research I would like to know about how to enhance biodiversity in the farm and about ground cover management, especially when rainfall is scarce.

F7. I have noticed that people are interested in what I do. I would like to keep on learning about ground cover management.

F8. Monitoring will be easier with a mobile phone app.

F9. The participatory component and the continuous flux of information sustained. Although my participation wasn´t as frequent as I would have liked, this research has helped me to learn a lot about the status of my soil and to better appreciate the evolution and effect of the regenerative practices we are applying.

F10. I liked meeting people working in the same line as me. Research on supplemental irrigation for ground cover management would be great.

F11. It would be nice and necessary to continue with this research for at least another 3 years to have more data to reflect on and learn from.

F12. The value given to participants´ experiences.

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4 DISCUSSION

In the following paragraphs we analyze farmers´ VSA results and insights, and discuss whether the participatory monitoring and evaluation project for agroecosystem restoration succeeded to achieve established goals: 1) to verify whether RA could restore the soil quality of degraded agroecosystems in semiarid regions based on farmers´ VSA, and 2) to enhance PM&E processes based on VSA to help farmers´ self-reflection, ownership and empowerment to implement locally adapted RA practices. We address the possible factors stimulating and hindering VSA tool adoption and project success and discuss farmers´ evaluation of the PM&E project aiming to depict learnings to contribute to improve PM&E for agroecosystem restoration.

4.1 Farmers´ impact assessment and participatory evaluation of RA

Farmers´ VSA of regenerative agriculture indicates some progress towards achieving soil quality restoration in the agroecosystems under evaluation. On average, regenerative agriculture performed better than conventional farming, however LISQ values in regenerative fields were still far from optimum, and the difference in average soil quality results between regenerative and conventional farming was relatively small. The results from the LISQ were somewhat contrasting or complementary to the TISQ results for which larger differences between regenerative and conventional fields were found for several important soil quality indicators (e.g. soil organic carbon, total soil Nitrogen content, microbial respiration rates)(Luján Soto et al., 2021). This might be explained by the fact that TISQ focus mainly on soil properties and supporting ecosystem services, while LISQ can be associated with supporting, regulating and provisioning ecosystem services that take a longer time to respond to enhanced soil quality. Beyond concrete restoration results, it is worth noting the importance of farmers observing progress in soil quality restoration (Cardoso et al., 2001; Masset and Haddad, 2015; Vernooy et al., 2006), especially for expected slow-response farming interventions like RA in semiarid environments. In other words, what matters is not only what is assessed but also who does the assessing and the processes generated in them. Progress observation might act as an incentive for farmers to continue applying RA and achieve higher restoration results in the longer term. Furthermore, farmers can complement VSA results with TISQ results (Table 3) (Ball et al., 2017; Guimarães et al., 2017; Luján Soto et al., 2021; 2020), improving their understanding of RA management and impacts, and increasing the confidence in RA. Together with the exchange of experiences with peer farmers, these increased insights might lead to enhanced RA efficiency and soil quality restoration results through social learning (Dessie et al., 2012; García-Nieto et al 2019; Luján Soto et al., 2021b; Suškevičs et al., 2018). Moreover, due to the slow soil responses to management changes in semiarid regions as a result of the lack of water for developing soil biological activity, greater soil quality improvements might be expected in the longer term (De Leijster et al., 2019; Luján Soto et al., 2021). Based on farmers´ VSA results we can affirm that RA might be a plausible solution to restore degraded agroecosystems in semiarid regions, accomplishing the first goal established for measuring success in this PM&E project for agroecosystem restoration.

Regarding the achievement of the second goal; along the whole PM&E project multiple mechanisms were activated to enhance individual and social learning (Suškevičs et al., 2019) as critical steps towards adoption and out-scaling of RA (Sol et al., 2013; Suškevičs et al., 2018). The iterative feedback processes (Figure 2) aimed, among other reasons, to help farmers´ self-reflection, ownership and empowerment to implement locally adapted RA. The achievement of this second goal can be also illustrated by farmers indicating that the farmer manual allowed them to see the soil in a different way and pay attention to parameters they overlooked before (Table 4), and by farmers´ understanding of the interconnection between TISQ and LISQ and the influence of farming management, climatic and biophysical conditions and regenerative practices on success (Table 3). It can be also sustained by farmers´ highlighting PM&E as an educational process that helped them to learn how they could adapt farm management to enhance soil properties (Table 5), and by the fact that farmers were able to assist other farmers by providing suggestions to help achieving targets for improving the sustainability of their farming systems (Table 3). Farmers increased knowledge and empowerment for natural resource management have been highlighted as outcomes in multiple other PM&E experiences (Cardoso et al., 2001, Vernnoy et al., 2006; Funder et al., 2013) however, these outcomes should not be taken for granted (Rahman, 2019). Farmers´ evaluation of the PM&E project (Table 4 and Table 5) evidences that involving farmers in PM&E and VSA tool development can enhance the monitoring, evaluation and efficiency of RA, helping them to understand the role of soil properties, soil functions and management in a more comprehensive way for improving their farming systems and achieving established restoration goals.

4.2 Farmers´ insights to enhance VSA and VSA tool adoption

Despite the overall positive evaluation of the PM&E process by participating farmers, it is important to note that, although all farmers took part in at least one PM&E activity (Appendix), just half of them provided VSA results, 9 farmers attended workshops 1 and 2, and 7 farmers joined workshops 3 and 4 (Appendix). These results lead us to think that the potential benefits of PM&E for enhancing learning and adoption of regenerative agriculture could be much greater than achieved, and to reflect on which factors determined VSA tool adoption and workshop attendance. Based on the potential factors stimulating and acting as barriers for VSA tool adoption, we discuss possible actions that might contribute to improve PM&E goals for agroecosystem restoration.

VSA tools stand out for being user-friendly tools that help to provide simple, informative, rapid and useful diagnosis of the soil quality (Ball et al., 2017), and facilitate information exchange between stakeholders of different backgrounds and levels of expertise (Guimarães et al., 2017; Triste et al., 2014). Farmers participating in the PM&E project recognized most of these benefits for the farmer manual

(Table 4). However, farmers also pointed out some difficulties regarding VSA tool adoption. They found it particularly complicated to integrate a VSA tool in their farming routine due to a lack of habit, and some participating farmers reported they already had their own method to record soil quality changes, making it redundant to include an extra method. Building on farmers´ insights on benefits, difficulties and suggestions regarding the VSA of RA impacts, and analyzing success factors and barriers for VSA tool adoption from the literature (Coteur et al., 2020; de Olde et al., 2018, 2016; Milgroom et al., 2007; Triste et al., 2014), three main learnings for enhancing VSA and VSA tool adoption arise:

1) Researchers/technicians in charge of monitoring projects must provide guidance and support to help farmers implementing VSA tools. For instance, by accompanying them in initial VSA to solve doubts, and to help them get into the habit of recording observations in a systematized way. To increase stakeholder engagement in research and thus, in VSA tool adoption, we actively included participating farmers since the beginning of the VSA tool development process, from indicator identification to VSA tool testing. This best practice helps generate user-friendly VSA tools (Table 4), and appears to be a factor stimulating VSA tool adoption (Bünemann et al., 2018; Triste et al., 2014). However, applying this best practice seems not to be sufficient to ensure VSA tool adoption since just half of participating farmers actually adopted the farmer manual and expressed difficulties integrating the tool in their farming routine (Table 4). VSA tool testing by farmers was facilitated by two of the researchers involved in the PM&E project (Appendix) supporting, each researcher, one of the two groups in which farmers were divided (Luján Soto el at., 2020). Additional individualized support in the application of the VSA tool seems necessary to facilitate farmers´ VSA tool adoption. The crucial role of the researcher/facilitator to accompany farmers´ processes and share project responsibilities to ensure project success has been highlighted also in other PAR projects (Cuéllar-Padilla and Calle-Collado, 2011; Ensor and Harvey, 2015), and appears to be particularly important regarding farmer training to use VSA tools for soil management improvement and farm sustainability (Ball et al., 2017; Coteur et al., 2020; Milgroom et al., 2007; Triste et al., 2014).

2) VSA tool adoption can be enhanced if participants see the usefulness of contributing to a common repository with their individual monitoring results that supports collaboration and large-scale landscape restoration. Since some farmers already recorded RA progresses using their own methods for their own use (Table 4), it seems necessary to reinforce the potential advantages of systematizing and storing

information collectively. For instance, as a way to create an empirical database to enhance farmers´ confidence on RA and increase adoption, which in turn could serve as evidence base required to receive private and public policy and economic support - i.e. payments for ecosystems services schemes or land restoration incentives- as identified by PM&E participating farmers (Table 5). This leads us to reflect on the need and importance of defining concrete VSA tool objectives together with stakeholders and end users beyond monitoring and research objectives. Ambiguous or partial definition of VSA tool objectives, and PM&E in general, has been previously identified as a possible factor hindering VSA tool adoption (Coteur et al., 2020; Triste et al., 2014). Furthermore, although farmers were actively involved in the development process of the farmer manual, some decisions, such as the tool format, were made for them to ease the process and adapt to available resources, which might have constrained VSA tool adoption (de Olde et al., 2018).

3) End users must be included in all design phases of VSA tools in order to meet their needs and make VSA more appealing to them, thus facilitating VSA tool adoption in farmers´ routine. This same learning has been previously highlighted by various authors regarding soil quality assessments and VSA tool adoption (Bünemann et al., 2018; Triste et al., 2014). This learning can be illustrated by farmers´ suggestion to incorporate practical farm advice or guidelines to help achieve better soil quality improvements, which might motivate them to continue monitoring RA impacts. Provision of guidelines for improving farm management to reduce soil erosion risk appeared to be a key factor stimulating VSA tool adoption by olive farmers in south Spain (Milgroom et al., 2007). Likewise, absence of guidelines appeared to be a key factor hindering VSA tool adoption by farmers in Flanders (Triste et al., 2014). Tool adoption might increase if the VSA tool directly contributes to action towards farm sustainability (Coteur et al., 2020; de Olde et al., 2018, 2016). Furthermore, farmers participating in this PM&E project expressed the need to renew and update the farmer manual by using digital technologies. In fact, developing new technologies for the use of VSA interactive tools is considered a promising arena (Guimarães et al., 2017), and some VSA tools have been already updated to digital format as mobile apps. For example the VESS app (Ball et al., 2007; Guimarães et al., 2011) that includes a GPS mapping feature to record sample locations for soil diagnosis, as was also suggested by participating farmers in this study (Table 4), and the recently launched SQAPP (ISQAPER EU Project, 2020). To this end, public and

private investments should be made available to help develop sound participatory research projects, monitoring technologies, and support farmers to attain land restoration and sustainability goals (FAO, 2019, Funder et al., 2013).

4.3 Farmers insights for improving PM&E

A major reason behind doing PAR, and specifically PM&E, is enabling participants´ empowerment for social transformation (Cuéllar-Padilla and Calle-Collado, 2011; Estrella et al., 2001; Fals-Borda and Rahman, 1991; Guzmán et al., 2013). Participation and learning are two key principles of PM&E (Estrella and Gaventa, 1998). Participation is considered both a means and an end for learning to strengthen people's capacity to make decisions for creating environments for change (Cuéllar-Padilla and Calle-Collado, 2011; Méndez et al., 2017; Vernooy et al., 2006). Drawing on farmers´ answers on 3 key aspects regarding participation and learning in this PM&E project, we identified several learnings to improve PM&E outcomes, particularly regarding RA adoption.

All farmers found it useful having been involved in the PM&E project to a greater or lesser extent. Farmers appreciated the participatory component of the research, the value given to them and to their experiences, and the workshop methodology to relate with farmers and researchers working with regenerative agriculture (Table 5). In this same line, farmers also highlighted that the PM&E generated a sense of belonging for them (Table 5). The PM&E process brought together people with similar views, a common purpose, and a shared philosophy on farming for agroecosystem restoration. Farmers´ responses regarding their experience in PM&E confirm earlier findings that participatory research helps building mutual trust and support relationships, confidence and empathy (Cuéllar-Padilla and Calle-Collado, 2011; Masset and Haddad, 2015; De Vente et al., 2016; Sewell et al., 2017), conducive conditions that might reinforce credence on farming innovation effectiveness and adoption. As a matter of fact, PAR processes have been highlighted for helping generate social cohesion and support between participants prompting the achievement of common goals (Cuéllar-Padilla and Calle-Collado, 2011; Guzmán et al., 2013; Méndez et al., 2017).

Participation was enhanced through multiple mechanisms along the PM&E process. Among these, participatory workshops were the backbone of the PM&E project and key to favor farmers establishing relations and sharing experiences. Although all participating farmers found the PM&E project helpful to relate to other farmers, some farmers reported it was of slight to moderate help (Table 5). This might respond to the fact that not all farmers could participate in all activities and attend all workshops (Appendix). The need to travel to the places where workshops were held, sometimes up to 2 hours' drive, and the fact that workshops were held during weekends to allow part-time farmers to attend, might have acted as barriers constraining farmer participation. In addition, there was no compensation for farmers to attend workshops beyond their own interest in participating, learning about soils, and sharing experiences about RA. Thus, while acknowledging the great importance of participatory research methods and techniques to motivate and enhance farmers´ engagement in research and sustainable agroecosystem initiatives, parallel mechanisms should be activated or reinforced to help generate ownership in research processes in the participants involved (Funder et al., 2013). Allocating greater public economic investment is necessary to support processes for agroecological transitions (FAO, 2019; Guzmán et al., 2013) and strengthening engagement of local organizations to scale out participatory and farmer-managed research and grassroots innovations (Pimbert, 2018).

Regarding the impact on farmers´ learning of RA, all farmers found that the PM&E project complied with this aspect. Farmers highlighted PM&E as a process where a continuous flux of information was kept amongst them. Furthermore, farmers also mentioned that thanks to the PM&E of RA impacts they were eager to implement new RA practices (Table 5). This confirms earlier claims that participatory research involving farmers and researchers into monitoring and evaluation can enhance farmers developing deeper understanding and knowledge on farming innovations leading to increased farmers confidence to trial and farmers´ capacity building (Cardoso et al., 2001; Dessie et al., 2012; Mapfumo et al., 2013; Sewell et al., 2017, Vernooy et al., 2006). Workshops are a particularly useful methodology to enhance participation, foster knowledge exchange and sharing of experiences, give voice to the wisdoms, concerns and needs of farmers, and empower them to be the changing engine of their realities (Barrios et al., 2012; Cuéllar-Padilla and Calle-Collado, 2011; Sewell et al., 2017). Farm visits during workshops appeared to particularly trigger farmers´ sharing of experiences and learning, building trust and confidence in RA, and encouraging farmers to experiment with different RA practices. Generating spaces for farmer-to-farmer diffusion of knowledge and on-farm experiences is clearly very important to facilitate learning and to foster farmer adoption of innovations (Pimbert, 2018; Sewell et al., 2017; Val et al., 2019; Vernooy et al., 2006; Wood et al., 2014; Lujan Soto et al., 2021b). Thus, peasant-to-peasant methodologies are crucial to foster farmers´ innovation adoption and enhance transitions towards agroecosystem sustainability and increase the impact of research on agroecosystem restoration.

Lastly, farmers highlighted that thanks to PM&E of the impacts of RA they learned to better appreciate the effect of the RA practices they were applying, to delve into soil analysis, to interpret and understand the importance of soil parameters and to act upon them (Table 5). These results denote that PM&E resulted successful in enhancing farmer capacity building. However, some farmers mentioned that the PM&E project was of slight to moderate help for them to learn about RA effects in their farms (Table 5). We found two main barriers that could be hindering learning progress. On one hand, the lack of VSA tool adoption and workshop attendance as explained above and, on the other hand, the fact that some farmers already had considerable experience on RA and acted more as knowledge "sources" to other participants. These two factors add to the fact that learning processes are gradual and require time. Therefore, developing a learning community of farmers and researchers that can provide a platform for exchange of experiences and technical support, and accompany farmers in the research process in the longer term, is crucial for learning, to identify further RA impacts, and to support adoption of farming innovations (FAO, 2019; Mapfumo et al., 2013; Pimbert, 2018; Sewell et al., 2017). Support for long-term participatory research is needed, especially when applied to sustainable farming in arid and semi-arid areas which are most vulnerable to irreversible land degradation and where visible changes in soil quality might take a long time to occur. This need has been claimed for decades in the sustainable farming arena (Bouma, 2019; FAO, 2019; Méndez et al., 2017), as well as in specific studies in Andalusia (Cuéllar-Padilla and Calle-Collado, 2011; De Leijster et al., 2019; Guzmán et al., 2013; Luján Soto et al., 2021), and should be urgently addressed if efficient, sound and inclusive land restoration and sustainable transitions are to be achieved.

This PM&E project was conceived as a continuous and dynamic learning process where modifications, as inherent part of the process, are required as the research and agroecosystem restoration processes progress, farmers and researchers dialogue, exchange information and learn, and context changes. Thus, modifications and suggestions to enhance the achievement of PM&E and agroecosystem restoration goals were expected, welcomed, and essential in the research process.

In the current UN decade for ecosystem restoration, ongoing climate change and increasing calls for agroecosystem Living Labs, including PM&E where the democratic involvement of participants is the bedrock of the whole research process, and the needs and concerns of the farming community are taken as the basis for collaborative research, represents a great opportunity to generate inclusive, engaging, and efficient transitions towards sustainable and resilient agroecosystems.

5 CONCLUSIONS

Participatory Monitoring and Evaluation (PM&E) through farmers' visual soil assessment indicated regenerative agriculture as a promising solution to restore degraded agroecosystems in semiarid Mediterranean drylands. Nevertheless, observed soil quality improvements evidenced by Local Soil Quality Indicators (LISQ) were relatively small, and more time and efforts are needed to attain desired restoration targets. The monitoring results based on LISQ and performed by farmers showed small improvements but were complementary to findings of Technical Indicators of Soil Quality performed by the researchers involved in the PM&E project. Farmer's evaluation of the research project highlighted the PM&E project as a process that helped them look differently at their land and their restoration efforts and facilitated the creation of relationships of support and trust, learning and capacity building that are fundamental conducive conditions to enhance farming innovation efficiency and adoption. Farmers confirmed that generating spaces for farmer-to-farmer diffusion of knowledge and on-farm experiences is a key driver to expedite farming testing and adoption of innovations. Farmers´ insights revealed the need to actively involve them in all decision making phases for VSA tool development and to support them in initial VSA tool implementation. This might help to develop tools that meet farmers´ needs, enhance farmers´ VSA tool adoption and facilitate reaching restoration goals. Furthermore, farmers´ evaluation of the co-developed VSA tool suggests the need to reinforce the multipurpose usefulness and potential benefits of collectively recording restoration progress in a systematized way to enhance VSA tool adoption. A number of context dependent factors acted as stimulators and barriers influencing the success of the different components of the PM&E project. Many farmers had difficulties in systematically integrating the VSA tool in their farm operation and were not always able to attend workshops. Therefore, the combination of different forms of in person and online participation and exchange of monitoring information is considered important. The development of a mobile phone application to support VSA can further facilitate active participation to create a common evidence base of the multiple impacts of RA under different conditions. Developing a learning community of farmers and researchers that can provide a platform for exchange of experiences and support in the research process in the longer term is crucial for social learning and to support adoption of farming innovations. This is especially important when harsh environmental conditions of semiarid and degraded landscapes result in an initially slow or intangible response to restoration efforts. The success of PM&E research for agroecosystem restoration can be improved by integrating iterative phases where farmers can evaluate and adjust research activities and outcomes. The process of PM&E that leads to enhanced social capital, learning and improved understanding of restoration efforts has as much value as the actual restoration outcomes on the ground.

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APPENDIX

Participation in different PM&E activities

Activities	**Participants**	**Total farmers**	**Total participants**
VSA of RA	F4, F5, F6, F7, F8, F9	6	6
Workshop 1 Participatory selection of soil quality indicators	F1, F2, F3, F4, F5, F6, F7, F8, F11, T1, O1, R1, R2, R4	9	14
Workshop 2 Validation of the Farmer manual	F1, F2, F3, F4, F6, F7, F8, F10, F11, T2, O2, O3, R1, R3	9	14
Workshop 3 Sharing monitoring experiences in regenerative agriculture	F4, F5, F6 ,F7, F8, F10, F12, R1	7	8
Workshop 4 Sharing monitoring experiences in regenerative agriculture	F1, F2, F4, F6, F7, F8, F10, R1	7	8
Farmers´ manual evaluation	F1, F2, F3, F4, F5, F6, F7, F8, F9, F10, F11, F12	12	12
Farmers´ PM&E research evaluation	F1, F2, F3, F4, F5, F6, F7, F8, F9, F10, F11, F12	12	12

Letters indicate different actors where: F=Farmer, R=Researcher, T=Technician from AlVelAl association, O=Observer (i.e. students, AlVelAl members…)