Participatory Monitoring and Evaluation of Regenerative Agriculture

From local knowledge and impacts to large-scale adoption

Monitorización y Evaluación Participativa en Agricultura Regenerativa

Del conocimiento y los impactos locales a la adopción a gran escala

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TÍTULO DE LA TESIS: Participatory Monitoring and Evaluation of Regenerative Agriculture. From local knowledge and impacts to large-scale adoption

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INFORME RAZONADO DEL/DE LOS DIRECTOR/ES DE LA TESIS

(se hará mención a la evolución y desarrollo de la tesis, así como a trabajos y publicaciones derivados de la misma).

La tesis doctoral que se presenta ha desarrollado un aporte muy valioso y original al estado de la cuestión sobre los procesos de transición agroecológica y de adopción de innovaciones, tales como la Agricultura Regenerativa y sobre los impactos de la Agricultura Regenerativa en la salud del suelo y los servicios ecosistémicos relacionados.

A través de un proceso de monitoreo y evaluación participativo, inspirado en las propuestas de la Investigación Acción Participativa y la Ciencia con la Gente, la tesis presenta propuestas metodológicas y respuestas a dos objetivos básicos:

1. Cómo evaluar los impactos de la implementación de prácticas de agricultura regenerativa sobre la salud del suelo y los servicios ecosistémicos relacionados, de manera accesible y asequible para y por las agricultoras y agricultores, que permitan impulsar y fomentar procesos de transición hacia manejos agroecológicos.

2. Evaluar el potencial para generar procesos de transición agroecológica que los diseños de monitoreo y evaluación participativos presentan, a través de su capacidad de generar aprendizaje social y articulación local.

Tanto los resultados presentados, como los diseños metodológicos desarrollados y testados en campo, suponen una importante contribución al campo de la Transición Agroecológica, los procesos de ciencia con la gente, y la adopción y escalado de prácticas de manejo sostenible de suelos. Esto se ve reforzado, al haber sido aplicado y desarrollado en un contexto semiárido, donde los procesos de adopción de innovaciones hacia la sostenibilidad, así como la evaluación de sus impactos, son de medio y largo recorrido.

Durante el desarrollo de la tesis, la doctoranda Raquel Luján Soto ha demostrado una alta capacidad y autonomía para la organización y planificación de su trabajo de investigación de una forma muy bien diseñada, estructurada y elaborada. La primera prueba de ello ha sido que ha conseguido una beca doctoral personal de la Fundación la Caixa para la elaboración de su investigación. Tiene mucho mérito por haber desarrollado una de las primeras investigaciones profundamente interdisciplinares ytransdisciplinares de monitorización y evaluación participativa de la agricultura regenerativa resultando en cuatro publicaciones científicas en revistas de alto impacto. La doctoranda ha combinado trabajo de campo con entrevistas, toma de muestras de suelo y vegetación, análisis químico y físico de laboratorio, organización de talleres con agricultores y análisis de resultados, todos aplicando metodologías científicas innovadoras y rigurosas. Ha presentado su trabajo en 2 congresos científicos internacionales y 2 congresos nacionales y a un público más amplio en un ”Digital Summit del Global Landscape Forum”. A lo largo de su trabajo en esta investigación participativa ha colaborado estrechamente con los agricultores y ha demostrado ser una muy buena comunicadora a nivel científico y para la diseminación, que consigue contactar con grupos de personas muy diversos. Durante el desarrollo de su investigación la doctoranda ha realizado una estancia en el ‘Mediterranean Institute for Agriculture, Environment and Development’ de la Universidad de Évora (Portugal).De esta investigación han derivado las siguientes publicaciones:

1. Luján Soto, R., Cuéllar Padilla, M., and de Vente, J. 2020. Participatory selection of soil quality indicators for monitoring the impacts of regenerative agriculture on ecosystem services. *Ecosystem Services*, *45*, 101157. https://doi.org/10.1016/j.ecoser.2020.101157

2. Luján Soto, R., Martínez-Mena, M., Cuéllar Padilla, M., and de Vente, J. 2021. Restoring soil quality of woody agroecosystems in Mediterranean drylands through regenerative agriculture. *Agriculture, Ecosystems & Environment*, *306*, 107191. https://doi.org/10.1016/j.agee.2020.107191

3. Luján Soto, R., de Vente, J., and Cuéllar Padilla, M. 2021. Learning from farmers´ experiences with participatory monitoring and evaluation of regenerative agriculture based on visual soil assessment. Journal of Rural Studies (in review)

4. Luján Soto, R., Cuéllar Padilla, M., Rivera Méndez, M., Pinto-Correia, T., Boix-Fayos, C., and de Vente, J. 2021. Participatory monitoring and evaluation of regenerative agriculture to enable social learning, adoption and out-scaling. Ecology & Society (in press)

Por todo ello, se autoriza la presentación de la tesis doctoral.

Córdoba, 1 de septiembre de 2021

Firma de los directores

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Raquel Luján Soto

Thesis

Submitted in fulfillment of the requirements for the degree of doctor by the

University of Córdoda

"No monopolice su conocimiento ni imponga arrogantemente sus técnicas, más bien respete y combine sus habilidades con el conocimiento de las comunidades investigadas o de base, teniéndolos como socios en pleno derecho y co-investigadores."

Fals Borda

Conference of southern sociologists. Atlanta 1995

La palabra humano se compone por el prefijo latín *humus-* que significa tierra y el sufijo *-anus* que indica pertenencia. Si queremos desarrollar ecosistemas sanos, funcionales y sostenibles precisamos entender que pertenecemos a la tierra y los suelos forman parte de nosotras.

"Um dia conversando com um agricultor agroecologico da Zona da Mata (Brasil) perguntei-lhe. Você sabe por que os solos aqui são vermelhos? Ele respondeu: porque têm vergonha de ficar pelados."

Irene Cardoso.

Profesora del departamento de suelos de la Universidad Federal de Viçosa, Brasil.

"He escogido muy pronto la libertad y, por lo tanto, también la incertidumbre. Frente a una vida gris y previsible, he optado por la locura de creer en mis sueños, de dibujar mis propios caminos en un mapa hecho a mi propia medida. Me juré a mi mismo que no moriría sin haber vivido."

Alain Vigneau.

Vida de Clown. La tragicomedia del ser

A mi madre y a mi abuela,

mujeres fuertes, luchadoras y sencillas,

mis fuentes de luz e inspiración,

por enseñarme a amar la tierra.

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Chapter 1

General Introduction

Chapter 1: General Introduction

1. Now or desert: shifting the agricultural model to reverse land degradation

Land degradation requires transition towards more sustainable agriculture (FAO 2018a, Cherlet 2018, UNCCD 2018, Tittonell 2015). Agroecosystems worldwide are facing unprecedented challenges posed by land degradation and related major threats such as climate change, desertification, biodiversity loss, decreasing crop production, food insecurity, and increased risk of floods and droughts (IPBES 2018, Cherlet 2018). The recently edited third edition of the World Atlas of Desertification (2018) reported that approximately one third of the earth's land is severely degraded and up to 75% is suffering from ongoing degradation, affecting the livelihoods of over 3.200 millions of people worldwide (IPBES 2018). The consequences of land degradation are especially devastating in semiarid regions, covering about 41% of the global land surface, which are recognized as one of the most susceptible biomes to land degradation while major providers of ecosystem services crucial for building resilience and sustainable livelihoods (Aguilera et al 2020, Berrahmouni et al 2015).

Agriculture is a major cause of land degradation due to unsustainable management practices (Gibbs and Salmon 2015, Cherlet et al 2018) that deteriorate the quality of soils compromising their capacity to function and deliver ecosystem services, and the failure of institutions to enact initiatives that include farmers in the decision process towards a sustainable change (Wilson and Junti 2005). Intensive tillage, monocultures, and use of chemical fertilizers and pesticides are some of the practices that are frequently used in the industrial agriculture model, and underlying land degradation. Given the bleak picture of our global agroecosystems, preventing, halting and reversing their degradation by promoting sustainable land management (SLM) approaches to rehabilitate soil quality and functioning has become an urgent need (Cherlet et al 2018, IPBES 2018, FAO 2018a). This challenge and quest for a transition towards more sustainable agroecosystems is at the forefront of main international agendas, as reflected in the Land Degradation Neutrality targets of the United Nations Convention to Combat Desertification (UNCCD), the United Nations Sustainable Development Goals (SDG), the french 4 per mille initiative, the European Union Green Deal and its Farm to Fork and Biodiversity strategies, and the new European Soil

Health and Food Mission "Caring for Soil is Caring for Life" (UNCCD 2018, European Commission 2019, 2020, European Environment Agency 2019, Rumpel et al 2018, Veerman et al 2020).

While agriculture is a major driver of land degradation, it is at the same time the sector most strongly affected by it, and can potentially form an important part of the solution. For this, it is necessary to foster and support agroecological transitions (HLPE 2019), promoting a shift of the current industrial agricultural model and creating supportive conditions for traditional agricultural systems towards sustainable and productive agroecosystems grounded in Sustainable Land Management (SLM) as potential foreseen solution (HLPE 2019, Rhodes 2017).

During the past decades there has been unprecedented interest and research effort in finding SLM approaches to prevent further degradation and effectively restore degraded agroecosystems. To this effect, Regenerative Agriculture (RA) has increasingly gained recognition as a promising solution to reverse land degradation and enhance ecosystem services (Giller et al 2020, Rhodes et al 2013, 2017). However, RA impact assessment has been limitedly addressed or provided contrasting results (Palm et al 2014), generating a mismatch between RA potential benefits and proven impacts, a fact that contributes to a still very low global adoption of RA. Furthermore, in semiarid regions, where water scarcity limits soil biological activity, soils are generally low responsive to management changes, and visible soil quality changes might take time to appear, hindering the adoption of RA where it is more needed.

Despite significant advances in scientific research and extensive local knowledge regarding SLM that can contribute to landscape restoration and prevention of further degradation, soil degradation continues to be a major sustainability issue, farmers´ SLM adoption still remains a major contemporary challenge, and soil conservation/restoration programs do often not reach expectations due to multiple barriers for adoption (Bouma 2019, Albaladejo et al 2021).

To advance in the adoption of effective solutions to land degradation, it is therefore vital to understand the socioeconomic and cultural drivers and barriers for adoption of conservation measures (Karimi et al 2021). Multiple factors influence the complexity surrounding farmers´ SLM adoption, including: assets, ambitions, values, agronomic, financial, tenure, market and policy barriers and opportunities, farmland characteristics and, closely related, knowledge and access to information on SLM, and farmers´ social networks (Schoonhoven and Runhaar 2018, Karimi et al 2021). To support the transition towards SLM requires an enabling environment and close collaboration with all stakeholders involved (Dumanski 2015, Sanz et al 2017, Aguilera et al 2020, Albaladejo et al 2021). Regarding the adoption of innovative SLM approaches in semiarid regions, like RA, where there are none or limited experiences that serve as reference for farmers to build on, there is increasing interest from scientists, policy makers, NGO's and farming communities to generate empirical evidence and joint efforts between farmers and researchers and increase the understanding of SLM impacts to overcome knowledge gaps, support farmers, and increase the confidence to foster SLM adoption and outscaling. There is however insufficient knowledge and experience in how such collaboration should be designed and what can be expected from it.

2. Regenerative Agriculture to foster agroecological transitions

Regenerative Agriculture is a sustainable land management approach that has gained increasing recognition as potential alternative to challenge the status quo of mainstream industrial agriculture (Giller et al 2021, Rhodes 2017, 2013), and by the fact that without rebuilding soils as a natural resource base, other SLM approaches (i.e. organic agriculture), have been insufficient to address land degradation while supporting the food and natural resource needs of a growing human population (Rhodes 2017).

Regenerative agriculture (RA) was firstly introduced in 1983 by Robert Rodale, the founder of the ecological research institute 'Rodale Institute'. Until well into the first decade of the 21st century, the RA concept was almost consigned to oblivion (Giller et al 2021). Recently, its focus on combating climate change and provisioning of ecosystem services has spiked its use by NGO´s, companies, associations, and researchers, coinciding with the increased concern and scientific evidence of the impacts of climate change and land degradation (Cherlet et al 2018), as is also reflected in the EU soil health mission and UN decade for ecosystems restoration (2021-2030). About to celebrate its 4th decade, RA still lacks a comprehensive scientific definition (Scheefer et al 2020), and interpretations vary depending on the farming system where RA is applied, restoration goals pursued and user´s objectives (Elevitch et al 2018, LaCanne and Lundgren 2018, Rhodes 2017). Most authors converge in understanding RA as an innovative SLM approach that focuses on the restoration of soil quality to enhance the provision of ecosystem services by optimizing resource management (Scheefer et al 2020).

Contemporaneously to the concept of RA, although first mentions can be traced back to the 1930s (Wezel et al 2009), the concept of Agroecology gained international recognition with Altieri´s definition of agroecology principles. Agroecology principles are well defined and documented (Wezel et al 2020), and nowadays this term has gained prominence in the scientific, agricultural and political discourse (Wezel et al 2020, HLPE 2019, FAO 2018a, 2018b). Agroecology is a dynamic concept with different definitions that, recognizing its transdisciplinary nature, place greater emphasis on the term understood as a science, a social movement, a set of farming practices, or different combinations of these 3 dimensions, depending on the context, concerns and priorities where agroecology is applied (Wezel et al 2009, 2020). As a science agroecology has been defined as the integration of research, education, action and change that brings ecological, economic and social sustainability to the food system (Gliessman 2018) using participatory action research (PAR) as its main research approach to facilitate transitions towards environmental, economic and socially sustainable agroecosystems (López-García 2021, Mendez et al 2017, Guzman et al 2013, Cuéllar and Calle 2011). As a set of practices, agroecology aims to improve agricultural systems by harnessing natural processes, creating synergies amongst the components of agroecosystems (Gliessman 2007, 1990), minimizing the use of agrochemical and agrotoxics, and using ecological processes and ecosystem services for the development and implementation of agricultural practices. Social movements see agroecology as a solution to transform agriculture for building locally relevant food systems that strengthen the economic viability of rural areas based on short marketing chains, and both fair and safe food production. The linkages and co-evolution of these 3 dimensions constitute the holistic approach of Agroecology (Wezel et al 2020).

From an agronomic perspective, RA and Agroecology share a common ground, as their principles and practices are broadly coincident, if not the same (Giller et al 2021, Atieri et al 2015). However, one main aspect differentiates both concepts. In 1996, during the World Food Summit held in Rome by FAO, La Via Campesina, an international peasant movement formed by more than 180 organizations from 81 countries, coined the term 'food sovereignty' and proposed it as the only way to end world hunger with environmentally sound, economically fair and socially just food systems. In brief, food sovereignty was defined as "the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems". Since then agroecology has been closely tied to food sovereignty (Wezel et al 2020). This link largely explains the evolution, expansion of scale, and scope of study of agroecology as a science, moving from the plot, to the farm and agroecosystem level, to encompassing the entire food system, and incorporating social and economic aspects. Social and economic objectives pursued with agroecology, include: financial independence of farmers with respect to agro-industries, market access and autonomy to favor self-governance, sustainability and adaptability of the system facing socio-economic shocks and climate change, social equity among all the stakeholders on all levels of the food system, rural development and preservation of the rural fabric, democratic governance, and exchange and sharing of knowledge in an horizontal way including different expertise (Dummont et al 2015). Thus, agroecological transitions can be seen as a sum of gradual changes in the socio-ecosystem that would allow it to improve its performance including social, economic and environmental aspects, and thus contribute to its greater resilience and adaptability to changes (Aguilera et al 2020, Tittonell 2019, 2015). The agroecological transition in terms of agricultural management practices implies the adoption of SLM by optimizing farming management practices, or the redesign of the system (Aguilera et al 2020, Tittonell 2019).

Returning to the concept of Regenerative Agriculture, this innovative SLM approach has recently gained increasing recognition as a plausible solution to restore degraded agroecosystems worldwide (Giller et al 2021). In the absence of a clear definition of RA, and lack of regulation and protection of the term, governmental agencies, industries and sector organizations might use different definitions depending on particular interests and even as a green washing strategy (Schreefel et al 2020), a fact that is raising increasing criticism and concern (Schreefel et al 2020, Giller et al 2021). In this thesis RA is understood as a farming approach that focuses on the restoration of soil quality as a basis to reverse land degradation, increase biodiversity, boost production, improve water availability and enhance the delivery of multiple ecosystem services (Rhodes 2017, 2013) by following 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). These principles translate into a diversity of practices at landscape and farm level that must be adapted to the different environmental and sociocultural contexts where they are applied (Rhodes 2017). Some common RA practices at landscape level include: keyline design, planting following contour curves, adoption of terraces, implementation of hedge rows and field hedges, creation of ponds and water reservoirs, increasing perennials and diversification of crops (Rhodes 2017, 2013). At farm level, most common RA practices include: reduced and no tillage, maintenance of permanent natural ground covers, adoption of green manures, and addition of organic amendments such as different types of compost and animal manure (Rhodes 2017, 2013). RA focuses strongly on the environmental dimension of sustainability, while objectives regarding social and economic dimensions continue to be vague and lack concrete frameworks for implementation (Schreefel et al 2020).

In recent years, community based farming associations worldwide have started to promote RA as a solution to restore degraded farmland, and included social and economic objectives that can be easily associated with Agroecology. In these cases the line that separates Agroecology and RA becomes blurred, and RA is used as SLM approach to foster agroecological transitions. This is the case of the AlVelAl agroecology association (www.alvelal.es) that promotes the adoption of RA in the high steppe plateau region of southeast Spain, which is the study area of this thesis. By applying RA, the AlVelAl agroecology association aims to restore the natural, social, and financial capital in the high steppe plateau region, and return the inspiration to people, by regenerating vast extensions of almond orchards. Furthermore AlVelAl promotes the diversification of market options and self-management of economic processes, aiming to rehabilitate the local economy and social fabric. Acknowledging the challenge that entails a large-scale and long term adoption of RA, AlVelAl started research collaborations with several research institutions, with the focus to create synergies and support research projects that aim to solve real problems and community knowledge needs, and that are practical, applied and relevant to the stakeholders involved.

3. Participatory action research

Top-down approaches have been found to be of low effectiveness to overcome barriers to adoption of SLM and support actual change on the ground (Chinseu et al 2019, Abi et al 2018). This may respond to the fact that hierarchical approaches commonly neglected or disregarded existing local knowledge, farming experiences, farmers´ needs and objectives, promoting solutions that were not adapted to the context where they were applied, nor were relevant for intended adopters (Chinseu et al 2019, Abi et al 2018). Participatory action research (PAR) emerged in the 70´s as an alternative to technocratic top-down research methods that, until nowadays, have been widely applied in the field of agricultural sciences, and have failed to involve farming communities into sustainable land management (Mendez et al 2017, Guzmán et al 2013, Cuéllar and Calle 2011, Fals-Borda and Rahman 1991). PAR aroused from the need to rescue local peasant knowledge recognizing the value of their diversity of farming practices and management of natural resources to produce food, conserve biodiversity, and generate multifunctional landscapes, maintaining for centuries sustainable agroecosystems based on resilience (Grajales 2009, Fals-Borda and Rahman 1991), and the need to collaboratively identify tailor-made solutions that are more likely to be adopted.

Since inception, PAR has been increasingly proposed as a way of democratizing the creation of knowledge grounded in real community needs to foster learning for social change (Fals-Borda 1985, Cuéllar and Calle 2011, Guzmán et al 2013, Mendez et al 2017, Lopez-García et al 2021). PAR emphasizes active participation, experimentation and action by members of communities that take part as subjects of the research. Thus, in PAR processes, researchers and non-researchers engage in an investigation, with the aim to better understand and resolve an issue of interest to all the parties involved (Mendez et al 2017). From this point of view, horizontal modes of relationship between farmers, practitioners and researchers are proposed based on the idea that research must be done with people through a "dialogue of wisdoms" (Altieri and Toledo 2011, Anderson et al 2018) and the recognition and respect of rural communities, their knowledge and their way to relate with nature (Grajales 2009). Doing science with people requires mechanisms to encourage meeting, joint reflection and the collective development of findings and conclusions (Cuéllar and Calle 2011).

PAR processes are flexible and diverse, however all PAR processes have a common background in collective self-experimentation processes backed up by evidential reasoning, fact-finding and learning (Cuéllar and Calle 2011, Mendez et al 2017). It is worth noting that, although there is no single recipe, most PAR processes are guided by these same key principles (Mendez et al 2017): 1) *Shared research interest:* PAR facilitates the identification of solutions to problems that are of common interest of all parties involved, through diverse methodologies and with triangulation from multiple perspectives. 2) *Belief in collective power:* the contribution of all participants is recognized and valued; 3) *Commitment to participation:* all partners share ownership and contribute in as many phases of the research as possible; 4) *Humility:* PAR is a space that acknowledges and values the wisdoms and limitations of each partner; 5) *Trust and accountability:* PAR facilitates the creation of trust and accountability by generating spaces for action, giving opportunities to share leadership and designing mechanisms for resolving conflicts; *6) Communication:* PAR processes acknowledge biases, amplify traditionally marginalized voices and perspectives, pursue transparency and prioritize disseminating results in multiple formats to increase accessibility.

Thus, PAR has been used to facilitate agroecological transitions and support farmers in the adoption of tailor made SLM solutions, through the construction of knowledge that is relevant and useful for all stakeholders involved. PAR has as main purpose the development of participants´ capacities for the organization, diagnosis, planning, implementation, evaluation and decision-making of aspects related to farm and natural resource management, consolidation of autonomous marketing, and in general, the transformation of participants´ realities to improve their environmental, social and economic conditions with a view to endogenous rural development (Mendez et al 2017, Guzman et al 2013, Cuéllar and Calle 2011). In brief, PAR aims to build community empowerment for achieving sustainable agri-food systems through collective action-reflection processes.

Participatory research involving farmers and researchers in an horizontal manner represents an opportunity to create tight collaborative networks, to facilitate the integration of local and scientific knowledge, thereby stimulating knowledge sharing and social learning, co-innovation and co-creation of solutions to help the transition towards sustainable agroecosystems (Raymond et al 2010, Cuéllar and Calle 2011, De Vente et al 2016, Reed et al 2018, Wiget et al 2020). Within participatory research, involving farmers and researchers into participatory monitoring and evaluation (PM&E) the impacts of innovative SLM, like RA, can potentially lead to enhanced innovation adoption by improving farmers´ access to information and knowledge on the effectiveness of SLM, and via the development of relationships and trust among stakeholders (Reed et al 2007, Stringer et al 2013, De Vente et al 2016). While these claims are often made, the complexity involving participatory processes in leading to long term adoption of SLM solutions is context dependent (Sterk et al 2013) and more knowledge and evidence in needed to make PAR claims to fully operate.

4. Participatory monitoring and evaluation of sustainable land management

Participatory Monitoring and Evaluation (PM&E) research is a horizontal approach included within PAR, which advocates for the full incorporation of the local population in the different phases of research for development processes (Estrella and Gaventa 1998, Estrella et al 2000, Vernoy 2006). PM&E strives to be an internal learning process that enables people to reflect on past experience, examine present realities, revisit objectives, and define future strategies, recognizing the different needs of stakeholders and negotiating their interests. PM&E seeks to generate processes that respond to the information needs of all those stakeholders involved, promoting self-reliance in decision making and problem solving. Thereby PM&E is foreseen to enhance learning and strengthen people's capacities to take action and promote change, which have led to the expectation that PM&E can facilitate adoption of contextualized SLM, and promote inclusive, relevant, resilient and long lasting sustainable transitions.

PM&E stands out from other research approaches for being eminently empirical and practical, since it is nourished by on field experimentation, and for being flexible and adaptive to local contexts and constantly changing circumstances, which stresses the need to select methods and tools that are culturally adapted and tailor made to the local context (Vernoy et al 2006). Most PM&E processes have in common the same 4 principles, and follow the same 4 phases, for their implementation and development (Estrella and Gaventa 1998, Estrella et al 2000). PM&E principles are: 1) *Participation principle:* active involvement of participants in all research phases, from decision making, to implementation, monitoring and evaluation of solutions, and use of evaluation results. 2) *Learning principle:* local knowledge and resources are the basis for activating a learning process among all participants in order to develop necessary conditions, local capacities and empower people to transform their reality. 3) *Negotiation principle:* negotiation is embedded in PM&E since it articulates a diversity of perceptions, needs and demands, seeking to transform power relations, and developing trust, support and empathy in the participants. 4) *Flexibility principle:* PM&E is a dynamic and flexible process that continually adapts to local needs and circumstances.

PM&E phases include: *1) Establishing the framework for the PM&E process, determining research objectives and indicators:* at initial stages stakeholders involved in the PM&E must define the objectives, including what will be monitored, how and by whom, *2) Gathering data:* data collection can include the use of both quantitative and qualitative methods and tools. The monitoring system developed may include a common set of indicators, or different sets of indicators for different stakeholder groups, *3) Analyzing data:* participants are involved in analyzing successes and constraints and in the formulation of conclusions and lessons learned, *4) Documenting and sharing information and defining actions to be taken:* results are shared between participants involved, and with other stakeholders, and discussed to decide appropriate actions to be taken based on the findings.

In PM&E phases different participatory techniques, methods and tools can be used and combined to achieve established targets, adapt to available resources, satisfy information needs of stakeholders involved, and enrich the results of the evaluation process. In this thesis we understand PM&E research as the joint collaboration between farmers and researchers in assessing the effectiveness of SLM at multiple levels. It implies making use of different participatory activities and tools to facilitate interaction, experimentation, knowledge exchange, integrate local/indigenous and scientific knowledge, learning, reduce power imbalances, critical evaluation, and engage stakeholders to support long term SLM. With participation we mean the active involvement of participants in the whole monitoring and evaluation process, supported by facilitation. We understand monitoring and evaluation of SLM as a continuous iterative learning and adaptation process that involves intensive local and scientific data gathering, testing of SLM, and the joint discussion of results by farmers and researchers.

PM&E of SLM holds the promise that it will enhance the relevance, legitimacy, and credibility of the SLM under research, broadening the basis of support for its implementation, and eventually lead to enhanced ownership and community empowerment, attitudinal change, and collective action for SLM adoption (Sol et al 2013, Van Der Wal et al 2014, Suškevičs et al 2018). However, there still a lack of empirical evidence if and how participatory monitoring and evaluation leads to individual and social learning and to actual increased adoption of SLM solutions. A number of studies reporting PM&E experiences have warned that achieved results 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).

5. The high steppe plateau of southeast Spain

The high steppe plateau of southeast Spain (Figure 1) is one of Europe's regions most affected by land degradation and desertification processes (Martínez-Valderrama et al 2016). The economy of the region largely relies on the primary sector and related second markets. One major characteristic of the high steppe plateau region is its depressed economy with around 30% of its active population unemployed, which determines two major social worries, the aging of the population and the migration of young people contributing to the depopulation of the region (Cruz Pardo et al 2010). The landscape forms a mosaic integrating vast extensions of rainfed agriculture, mostly woody crops and cereals, esparto scrublands and dry open Mediterranean forest (Figure 1).

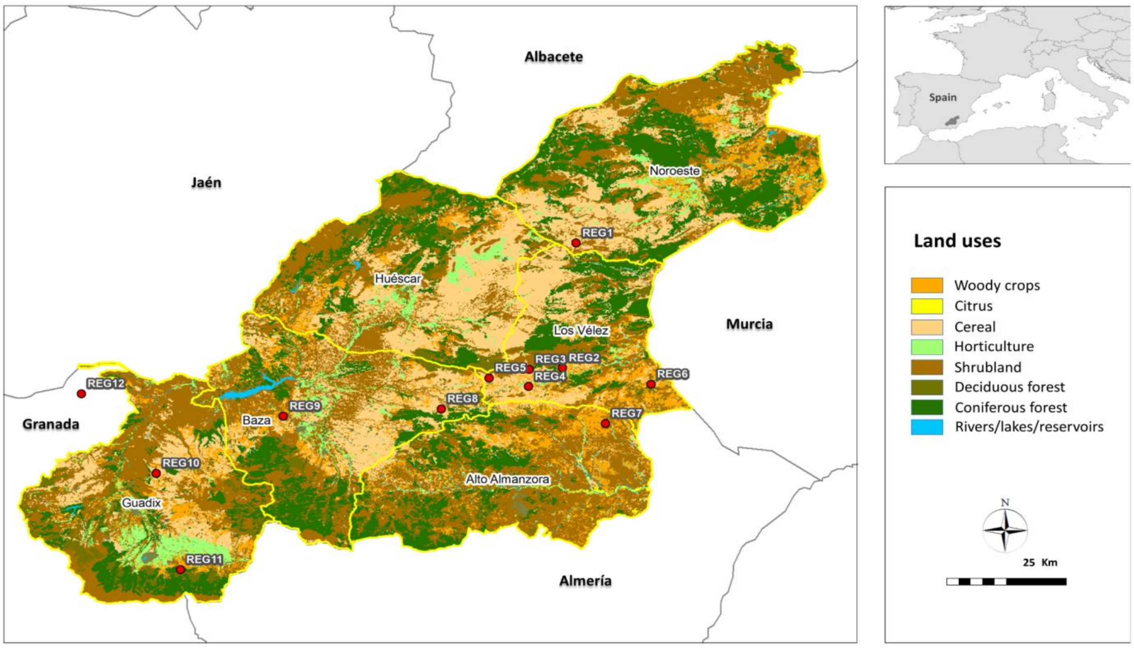


Figure 1 Map of the high steppe plateau region where the AlVelAl agroecology association operates. Yellow lines define county borders within the autonomous regions of Andalusia and Murcia, red dots represent the 12 farms involved in the participatory research project of this thesis.

The industrialization process, particularly from the second half of the XX century, and entrance of Spain to the EU has determined the social, economic and environmental dynamics in the region, which are closely intertwined.

Since the 1950's, the region has experienced major farm management changes. The mechanization of farming activities and the application of agrochemicals was patently promoted by the green revolution model and endorsed by governmental institutions through subsidies to farmers until the late 1990. This fact supposed a transition from traditional agriculture, which was essentially organic, to conventional farming resulting in multiple environmental, social and economic impacts. Environmentally, soil and water conservation structures were abandoned to facilitate the transit of agricultural machinery (Bellin et al 2009), it supposed a shift from cereal to woody perennial farming (Cruz Pardo et al 2010), the near total disappearance of sheep farming (Toro-Mujica et al 2015), and the intensification of tilling practices (Clar et al 2018), resulting in a considerable increase of erosion rates and land degradation (Garcia-Ruiz 2010, van Leeuwen et al 2019).

Image 1 Landscape in the Alto Almanzora county of the high steppe plateau of southeast Spain dominated by conventional and organic almond farms with bare soil due to frequent tillage.

Socially, it supposed a break up with the traditional peasant lifestyle and the loss of autonomy of a self-controlled resource based system, including loss of non-material resources such as farmers´ social networks and transfer of traditional knowledge (Otero Rozas et al 2013, Van der Ploeg 2012). The loss of farmers' autonomy was also reflected in the economic sphere, particularly evidenced by reduced economic profits and higher farmers´ dependence on subsidies to make farming economically viable (van Leeuwen et al 2019). Nowadays, rainfed almond farming occupies the largest area destined for woody crops in the high steppe plateau (Image 1), and is the fastest expanding (i.e. 11 % between 2010 and 2017), due to an increasing economic appreciation and doubling of almond nuts market price (Ministerio de Agricultura Pesca y Alimentación 2018). In fact, this region represents the world's largest area for the production of organic rainfed almonds.

While changes in land use and farming management to more intensive systems lie behind the human causes exacerbating land degradation; torrential rainfall events, highly erodible soils and steep slopes are behind the natural causes. The climate is semiarid Mediterranean, with on average 350 mm of annual precipitation concentrated in few rainfall events, wide daily and seasonal thermal amplitudes, characterized by long periods of drought, on average 330 dry days per year, and frost periods that usually extend about 6 months (Cruz Pardo et al 2010). Average winter and summer temperatures range between 0-10 ◦C and 20-28 ◦C respectively (Cruz Pardo et al 2010). Predominant soils are Calcic Cambisols, Calcic Regosols and Leptosols (FAO classification), covering about 82 % percent of the soils in the study area (Cruz Pardo et al 2010). These extreme climatic conditions constrain vegetative growth to very narrow periods of time and lead to frequent loss of harvest due to frost, hail and drought, reflected in highly irregular crop yields between years.

Confronted with this panorama, in 2015, local farmers created the agroecology association AlVelAl with the support of the Commonland foundation, regional governments, local businesses, and research institutions. The AlVelAl agroecology association aims to foster the implementation of regenerative agriculture to restore vast extensions of degraded land by offering technical advice, economic and informational support to farmers (www.alvelal.es).

While promising (De Leijster et al 2019), RA has not yet been widely adopted by farmers of the steppe high plateau of southeast Spain, nor in semiarid regions in general. 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 are major obstacles hindering RA adoption.

To effectively address this knowledge gap, support farmers and expedite RA adoption requires joining efforts between farmers and researchers, putting together local and scientific knowledge to improve the understanding of RA. Bringing these issues to center stage, we initiated this PhD research project in close collaboration with the AlVelAl association around participatory monitoring and evaluation the impacts of RA on soil quality and related ecosystem services, involving local farmers pioneering in implementing RA practices, and researchers, as described in this thesis. By bringing together pioneering RA farmers and researchers into PM&E, I aimed to integrate the existing experiences and local knowledge on RA, generating a knowledge based from where to build on, support and accompany farmers by providing scientific data that could help them to contrast, validate and evaluate the restoration potential of the different RA systems on soil quality and agroecosystem functioning of degraded almond farms.

It is expected that involving farmers and researchers in the assessment, monitoring and evaluation of RA will help to overcome adoption barriers, by generating a greater knowledge base grounded on empirical evidence, helping them to adapt the design of their agroecosystems to maximize RA benefits on soil quality restoration and provision of ecosystem services, increasing the confidence on RA, and creating ownership and trust through social learning. There is however limited empirical evidence of PM&E processes on social learning to increase SLM adoption, and this is even scarcer in semi-arid contexts, where the processes of adoption of innovations towards sustainability, as well as the evaluation of their impacts, are medium and long haul.

6. Thesis hypotheses and objectives

The main hypotheses of this thesis are:

1. Regenerative agriculture contributes to improving soil quality, crop productivity and the provision of multiple ecosystem services in semiarid areas, helping to generate more sustainable agroecosystems.

2. Involving farmers in participatory monitoring and evaluation of regenerative agriculture contributes to enhancing knowledge exchange, social learning and increased understanding on the impacts and benefits of RA, enhancing adoption of effective solutions to reverse land degradation.

The main objective of this thesis is to contribute to enhanced knowledge exchange between farmers and researchers through participatory monitoring and evaluation the impacts of regenerative agriculture on soil quality and agroecosystem restoration, to improve the understanding and effectiveness of regenerative agriculture and thereby facilitate its large-scale adoption. This main objective is articulated by two general objectives, each one subdivided by two specific goals:

1. To assess the impacts of regenerative agriculture on soil quality restoration, productivity and ecosystem services in almond agroecosystems of Mediterranean drylands to advise the redesign towards more resilient and sustainable agroecosystems.

1.1. To select most relevant local and technical indicators of soil quality to allow a comprehensive and feasible assessment of regenerative agriculture impacts on agroecosystem sustainability, informative and useful for farmers, researchers and stakeholders involved (Chapter 2).

1.2. To demonstrate the contribution of regenerative agriculture on the restoration of soil functionality and sustainability of agroecosystems through participatory monitoring using selected technical and local indicators (Chapter 3 and Chapter 4).

2. To explore how participatory monitoring and evaluation can contribute to increase knowledge exchange and enable social learning supporting farmers´ adoption and out-scaling of effective solutions.

2.1. To assess how participatory monitoring and evaluation contributes to shaping farmers' knowledge and perceptions about the impacts and benefits of regenerative agriculture on land degradation, crop productivity, and socio-economical aspects (Chapter 5).

2.2. To evaluate the contribution of participatory monitoring and evaluation to strengthen and enlarge farmer relations and social networks through the acquisition, exchange and more horizontal distribution of knowledge on regenerative agriculture (Chapter 5).

7. Research methodology

Figure 2 illustrates the interdisciplinary framework of this PM&E research (Figure 2) that combines a number of quantitative and qualitative methods in order to address the two objectives and subdivided specific objectives that vertebrate this thesis.

With regard to objective 1:

The methodology to address objective 1.1 consisted in a literature review and the design of a PM&E framework which vertebrates the whole PM&E research. We develop a series of participatory workshops involving participating local farmers and researchers for the identification and selection of local indicators of soil quality. We developed a visual soil assessment tool integrating selected local indicators. In parallel, based on scientific literature and expert consultation we identified, selected and prioritized technical indicators of soil quality (Figure 2, step 1).

To address objective 1.2, I assessed RA impacts by using previously selected technical indicators of soil quality. I clustered RA systems based on the RA practices farmers applied and used statistical analysis to establish significant differences and find insights on the impacts of different combinations of RA practices on soil quality to help finding best solutions (Figure 2, step 2.a). In parallel, participating farmers assessed RA impacts at their farms by using the previously developed VSA tool integrating local indicators of soil quality (Figure 2, step 2b), and evaluated the PM&E research project for further improvements.

Participatory assessment of the impacts of regenerative agriculture on soil quality restoration, productivity and ecosystem services in almond agroecosystems of Mediterranean drylands can help to advise the redesign of management strategies towards more resilient and sustainable agroecosystems (objective 1) supported by a strong empirical and scientific base.

With regard to objective 2:

To address objective 2.1, I used fuzzy cognitive mapping (FCM), a semi-quantitative and graphical methodology, before starting monitoring activities and after 3 years of PM&E research, to evaluate the influence of the PM&E research on the evolution of farmers´ perceptions of RA impacts on land degradation, crop performance and related socioeconomic and environmental aspects.

To address the objective 2.2, I used social network analysis (SNA), a semi-quantitative and graphical methodology, before starting monitoring activities and after 3 years of PM&E research, to evaluate the influence of the PM&E research on the evolution of farmers sharing of RA information to the people integrating their relational networks.

The combination of FCM and SNA allows to evaluate whether the PM&E research contributed to enable learning and building social interactions of support, trust and exchange of information, generating a collective change in participating farmers´ perceptions about RA impacts, or in other words, whether PM&E contributed to farmers social learning on RA (objective 2), which is a precondition to favor adoption and out-scaling of farming innovations like RA.

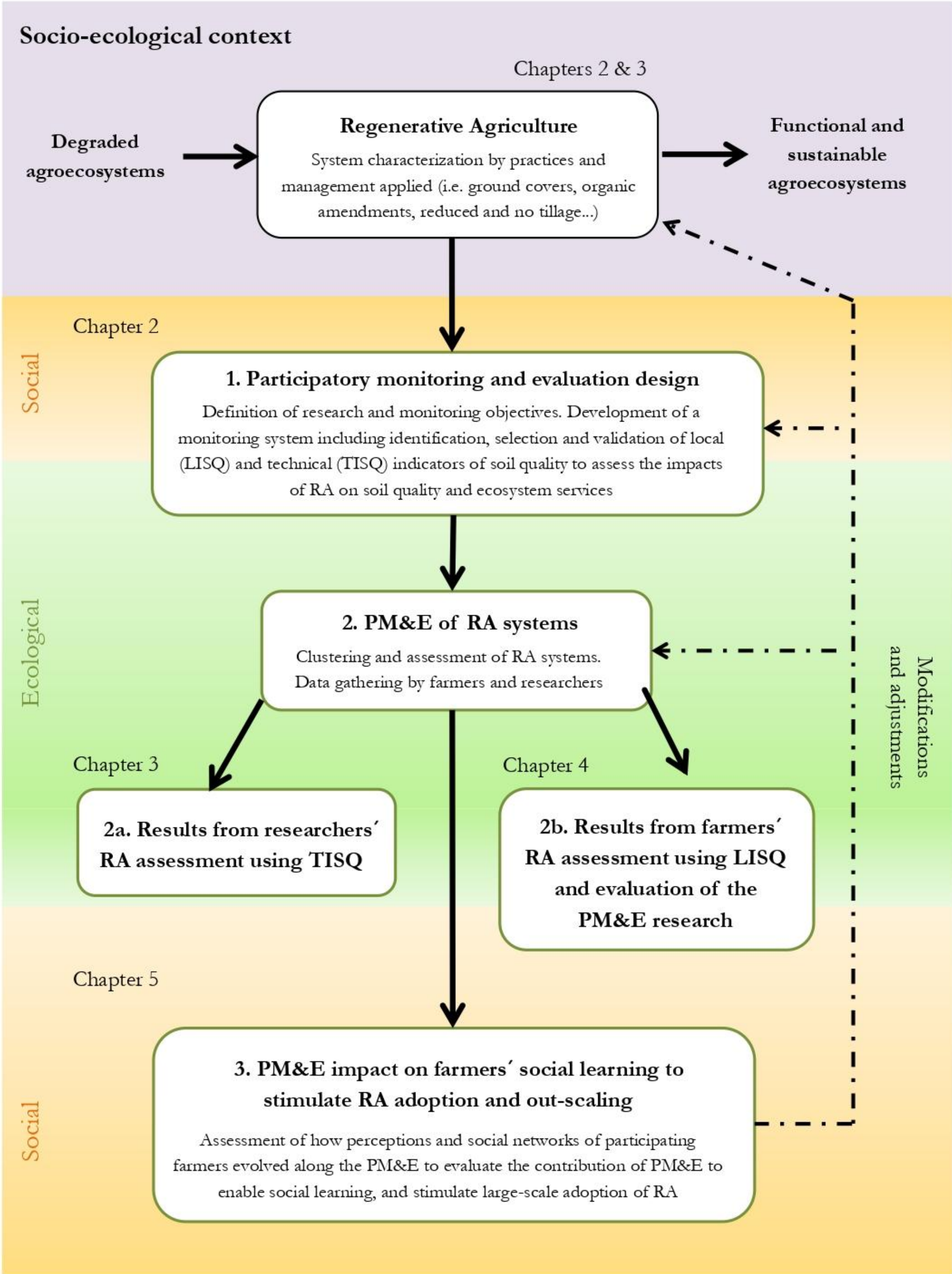


Figure 2 Methodology used to address the objectives of this thesis research.

8. Thesis Outline

After the introduction in Chapter 1 to the topic, research objectives and general characterization of the study area used in this thesis, the following four chapters have either been published or are under review in international scientific journals. The last Chapter 6 provides a synthesis of overall conclusions of this thesis.

Chapter 1 discusses regenerative agriculture as a suitable farming approach for the restoration of soil quality and ecosystem services in degraded agroecosystems, and the relevance of using integrative and interdisciplinary participatory research based on participatory monitoring and evaluation to enhance a large-scale adoption of regenerative agriculture in semiarid regions. It also presents the study area, the high steppe plateau of southeast Spain, where this research was carried out, and where an ongoing transition towards regenerative agriculture is taking place. The information described in this chapter ends up introducing the research hypotheses and objectives, general methodology and thesis outline.

Chapter 2 presents a new methodological framework to guide the PM&E process and to facilitate the selection of indicators to monitor the impacts of regenerative agriculture on soil quality and ecosystem services. This chapter presents most relevant local and technical indicators of soil quality, identified together with farmers, to co-generate a monitoring system for assessing the restoration process of degraded agroecosystems. It discusses the complementarity of both sets of indicators integrating the monitoring system to provide a more comprehensive, relevant and feasible assessment of the impacts of regenerative agriculture. It also presents a co-developed visual soil assessment tool named "the farmer manual" integrating selected local indicators of soil quality. The farmer manual and selected technical indicators of soil quality, as well as the participatory research process, developed and presented in this chapter are crucial for the evaluation of regenerative agriculture by farmers and researchers, and for the evaluation of the PM&E research project presented in the following chapters of this thesis.

Chapter 3 presents the results of the researchers´ impact assessment of regenerative agriculture on soil quality and agroecosystem restoration in the farms of participating farmers using technical indicators of soil quality that include physical, chemical and biological soil properties and crop performance indicators.

It presents the restoration results of 4 different types of regenerative treatments, distinguished based on the regenerative practices applied by farmers.

Chapter 4 presents the results of farmers´ impact assessment of regenerative agriculture using the co-developed farmer manual for visual soil assessment integrating local indicators of soil quality. It also presents farmers´ evaluation of the participatory monitoring and evaluation research project and the visual soil assessment tool, and depicts learnings for how to enhance PM&E research outcomes.

Chapter 5 presents the evaluation of the participatory monitoring and evaluation research of regenerative agriculture impacts on enabling farmers´ social learning to enhance regenerative agriculture adoption and out-scaling. For this purpose, the assessment of the evolution, before starting the PM&E research and after 3 years of research, of farmers´ perceptions on regenerative agriculture impacts, and farmers´ social networks regarding information sharing on regenerative agriculture, are presented and discussed.

The final chapter 6, "General conclusions", discusses the outcomes and implications of the thesis as a whole. It highlights the importance of generating close collaborations between farmers and researchers to co-generate and deepen the knowledge on regenerative agriculture, and sustainable land management in general, to foster resilient and long lasting transitions towards sustainable and functional agroecosystems.

Chapter 2

Participatory selection of soil quality indicators for monitoring the impacts of regenerative agriculture on ecosystem services

This chapter was published as:
Luján Soto, R., Cuéllar Padilla, M., and de Vente, J. 2020. Participatory selection of soil quality indicators for monitoring the impacts of regenerative agriculture on ecosystem services. Ecosystem Services, 45, 101157.

https://doi.org/10.1016/j.ecoser.2020.101157

ABSTRACT

Improving the understanding and fostering large-scale adoption of regenerative agriculture (RA) requires soil quality monitoring systems that integrate farmers' and researchers' knowledge. This is especially relevant for participatory impact assessment in semiarid areas prone to land degradation that typically respond slowly to management changes, often resulting in low RA adoption rates. We developed a framework for the identification and selection of local and technical soil quality indicators and for the development of a visual soil assessment tool, to participatory monitor the impacts of RA by farmers and researchers. We applied this framework in a large-scale restoration project in southeast Spain together with almond farmers implementing RA. Local indicators selected by farmers focused mostly on water regulation, erosion control, soil fertility, crop performance and main supporting, regulating and provisioning ecosystem services. Technical indicators selected by researchers focused mostly on soil properties including aggregate stability, soil nutrients, microbial biomass and activity, and leaf nutrients, covering crucial supporting services. The combination of indicators provided complementary information, improving the feasibility of RA impact assessment. This integrated soil quality monitoring system offers a practical tool to enhance knowledge exchange and mutual learning to support the implementation of RA and optimize the delivery of ecosystem services.

Chapter 3

Restoring soil quality of woody agroecosystems in Mediterranean drylands through regenerative agriculture

This chapter was published as:
Luján Soto, R., Martínez-Mena, M., Cuéllar Padilla, M., and de Vente, J. 2021. Restoring soil quality of woody agroecosystems in Mediterranean drylands through regenerative agriculture. Agriculture, Ecosystems & Environment, 306, 107191.

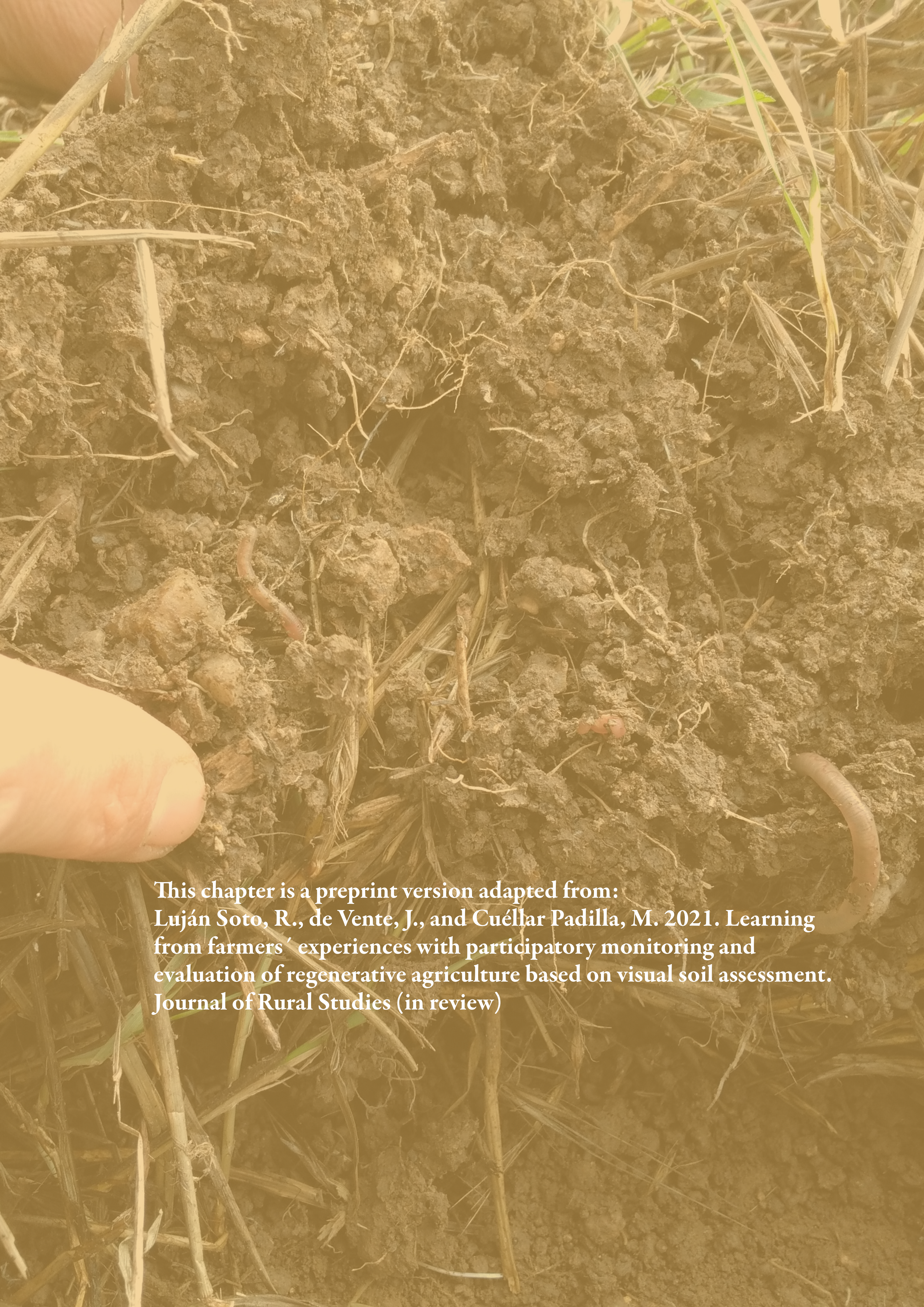
https://doi.org/10.1016/j.agee.2020.107191

ABSTRACT

Regenerative agriculture (RA) is gaining increasing recognition as a plausible solution to restore degraded agroecosystems. In Mediterranean drylands, RA is at incipient state of development and has been limitedly adopted by farmers, partly due to the lack of empirical evidence on its impacts. To support its large-scale adoption, we carried out a participatory monitoring project in southeast Spain, involving local farmers applying different RA practices in 9 almond farms. To assess the effect of RA, in each farm we selected one field with regenerative management and one nearby field with conventional management based on frequent tillage (CT). We clustered fields under regenerative management based on the RA practices applied by farmers and distinguished 4 types of RA treatments: 1) reduced tillage with green manure (GM), 2) reduced tillage with organic amendments (OA), 3) reduced tillage with green manure and organic amendments (GM&OA), and 4) no tillage with permanent natural covers and organic amendments (NT&OA). We evaluated the impacts of RA compared to CT by comparing physical (bulk density and aggregate stability), chemical (pH, salinity, total N, P, K, available P, and exchangeable cations) and biological (SOC, POC, PON, microbial activity) properties of soil quality and the nutritional status of almond trees (leaf N, P and K). Our results show that GM improved soil physical properties, presenting higher soil aggregate stability. We found that OA improved most soil chemical and biological properties, showing higher contents of SOC, POC, PON, total N, K, P, available P, exchangeable cations and microbial respiration. RA treatments combining ground covers and organic amendments (GM&OA and NT&OA) exhibited greater overall soil quality restoration than individual practices. NT&OA stood out for presenting the highest soil quality improvements. All RA treatments maintained similar crop nutritional status compared to CT. We conclude that RA has strong potential to restore the physical, chemical and biological quality of soils of woody agroecosystems in Mediterranean drylands without compromising their nutritional status, thereby enhancing their resilience to climate change and long term sustainability.

Chapter 4

Learning from farmers' experiences with participatory monitoring and evaluation of regenerative agriculture based on visual soil assessment



This chapter is a preprint version adapted from:
Luján Soto, R., de Vente, J., and Cuéllar Padilla, M. 2021. Learning from farmers´ experiences with participatory monitoring and evaluation of regenerative agriculture based on visual soil assessment. Journal of Rural Studies (in review)

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 research project to evaluate the impacts of regenerative agriculture between farmers and researchers in the Mediterranean drylands of Spain. Here we present and evaluate the participatory project outcomes by reporting farmers´ VSA monitoring results on regenerative agriculture impacts, and documenting farmers´ valuation and insights on the visual soil assessment (VSA) and other key aspects of the participatory monitoring and evaluation in the third year of the research 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 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 format design of VSA tools to adjust them to their priorities, possibilities and needs for enhanced VSA tool adoption. Farmers highlighted the importance of participatory monitoring and evaluation research 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.

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 been limitedly adopted 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 involving farmers and researchers for agroecosystem restoration is crucial to enhance the adoption of farming innovations like RA, and ensure the long term sustainability of agroecosystems (Cuéllar and Calle, 2011; Guzmán et al., 2013; Mapfumo et al., 2013; Pimbert, 2018; Stoate et al., 2019). Participatory monitoring and evaluation (PM&E) the impacts of innovative farming approaches can potentially lead to higher innovation adoption by enhancing farmers access to scientific and local knowledge from different RA experiences, and by fostering 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). As such, PM&E is expected to support farmer capacity building, empowerment and confidence on RA leading to increased RA adoption and efficiency (Dessie et al., 2012; Jemberu et al., 2018; Vernooy et al., 2006, Luján Soto et al in review). 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 (Luján Soto et al., 2020).

Visual soil assessment (VSA) tools have been broadly promoted to facilitate PM&E 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 soil technical analyses for the interpretation of degradation and restoration issues (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 –in type and complexity- 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 translating 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).

Involving farmers in PM&E research can generate multiple benefits both in the participants' experience and in the impact of farming interventions (Cardoso et al., 2001; Estrella et al., 2001; Estrella and Gaventa, 1998; Luján Soto et al., 2020; Schwilch et al., 2011; Sewell et al., 2017; Vernooy et al., 2006). By combining scientific and local empirical knowledge, PM&E intends to increase the insight of agricultural innovation impacts and progress towards restoration goals, which is expected to enable social learning, motivate farmers to engage in research and consolidate the adoption of farming innovations. Especially in the case of interventions like RA in semiarid regions for which no immediate results are expected for crucial aspects like crop yield, 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 (Luján Soto et al., 2020).

Considering that project success in RA, sustainable land management and related topics has been rarely evaluated (Chaffin and Gosnell, 2015), it is no wonder that there is also a lack of information regarding the perception and experiences of those subjects from whom land management change is required or expected, and which can be of great help to decide appropriate actions to improve project outcomes. In participatory action research projects, agroecosystem restoration is considered successful when progress is made towards achieving agroecosystem restoration targets, through a learning-based (adaptive) decision process, and hence when established goals of participatory research are achieved (Chaffin and Gosnell, 2015). In particular, in PM&E research 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 research 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 research 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 research project, and provide recommendations for practitioners to improve PM&E research outcomes.

MATERIALS AND METHODS

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).

Study context

In 2015 substantial efforts to counter land degradation and return the sustainability of agroecosystems in the high steppe plateau commenced to materialize. Local farmers started to apply regenerative agriculture (RA) in their almond farms and created the AlVelAl farmer association with the support of the Commonland foundation, business entrepreneurs, regional governments, and research institutions aiming to foster a large-scale adoption of RA for landscape restoration in a time frame of 20 years (Ferwerda, 2015). Members of AlVelAl considered RA a promising farming approach to restore soil quality and enhance the functionality of agroecosystems and the delivery of ecosystem services 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 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 for maximizing restoration success without the need of continual technical support.

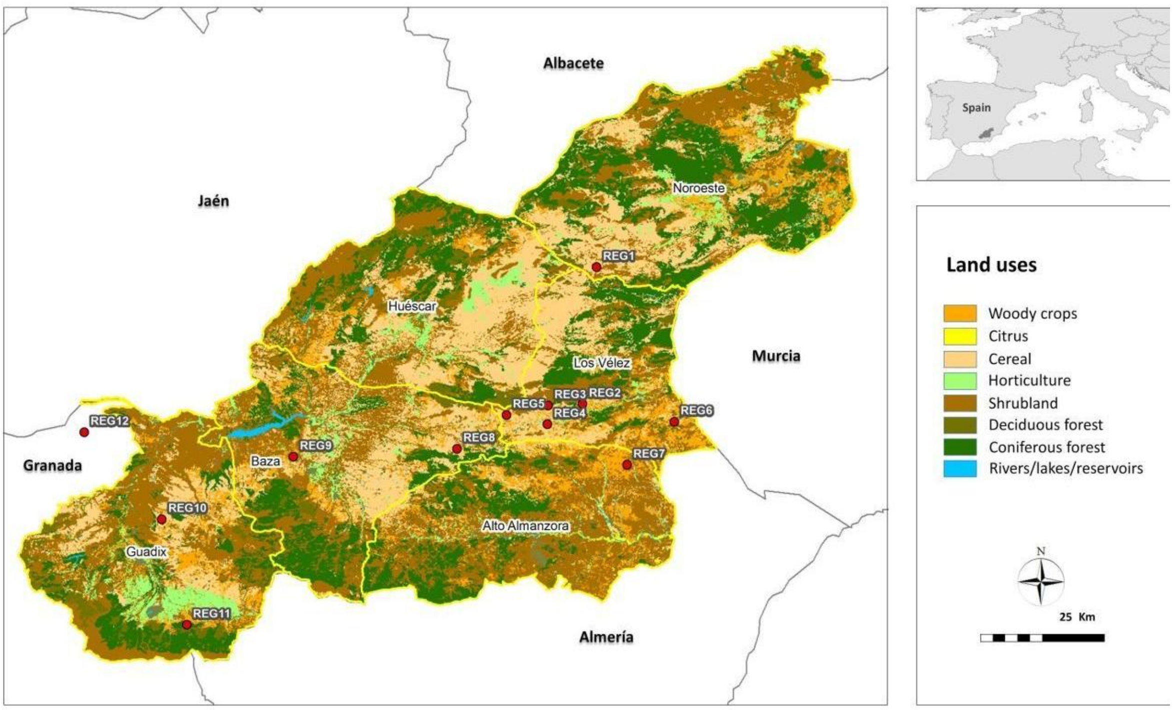


Figure 1 Map of the territory where the AlVelAl association operates. Yellow lines define county borders within the autonomous regions of Andalusia and Murcia; red dots represent the 12 farms of participating farmers involved in the participatory monitoring and evaluation research project.

Phases 1 to 5 were addressed during the first year of the research project starting in 2017, and results reported in a separate publication (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 another previous publication (Luján Soto et al., 2021).

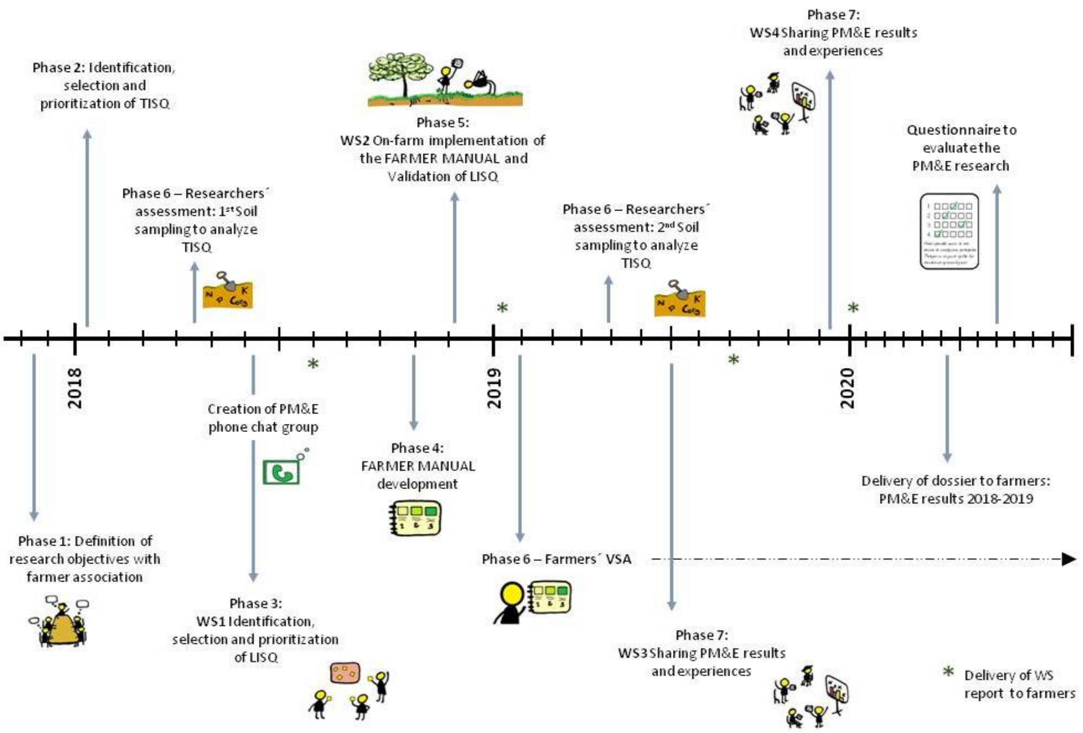


Figure 2 Process roadmap outline depicting PM&E phases. Adapted from Luján Soto et al. 2021b

Evaluation of the participatory monitoring and evaluation research 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 thought as a major dialogue space between all participating farmers and researchers involved in the PM&E that would serve to follow the restoration progress of participating farms, to verify whether selected indicators and our co-developed VSA tool was 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 research based on farmers´ and researchers´ observations. Therewith serving as a major feedback phase to learn and implement changes to enhance the consecution of intended goals (Luján Soto et al., 2020).

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 research project, in parallel to workshops, we developed multiple mechanisms to enhance knowledge exchange and support with participating farmers and researchers including a phone chat group, frequent email contact, the delivery of workshop and progress reports, farm visits, formal and informal interviews (Luján Soto et al., 2020).

Workshops were designed in such a way that each exercise could 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 the conclusion of each workshop, a report with workshop results was sent by email to all farmers involved in the PM&E research project.

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 research project for them, and

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-generate proposals between farmers and researchers for improving these results.	Refreshing TISQ. Collectively discuss TISQ results and contrast with LISQ, influencing causes, and how to improve them
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

specifically about 3 key aspects to confirm whether intended goals of the PM&E research 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 their experiences forming part of the PM&E research project.

RESULTS

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, 4 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 farmers on 14 local indicators of soil quality (LISQ) comprising the farmer manual.

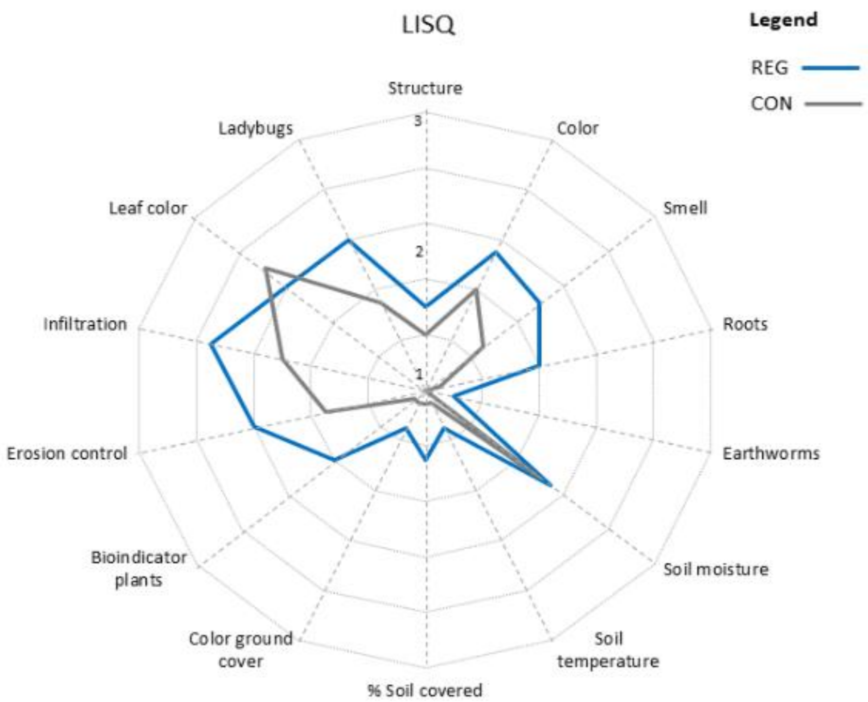


Figure 3 Amoeba diagram presenting farmers´ visual soil assessment results on regenerative agriculture and conventional farming impacts on 14 local indicators of soil quality (LISQ).

Average LISQ scores based on the results reported by six farmers range from 1 (low soil quality) to 3 (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. Bioindicator plants, soil roots, erosion control, infiltration capacity, soil smell, and ladybugs, were the indicators that 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.

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 2 workshops, 4 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 the levels of organic matter 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 that 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 practice applied (e.g. organic amendments, green manure, reduced or no tillage, etc.) the management of the 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

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 erosion.	Using soil terraces. Continue adding compost and green manure
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

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 and 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 LISQ results between different regenerative farms on a number of indicators. They discussed the importance of making comparisons "fair", thus between regenerative and neighboring conventionally managed fields, and not between regenerative farms because of the differences in biophysical and climatic conditions that can be constraining or stimulating the effectiveness of RA.

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).

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

To enhance the PM&E process through the visual soil assessment 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 VSA improvement registered by participating farmers 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 for RA practices to help improving indicators´ results

Farmers´ evaluation of the PM&E research project

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

Table 5 Farmers evaluation of the PM&E research 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.

DISCUSSION

In the following paragraphs we analyze farmers´ results and insights, and discuss whether the participatory monitoring and evaluation research 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 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 research project, aiming to depict learnings to contribute to improved PM&E research for agroecosystem restoration.

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 are somewhat contrasting or complementary to the TISQ results for which larger differences were found for several important soil quality indicators (e.g. soil organic carbon, total soil Nitrogen content, microbial respiration rates) under RA as compared to conventional management (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 (Luján Soto et al., 2021). Beyond concrete attained restoration results, it is worth noting the importance of farmers observing progress in soil quality restoration (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) (Luján Soto et al., 2021), improving their understanding on RA management and impacts, and increasing the confidence in RA (Ball et al., 2017; Guimarães et al., 2017; Luján Soto et al., 2020). Together with exchange of experiences with peer farmers, these increased insights might lead to enhanced RA efficiency and soil quality restoration results through social learning (Luján Soto et al., in review). 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 research project for agroecosystem restoration.

Regarding the achievement of the second goal; along the whole PM&E research project multiple mechanisms were activated to enhance individual and social learning (Luján Soto et al., in review) as critical steps towards adoption and out-scaling of RA (Sol et al., 2013; Suškevičs et al., 2018). The iterative feedback processes (Figure 2) within this PM&E research aimed, among other reasons, to enhance VSA of RA 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 mentioning that the farmer manual allowed them to see the soil in a different way and pay attention to parameters they did not pay attention to before (Table 4), and by farmers´ understanding on 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 the 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´ insights on the VSA and PM&E research (Table 4 and Table 5) evidence 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.

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 research activity, just half of them provided VSA results, 9 farmers attended workshops 1 and 2, and 7 joined workshops 3 and 4 (Appendix). These results lead us to think that the potential benefits of PM&E research 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 research 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 research project recognized most of these VSA tool benefits for the farmer manual used in this project (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 VSA, and analyzing success factors and barriers stimulating or hindering 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) The researchers or technicians in charge of the monitoring project must provide guidance and support to help farmers implementing VSA tools. For instance, accompanying farmers 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 they themselves 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 (Appendix) supporting, each researcher, one of the two groups in which farmers were divided (Luján Soto el at 2020). Additional individualized help 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 in participatory action research projects (Cuéllar-Padilla and Calle-Collado, 2011; Ensor and Harvey, 2015), and appears to be particularly important regarding farmer training for using 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 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 learning 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). Reflecting on this led us to think about the following third learning.

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 research 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).

Farmers´ insights for improving PM&E research

A major reason behind doing participatory action research, and specifically PM&E, is enabling participants´ empowerment for social transformation (Cuéllar and Calle, 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 and Calle, 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 research, we discuss the impact of PM&E on farmers to enhance RA adoption, and bring some learnings to improve PM&E outcomes.

All farmers found it useful having been involved in the PM&E research project to a greater or lesser extent. Among others, 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 (Table 5), conducive conditions that might reinforce credence on farming innovation effectiveness and adoption (Cuéllar and Calle, 2011; De Vente et al., 2016; Sewell et al., 2017). As a matter of fact, participatory action research processes have been highlighted for helping generate social cohesion and support between participants prompting the achievement of common goals (Cuéllar and Calle, 2011; Guzmán et al., 2013; Méndez et al., 2017).

Participation was enhanced through multiple mechanisms along the PM&E research. Among these, participatory workshops were the backbone of the PM&E research and key to favor farmers establishing relations and sharing experiences. Although all participating farmers found the PM&E research 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. 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 complied with this aspect. Farmers highlighted the 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 research they were eager to implement new RA practices (Table 5). This confirms earlier claims that participatory research involving farmers and researchers 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). 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 and Calle, 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 diverse 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., in review). Thus, we find it crucial to include peasant-to-peasant methodologies to foster farmers´ innovation adoption and enhance transitions towards agroecosystem sustainability, to increase the impact of research on natural resource management, agroecosystem restoration and sustainability related topics.

Lastly, farmers highlighted that thanks to PM&E they learned to better appreciate the effect of the regenerative practices they are 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 successfully in enhancing farmer capacity building. However, some farmers mentioned that the PM&E research 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 and Calle, 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 research 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 process, 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, efficient, and sound restoration processes and transitions towards sustainable and resilient agroecosystems.

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, although observed soil quality improvements were relatively small, and more time and efforts are needed to attain desired restoration targets. The monitoring results based on Local Indicators of Soil Quality (LISQ) performed by farmers showed small improvements but were complementary to findings of Technical Indicators of Soil Quality. Farmer's evaluation of the research project highlighted the PM&E research 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 of VSA tools and support them in initial implementation, in order to develop tools that meet farmers´ needs, to enhance VSA tool adoption, and facilitate reaching restoration goals. Furthermore, farmers´ evaluation of the farmer manual 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 research project for agroecosystem restoration. Many farmers have difficulties in systematically integrating the VSA tool in their farm operation and cannot always 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…)

Chapter 5

Participatory monitoring and evaluation of regenerative agriculture to enable social learning, adoption and out-scaling

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ABSTRACT

The advanced state of land degradation world-wide urges the large-scale adoption of sustainable land management (SLM). Social learning is considered an important precondition for the adoption of innovative and contextualized SLM. Involving farmers and researchers in participatory monitoring and evaluation of innovative SLM, like regenerative agriculture, is expected to enable social learning. Although there is a growing body of literature asserting the achievement of social learning through participatory processes, social learning has been loosely defined, sparsely assessed, and only partially covered when measured. In this paper we present an assessment of how participatory monitoring and evaluation (PM&E) of regenerative agriculture in southeast Spain, involving local farmers and researchers, enabled social learning, effectively increasing knowledge exchange and shared understanding of regenerative agriculture impacts among participating farmers. We measured whether social learning occurred by covering its social-cognitive (perceptions) and social-relational (social networks) dimensions, and discussed the potential of PM&E to foster adoption and out-scaling of SLM. We used fuzzy cognitive mapping and social network analysis as graphical semi-quantitative methods to assess changes in farmers´ perceptions and shared fluxes of information on regenerative agriculture in a time span of nearly three years. Our results showed that PM&E enabled social learning amongst participating farmers who strengthened and enlarged their social networks on information sharing, and presented a more complex and broader shared understanding of regenerative agriculture impacts and benefits. We argue that PM&E thereby creates crucial preconditions for the adoption and out-scaling of SLM. Our findings are relevant for the design of PM&E processes, Living Labs, and landscape restoration initiatives that aim to support farmers´ adoption and out-scaling of innovative and contextualized SLM.

INTRODUCTION

"The way of thinking defines the way of acting, and our actions define how to build the future of the living planet"

(Andean farming community)

The advanced state of land degradation, affecting over 3.2 billion people world-wide, has raised international concern regarding sustainability of socio-ecological systems (IPBES 2018) and urges the large-scale adoption of contextualized sustainable land management (SLM) (Cherlet et al. 2018). SLM is also of vital importance for nature based climate change adaptation and mitigation strategies (Sanz et al. 2017, Eekhout and de Vente 2019). While both scientific and local knowledge have strongly advanced our understanding of the effectiveness of SLM practices, large-scale implementation is lagging behind and is only possible when farmers, land owners, their livelihoods and communities are at the heart of such initiatives (Reed et al. 2011, Bouma 2019, Albaladejo et al. 2021).

Farmers´ SLM adoption remains a major contemporary challenge, particularly in light of the need to change dominant farming paradigms and engage in more sustainable farming practices across all sectors and farm types. This challenge and quest for a transition towards more sustainable land use is also reflected in the Land Degradation Neutrality targets of the United Nations Convention to Combat Desertification (UNCCD), the United Nations Sustainable Development Goals (SDG), the European Union Green Deal and its Farm to Fork and Biodiversity Strategies (UNCCD 2018, European Commission 2019, 2020, European Environment Agency 2019). A myriad of factors influences the complexity surrounding farmers´ SLM adoption, including: assets, ambitions, values, agronomic, financial, market and policy barriers and opportunities, farmland characteristics and, closely related, knowledge and access to information on SLM, and social networks (Schoonhoven and Runhaar 2018, Chinseu et al. 2019). Enabling environments, including policy and legal frameworks, regulations, markets, sector infrastructures with stable configurations, and education and extension systems are needed to support the transition to SLM (Sutherland et al. 2015, Pinto-Correia and Azeda 2017, Kuhmonen 2018). It is particularly important stimulating the creation of tight collaborative networks that enhance farmers' acquisition and sharing of knowledge, to stimulate social learning that is an increasingly recognized key factor for successful SLM adoption (Wals 2007, Kristjanson et al. 2014, Ensor and Harvey 2015, Hermans et al. 2017).

Social learning is important to facilitate adoption of SLM, and transitions in environmental management in general (Pahl-Wolst 2007), because farmers´ mental constructions and perceptions have a great influence on their farming practices (Segnon et al. 2015, Vuillot et al. 2016, Teixeira et al. 2018). For instance, Liu and Luo (2018) found that knowledge on land conservation practices was the factor that influenced farmers´ land use behavior most. Similarly, Dessie et al (2012) found that participatory research involving farmers and researchers enabled social learning, which translated into higher farmer adoption of soil terraces compared to farmers who did not participate in this research. Participatory processes characterized by discursive fairness fostering knowledge exchange between farmers, researchers and other stakeholders to address issues of common interest may strengthen the creation of relations of support and trust among participants, and the integration of different knowledge gleaned from one another to develop new shared understanding (Scholz et al. 2014).

Social learning acquires special relevance when it comes to innovative SLM of which there are none or limited previous experiences that serve as reference for farmers to build on. Innovative SLM refers to novel and alternative practices and methods, aiming to integrate the management of land, water, and environmental resources, challenging the status quo of mainstream approaches commonly used in the area. Like all innovations, due to lack of previous experience, innovative SLM therefore involves a higher implementation risk than SLM that is well established and tested in the area.

Social learning processes for adoption of SLM

To increase its impact, research needs to be effectively designed to fit, accompany and facilitate the processes through which individuals, communities and societies learn and adapt their behavior to environmental and socioeconomic change (Ensor and Harvey 2015). Research supporting social learning through an iterative process of working together with farmers in a continuous partnership, where new knowledge and collective understanding emerge by integrating different knowledge systems, may substantially contribute to expedite SLM adoption (Harvey et al. 2013). This is particularly relevant since farmers´ perceptions and beliefs about farm management practices are often grounded in tradition and long term practice supporting path-dependency (Darnhofer 2020). Together with the lack of knowledge and the uncertainty regarding the impacts of adopting innovative SLM, this often hampers the transition to SLM (Zinck and Farshad 1995, Schwilch et al. 2011, Marques et al. 2015). However, there is evidence that bottom-up and locally driven processes stimulate the accumulation of experience and learning and, as knowledge increases, initial beliefs get updated, the utilization of the innovation gets increasingly efficient (Darnhofer et al. 2016, Fieldsend et al. 2021), and uncertainty about innovation performance and perceived barriers tend to ameliorate, eventually leading to farmers´ innovation adoption (Monge et al. 2008, Harvey et al. 2013).

Following Reed´s (2010) definition, we understand 'social learning' as i) a change in understanding that takes place in the individuals involved; ii) goes beyond individuals and becomes situated within the community of practice; and iii) occurs through social interactions and processes between actors within a social network. Social learning is expected to happen when stakeholders interact, share their experiences, collaborate, negotiate, and consult each other, building relationships and developing networks for information-sharing and mutual support (Reed et al. 2010, Johnson et al. 2012, Van Der Wal et al. 2014). Social learning implies an increased shared understanding, or in other words, a higher convergence of perceptions of the individuals involved in participatory processes (Scholz et al. 2014).

Participatory research involving farmers and researchers in an horizontal manner represents an opportunity to integrate local and scientific knowledge and facilitate knowledge sharing, thereby stimulating social learning, co-innovation and co-creation of solutions to help the transition towards sustainable food systems (Raymond et al. 2010, Cuéllar and Calle 2011, De Vente et al. 2016, Reed et al. 2018, Wiget et al. 2020). Within participatory research, involving farmers and researchers into participatory monitoring and evaluation (PM&E) the impacts of innovative SLM can potentially lead to enhanced innovation adoption by improving farmers´ access to information and knowledge on the effectiveness of SLM and via the development of relationships and trust among stakeholders (Reed et al. 2007, Stringer et al. 2013, De Vente et al. 2016).

Participatory Monitoring and Evaluation of SLM

We understand participatory monitoring and evaluation (PM&E) as the joint collaboration between farmers and researchers in assessing the effectiveness of SLM practices at multiple levels. It implies making use of different participatory activities and tools (Reed et al. 2013, Ensor and Harvey 2015, Ernst 2019) to facilitate interaction, integrate local/indigenous and scientific knowledge, reduce power imbalances and engage stakeholders to support long term SLM (Luján Soto et al. 2020). With participation we mean the active involvement of participants in the whole research process supported by facilitation. We understand monitoring and assessment of SLM as a continuous learning and adaptation feedback process that involves intensive local and scientific data gathering, trial and test of SLM, and the joint discussion of results by farmers and researchers (Luján Soto et al. 2020).

PM&E involving farmers and researchers in a horizontal manner can stimulate social learning through various mechanisms: i) Learning from farmers' own experiences "seeing is believing": by farmers´ self-evaluation and self-reflection on the impacts of adopted SLM practices (Ball et al. 2017); ii) Learning from farmers´ experiences "peer to peer": by sharing information with farmers involved in PM&E (Wood et al. 2014) and iii) Learning from scientific knowledge "different expertise"**:** by integrating and contrasting scientific and local knowledge based on SLM observations and technical results (Estrella et al. 2000, Cardoso et al. 2001, Stringer et al. 2013, Ball et al. 2017, García-Nieto et al. 2019). PM&E can potentially lead to SLM out-scaling by: iv) Increasing the number of farmers with access to SLM information ("contagion effect")**:** by creating a dense collaborative PM&E network that facilitates the exchange and dissemination of SLM information (Parra-Lopez et al. 2007, Wood et al. 2014, Tran et al. 2018, Skaalsveen et al. 2020). Out-scaling is therefore understood as the replication of successful innovations through horizontal diffusion processes to increase the number of people or communities impacted (Hermans et al. 2013, López-García et al. 2021). It is a horizontal process that concerns how knowledge and innovations travel between different types of organizations. It differs from up-scaling, which entails vertical or hierarchical links to translate the results of innovation in political terms, by changing laws and policies (Hermans et al. 2013, 2017, Moore et al. 2015), and from scaling deep, which implies impacting cultural roots, changing cultural values, beliefs and norms (Moore et al. 2015).

Therefore, it is expected that PM&E of SLM will enhance the relevance, legitimacy, and credibility of the solution, broadening the basis of support for its implementation (Van Der Wal et al. 2014, Luján Soto et al. 2020), and eventually lead to enhanced ownership and community empowerment, attitudinal change, and collective action for SLM adoption (Sol et al. 2013, Phuong et al. 2018, Suškevičs et al. 2018). This focus on collective action also helps understanding why social learning is considered crucial in landscape, environmental and natural resource management, innovation adoption and climate change adaptation (Muro and Jeffrey 2008, Ensor and Harvey 2015, Hermans et al. 2017). These ideas directly connect to the recent renewed interest in setting up Living Labs and Lighthouse farms to foster social learning by doing, and facilitate knowledge exchange between researchers and farmers, as is also evidenced in the 'European Mission for Soil Health and Food' (Veerman et al. 2020).

Although social learning has been used for decades in the literature, there has been little consensus on a definition, the processes involved, and its outcomes (Reed et al. 2010). Unsurprisingly, there is a lack of empirical evidence proving that participatory research actually promotes social learning (Reed et al. 2010), since cognitive change has rarely been investigated (Ernst 2019), and social interactions in participatory settings are commonly presumed. In recent years, there has been an increasing effort to demonstrate the potential of multi-stakeholder participatory research approaches to enable social learning on SLM, natural resource management and related topics, such as participatory modeling (Henly-Shepard et al. 2015, Voinov et al. 2016), participatory mapping (García-Nieto et al. 2019) and participatory development of future scenarios for community-based management (Johnson et al. 2012). However, scientific studies on PM&E of SLM providing empirical evidence on social learning continue to be scarce, especially regarding innovative SLM.

The objective of this paper is to evaluate the potential of PM&E to enable social learning in support of the adoption and out-scaling of innovative SLM, by: i) favoring the co-creation of knowledge and a common understanding on the impacts of innovative SLM on participating farmers, and ii) strengthening and enlarging farmers´ social networks and potential for knowledge and innovative SLM information sharing. For this purpose, we initiated a PM&E project in a farming region in southeastern Spain to assess the impacts of Regenerative Agriculture involving 12 local farmers pioneering in applying Regenerative Agriculture in the region. We assessed how PM&E affected farmers' perceptions and social networks over time, and discussed the relevance of the results regarding innovative SLM adoption and out-scaling. To our knowledge this is one of the first scientific studies in the field of PM&E of innovative SLM that assessed social learning including both the social-cognitive (perceptions) and the social-relational (social networks) dimensions. We believe this PM&E project could serve as inspiration for the design of future Living Labs and restoration initiatives based on innovative SLM.

MATERIALS AND METHODS

Study context

The participatory research reported here was conducted in the steppe high plateau, in the semiarid southeast of Spain, in collaboration with members of the farmer association AlVelAl. The semiarid southeast of Spain is one of Europe's regions most affected by land degradation and desertification processes (Martínez-Valderrama et al. 2016), and represents one of the world's largest areas for the production of rainfed organic almonds. Since the 1950's the region has experienced major farm management changes. The mechanization of farming activities and the application of agrochemicals was patently promoted by the green revolution model and endorsed by governmental institutions through subsidies to farmers until the late 1990's. This transition from traditional and essentially organic to conventional farming resulted in multiple environmental, social and economic impacts. Environmentally, this led to the abandonment of soil and water conservation structures (Bellin et al. 2009), a shift from cereal to woody perennial farming (Cruz Pardo et al. 2010), the near total disappearance of sheep farming (Toro-Mujica et al. 2015), and the intensification of tilling practices (Clar et al. 2018), resulting in a considerable increase of erosion rates and land degradation (García-Ruiz 2010, van Leeuwen et al. 2019). Socially, it led to a break up with the traditional peasant lifestyle and the loss of autonomy of a self-controlled resource based system, including loss of non-material resources such as farmers´ social networks and transfer of traditional knowledge. The loss of farmers' autonomy was also reflected in the economic sphere, particularly evidenced by reduced economic profits and higher farmers´ dependence on subsidies to make farming economically viable (van Leeuwen et al. 2019).

Confronted with this panorama, in 2015, local farmers created the farmer association AlVelAl. The AlVelAl association is supported by the Commonland foundation, regional governments, local businesses, and research institutions, and aims to restore vast extensions of degraded land, promoting and facilitating the adoption of Regenerative Agriculture (RA) by offering technical advice and economic support. RA is an innovative SLM approach foreseen as a promising solution to reverse and prevent further land degradation and enhance the delivery of ecosystem services through the adoption of soil restoration practices under four main principles: 1) minimum soil disturbance, 2) enhance soil fertility, 3) reduce spatial-temporal events of bare soil, and 4) diversify cropping systems with integration of livestock

(Rhodes 2013, 2017, Elevitch et al. 2018, LaCanne and Lundgren 2018). RA includes practices at landscape and farm level. Most commonly promoted RA practices at farm level include reduced tillage, organic amendments, and cover crops used as green manure, but also practices like crop diversification, inclusion of livestock in agro(silvo)pastoral systems, and water harvesting.

While promising (De Leijster et al. 2019, Luján Soto et al. 2021), RA has been limitedly adopted in the high steppe plateau in southeastern Spain, and in semiarid regions in general. This might be due to the lack of empirical data proving RA effectiveness (Lee et al. 2019) and the generally slow response of soils to management changes in semiarid conditions, which may delay the appearance of visible results discouraging farmers from adopting RA.

Participatory Monitoring and Evaluation (PM&E) in southeastern Spain

In view of the needs and potentials for social learning to help the design, adoption and enhance

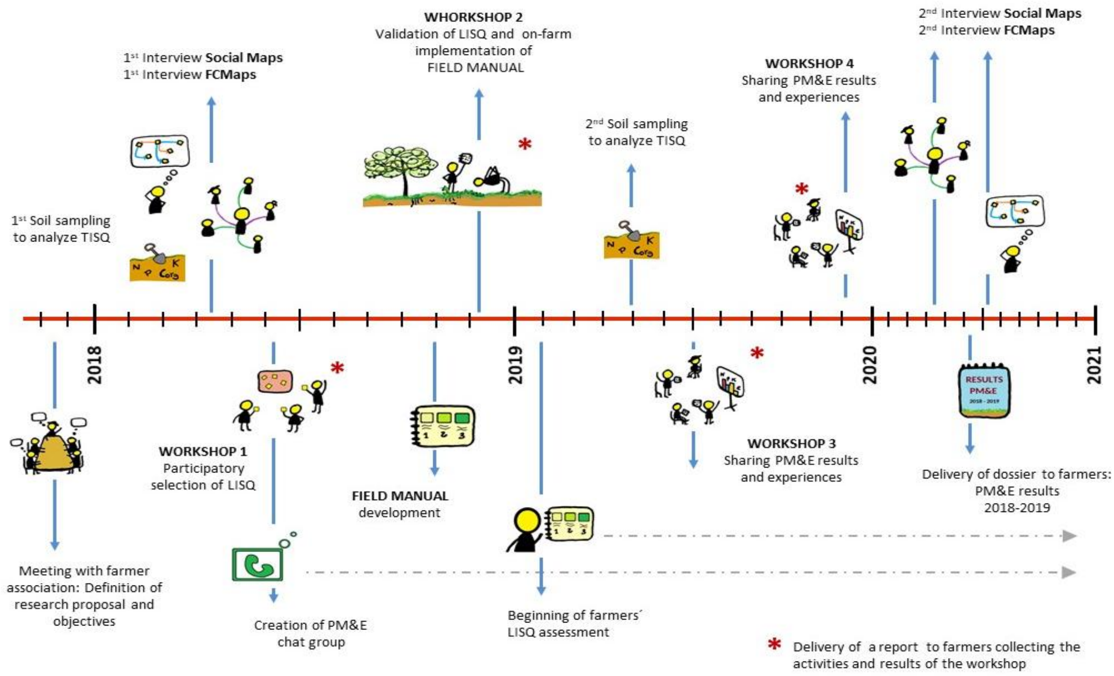

Figure 1 Timeline of the participatory monitoring and evaluation (PM&E) project displaying main events. The current research presents the results and analysis of the first and second interview rounds applying Fuzzy Cognitive Mapping and Social Network Analysis. Monthly spacing has been reduced in the timeline each year to enhance representation of events. The acronyms used are defined as: TISQ: Technical Indicators of Soil quality; LISQ: Local Indicators of Soil Quality; FCMaps: Fuzzy Cognitive Maps.

implementation of RA in the high steppe plateau, we designed and initiated a PM&E research project (Luján Soto et al. 2020) (Figure 1) involving local pioneering farmers already implementing RA that were members of AlVelAl (Table 1) and researchers to assess RA impacts on soils and related ecosystem services (Luján Soto et al. 2021).

Table 1 Description of participating farmers and farms according to main regenerative agriculture principles and practices implemented in the parcels selected for participatory monitoring and evaluation

				Regenerative principles and practices applied			
Farmer	Role in farmer association	Year of RA implementation	Farm size (ha)	Minimum soil disturbance	Organic amendments	Reduction of spatial temporal events of bare soil	Diversification & integration of livestock
S1	board member	2015	1700	Reduced tillage	Bokashi compost	Winter natural covers	Sheep integration
S2	member	2014	36	Reduced tillage	Sheep - goat manure	Winter natural covers	
S3	member	2014	70	Reduced tillage	Bokashi & sheep manure	Winter natural covers	
S4	member	2008	200	No tillage	Bokashi compost	Permanent natural covers; Prunings mulched	Sheep integration
S5	member	2016	250	Reduced tillage	Sheep manure	Winter natural covers	Sheep integration
S6	member	2017	78	No tillage	Green manure	Permanent natural covers	Sheep integration
S7	board member	2008	250	Reduced tillage	Bokashi compost	Vegetation strips between almond lines; Prunings mulched	Sheep integration
S8	member	2014	18	Reduced tillage	Bokashi compost	Winter natural covers; Prunings mulched	
S9	research technician	2013	35	Reduced tillage	Compost & sheep manure, Green manure	Winter natural covers; Prunings mulched	
S10	member	2006	100	Reduced tillage	Bokashi & pelletized organic fertilizers	Winter natural covers; Prunings mulched	Sheep integration
S11	member	2016	12	Reduced tillage	Green manure	Winter natural covers; Prunings mulched	
S12	secretary	2015	120	Reduced tillage	Green manure	Winter natural covers	Sheep integration

The PM&E research project formally started in 2017 with a get together with AlVelAl board members to define the participatory research objectives and approach. Subsequently we initiated the PM&E project with 12 almond farmers that expressed their interest in participating (Luján Soto et al. 2020). This first meeting was followed by several participatory activities using a diversity of participatory tools to incentivize social learning (Ensor and Harvey 2015, Ernst 2019, Suškevičs et al. 2019). This included: field visits; soil assessments using technical indicators of soil quality (TISQ); two participatory workshops to identify, select, prioritize and validate local indicators of soil quality (LISQ); the development and on-farm implementation of a field manual for farmers' quarterly visual assessment of RA; and a series of participatory workshops and activities to facilitate the exchange of monitoring and evaluation results from LISQ and TISQ between participating farmers and researchers, reflect on RA impacts and effectiveness, and keep participants engaged (Luján Soto et al. 2020). Additionally, we created a phone chat group to accompany farmers in the PM&E process, solve doubts, share information and enhance discussion on RA practices (Figure 1). To evaluate whether PM&E enabled social learning, we assessed farmer´s social networks on RA information sharing using Social Network Analysis (SNA), and farmer´s perceptions on RA impacts and benefits using Fuzzy Cognitive Mapping (FCM), at the start of the project and in the 3rd year of farmers' active involvement in PM&E (Figure 1).

Constructing Fuzzy Cognitive Maps with farmers

Fuzzy cognitive mapping (FCM) is an integrated and semi-quantitative research tool simple to use in participatory settings, developed to assess, compare and reveal people's changes in knowledge systems by illustrating changes in perceptions on a particular issue from a systems understanding (Özesmi and Özesmi 2004). We carried out individual interviews using FCM, to map farmers´ perceptions regarding regenerative agriculture impacts, in spring 2018 (pre PM&E) and summer 2020 (post PM&E). In order to evaluate the influence of PM&E on shaping farmers´ perceptions, we generated a total of 10 individual FCMaps (1 per farmer) before (pre PM&E) initiating monitoring activities, and 10 FCMaps in the third year of the project (post PM&E) (Figure 1). We discarded the perceptions of two participating farmers in the comparative assessment because we could not conduct the FCM interview either at the beginning or at the end of the PM&E project for logistical reasons. Interviews for creating these individual FCMaps were conducted around 3 main questions related to farmers´ specific realities. The questions were stated as: Q1) *"Which factors influenced land degradation in the region?"*, Q2) *"Which factors influence crop production?"* and, Q3) *"What are the impacts of Regenerative Agriculture and particularly the 3 most common implemented RA practices (i.e. organic amendments, green manure, and reduced tillage), on land degradation, crop production and other socio-economic factors you consider important?*

To facilitate the response to these questions, before the interview, a short explanation of FCM was given to the farmers, highlighting relevant aspects of the methodology and emphasizing the fact that there was no right or wrong answer. The interviews were carried out following a sequence of steps to guarantee that all factors farmers considered relevant were being mapped. Each step was also explained in detail to ensure that the given instructions were clear to all farmers.

Firstly, in Step 1, we presented an A0 sheet of paper to the farmer with 6 adhesive "*Entry notes"*. Each *Entry note* had a key word written on it related to the question being asked. We used colored notes to facilitate visual differentiation. The 6 *Entry notes* and colors used were: "Land Degradation" in yellow (question 1), "Production" in blue (question 2), "Regenerative Agriculture", "Green Manure", "Compost/Org. amendments", and "Reduced Tillage", in green (question 3) (Figure 2).

Once the *Entry notes* were placed, we proceeded with Step 2 in which the first question was asked to the farmer. Answers were collected in keywords identified by the researcher/facilitator and written in separate adhesive notes, which were then placed on the A0 sheet of paper close to the related *Entry note* to facilitate drawing connections between items in the following steps.

When the farmer concluded answering the first question, we moved to Step 3 in which the farmer was asked to establish and value relations between mapped items and the related *Entry Note.* In this step the farmer had to indicate the direction, type and strength of the relations. First, the direction of the relation was indicated, and drawn with an arrow when necessary, starting at the influencing item and pointing towards the item being influenced. Secondly, the type of relation, which could be either positive or negative, was marked with a (+) and (-) symbol respectively. Finally, the strength of connections was ranked using a 1 (weak) to 5 (strong) scale (Figure 2).

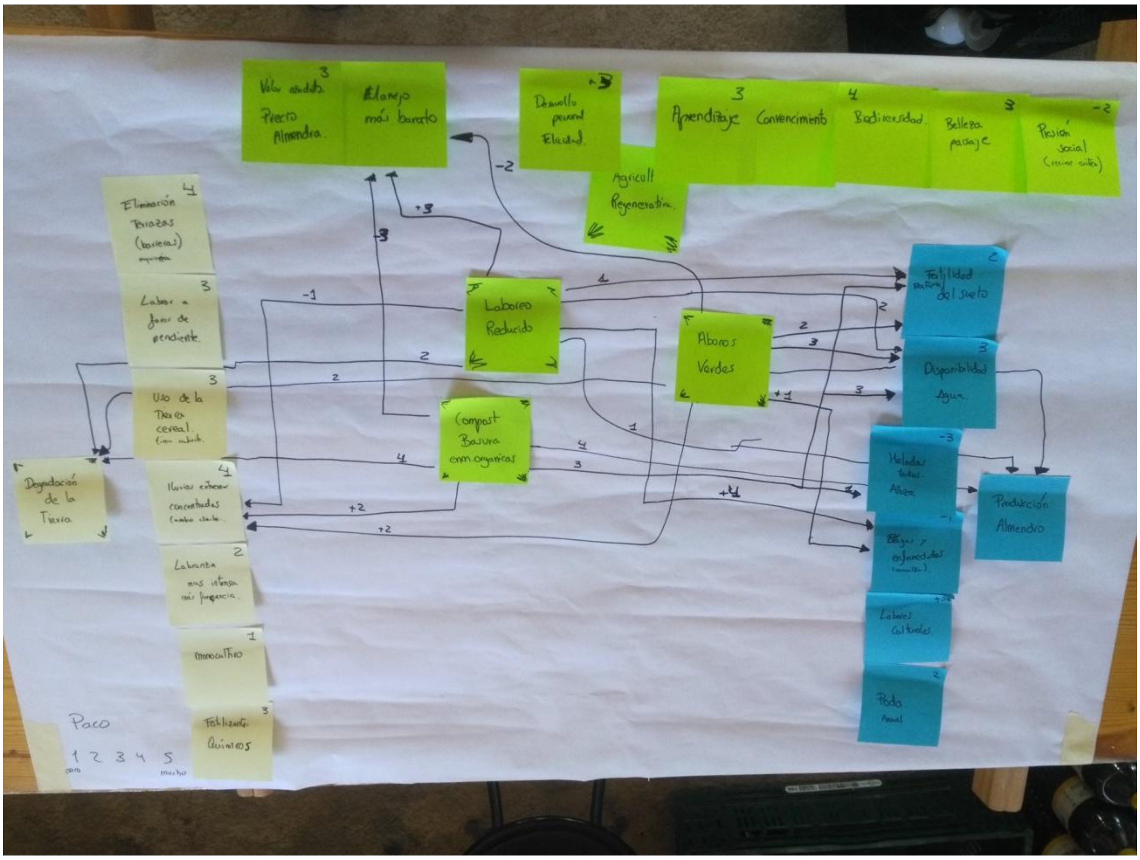

Figure 2 Example of a Fuzzy Cognitive Map constructed with a participating farmer in summer 2020

In FCM, arrows are used to draw connections between items, ending up, in many cases, with numerous intersecting arrows that can complicate the visual lecture and ranking of the established relations. To avoid arrow jumbles, each keyword answering a question was collected in an adhesive note with the same color as its related *Entry note*, that is to say, factors influencing land degradation were written in yellow notes, crop production influencing factors in blue notes, and impacts of RA and specific RA practices in green ones. In this way we could establish connections between items without the need of drawing arrows. Arrows were only drawn when an item was previously mentioned to answer a question, and to establish connections between already mapped items. Once connections were established and question 1 was completed, we moved to questions 2 and 3, following the same procedure as described above. The farmer was reminded of the possibility to establish connections between any mapped items if they found a relation.

To facilitate the response to question 3, the farmer was first asked to draw connections between each RA practice, land degradation and production and their influencing factors. If the farmer would find the impact of all RA practices to be the same over one item (in direction, type and strength) or could not establish differences between RA practices, just one arrow to the "Regenerative Agriculture" *Entry note* would be drawn, indicating the direction, type and strength of the connection. Lastly, the farmer was asked about the social and economic impacts of RA. Before concluding the exercise, farmers were asked if they agreed with the resulting map and to make any modification or addition they felt necessary.

FCM processing and statistical analysis

We followed a set of good practices for FCMap-building to ensure transparency and reproducibility of the process (Olazabal et al. 2018). Good practices included interpretation and pre-processing of individual maps, selection of a common terminology, renaming of concepts, and reversal of weight signs to increase consistency, creation of individual maps and adjacency matrices (Appendix 1, Appendix 2, Appendix 3, Appendix 4), and aggregation of individual adjacency matrices into collective FCMaps (Olazabal et al. 2018).

FCMaps were analyzed using the software FCMapper Vs 1.0 (Papageorgiou 2013). The analysis included the total number of factors (nodes), the total number of connections (arrows), and the factor type categorized depending on the type of arrow they received or transmitted. Transmitter factors only have outgoing arrows, indicating they influence other factors. Receiver factors only have ingoing arrows, indicating they are influenced by other factors. Ordinary factors have outgoing and ingoing arrows, indicating they influence and are influenced by other factors of the system. The strengths of arrows were rescaled to a range from 0.2 to 1.0 (positive connections) and -0.2 to -1.0 (negative connections). The centrality of factors was determined by the sum of absolute weights of in and out-going arrows. In addition, factors were categorized into five groups as: Biophysical & Environmental, Management, Economic, Social, and Political & Cultural.

Individual FCMaps were combined to obtain two collective maps: one collective FCMap integrating the 10 individual FCMaps of farmers´ perceptions before starting the PM&E, and one collective FCMap integrating the perceptions of these same 10 farmers in the third year of PM&E. Collective FCMaps were created by merging the factors and summing the connections between the same factors of all farmers in each time period. The weight of connections was divided by the number of farmers to derive mean centrality scores. Positive and negative connections between the same factors cancelled each other out. We used Gephi Software version 0.9.2 (Bastian et al. 2009) for graphical representation of FCMaps.

To assess differences in farmers´ perceptions before taking part (pre PM&E) and in the third year (post PM&E) of PM&E project and evaluate whether individual and collective learning occurred, we analyzed the evolution of individual farmer´s perceptions - the change in individual FCMaps pre-PM&E and post PM&E -, and compared it with the evolution of farmers´ perceptions as a group - the change in collective FCMaps pre-PM&E and post-PM&E -. We analyzed FCM indices, categorical groups of factors and centrality of RA practices using the non-parametric Wilcoxon Signed Rank Statistical tests for paired dependent samples in R (version 3.6.2)(R Core Team 2020) with n=10 and significance level < 0,05.

Interviews to construct social networks on RA information fluxes

We carried out 12 interviews in spring 2018 (pre PM&E) and 12 interviews in spring 2020 (post PM&E) to measure and map the evolution of RA information fluxes within the social networks of farmers taking part in PM&E. Interviews in 2018, prior to the start of monitoring activities, were held in person, while interviews in 2020 were done by phone due to COVID-19 quarantine restrictions enforced by the national government. The interview included 2 parts. The first part consisted of baseline information including: i) name of the farmer, ii) function within AlVelAl association, iii) profession and working institution or organization and iv) time practicing Regenerative Agriculture. The second part consisted in two main "Name Generator" questions to compose: i) a list of people who transfer information (Alters) and ii) a list of people who receive information (Egos). Questions were asked as follows: *Q1) "Who are the people from whom you receive information on regenerative agriculture? Specify the frequency", and Q2) "Who are the people to whom you give information on regenerative agriculture? Specify the frequency".* The frequency of information exchange was measured using a Likert scale with scores to streamline the answering process (Very often (5); Often (4); Occasionally (3); Seldom (2); and Very Seldom (1)).

Social network processing and analysis

We used Gephi Software version 0.9.2 (Bastian et al. 2009) for graphical representation of information fluxes of PM&E farmers within their social networks. We include all fluxes of information mentioned by PM&E farmers, therefore, when a PM&E farmer mentioned that she or he received or transferred information to another person, it was included in the analysis regardless if the appointee did not mention the same flux of information.

Table 2 Definition of Social Network Analysis metrics regarding information sharing and interpretation of responses to stimulate social learning on regenerative agriculture, enhancing adoption and out-scaling

METRICS	DEFINITION	RESPONSE
Dimension	Network size or number of actors. It is critical for a network structure because resources are limited for each actor to build up or maintain social relations and fluxes of information.	The higher the dimension –connected actors- the greater the network cohesion. More actors have access to RA information
Indegree centrality	Number of information fluxes an actor receives. Is characteristic of people or networks that require information, are eager to learn and adapt, and are innovative.	The higher the average indegree of the PM&E network, the higher the consolidation potential of RA practices. PM&E farmers receive RA information from more people
Outdegree centrality	Number of information fluxes shared by an actor. It is a measure of empowerment. Characteristic of persons or networks with a lot of knowledge and experience, or access to information.	The higher the average outdegree of the PM&E: i) the higher the consolidation potential of RA practices and, ii) the higher the capacity to influence adoption beyond the group of PM&E farmers PM&E farmers share RA information with more people, increasing their capability to induce RA adoption
Betweenness "centrality"	It is a measure of power. It calculates the frequency in which an actor is situated in the shortest geodesic paths between other actors in the network. That is to say, it is necessary to pass through her/him to reach the others, thus indicating the ability to control information sharing paths.	The higher the betweenness centrality the higher the brokerage of information, but also the higher the innovation potential. Higher capacity to propagate RA information
Two step reach "betweenness"	It tells us the percentage of all actors involved in a network that an actor can reach in 2 steps. This metric indicates efficiency, independence and empowerment. It can be used as an alternative of average geodesic distance and closeness.	The higher the percentage, the faster RA information could reach all actors. RA information is easily available for anyone in the network, or actors have more rapid access to RA information
Homophily	The E-Index measures homophily which is the tendency of people to choose people who are similar to themselves in socially significant attributes (i.e. profession, gender, race).	E-Index goes from (-1) to (+1): Negative values indicate information sharing occurs more among farmers than with other actors, while positive values indicate the opposite.

We analyzed survey data using UCINET software (Borgatti et al. 2002) for egocentric metrics calculations. We used descriptive analysis and selected a set of metrics to analyze the temporal evolution of farmer social networks during the PM&E (Table 2). Centrality measures - indegree centrality, outdegree centrality, betweenness centrality- are commonly used to understand the potential for creation and sharing of knowledge in networks (Simpson and de Loë 2017, Beaman and Dillon 2018, Skaalsveen et al. 2020). The level of homophily indicates whether information and knowledge sharing occurs between the same type of actors (e.g. mostly farmer-to-farmer interactions) or between different actors (Beaman and Dillon 2018, Skaalsveen et al. 2020). Two step reach "betweenness" indicates how fast information can reach actors in a network (Hanneman and Riddle 2011). Centrality, betweeness and homophily metrics are widely used to assess knowledge sharing and potential diffusion of SLM and agricultural innovations in farmers´ networks (Simpson and de Loë. 2017, Beaman and Dillon 2018, Skaalsveen et al. 2020).

RESULTS

Farmers´ perceptions

The most relevant result from the evolution of individual FCM is that farmers mentioned significantly more factors (p-value=0.006) and more connections between factors (p-value=0.022) after taking part in PM&E (Table 3) (Figure 3) (Appendix 4). When we combined all individual FCMaps into collective FCMaps (Figure 3), we observed that the number of factors mentioned by farmers was higher post PM&E, but there were 14 less connections between factors (Table 3). Moreover, just 10 of the 65 mentioned factors (i.e. 15%) were cited by 5 or more farmers before PM&E, while the number increased to 22 factors out of 73 after PM&E (i.e. 30%). Furthermore, a higher number of farmers connected common RA practices - reduced tillage (RT), organic amendments (OA) and green manure (GM) - to land degradation and production (Table A5.1) (Table A5.2).

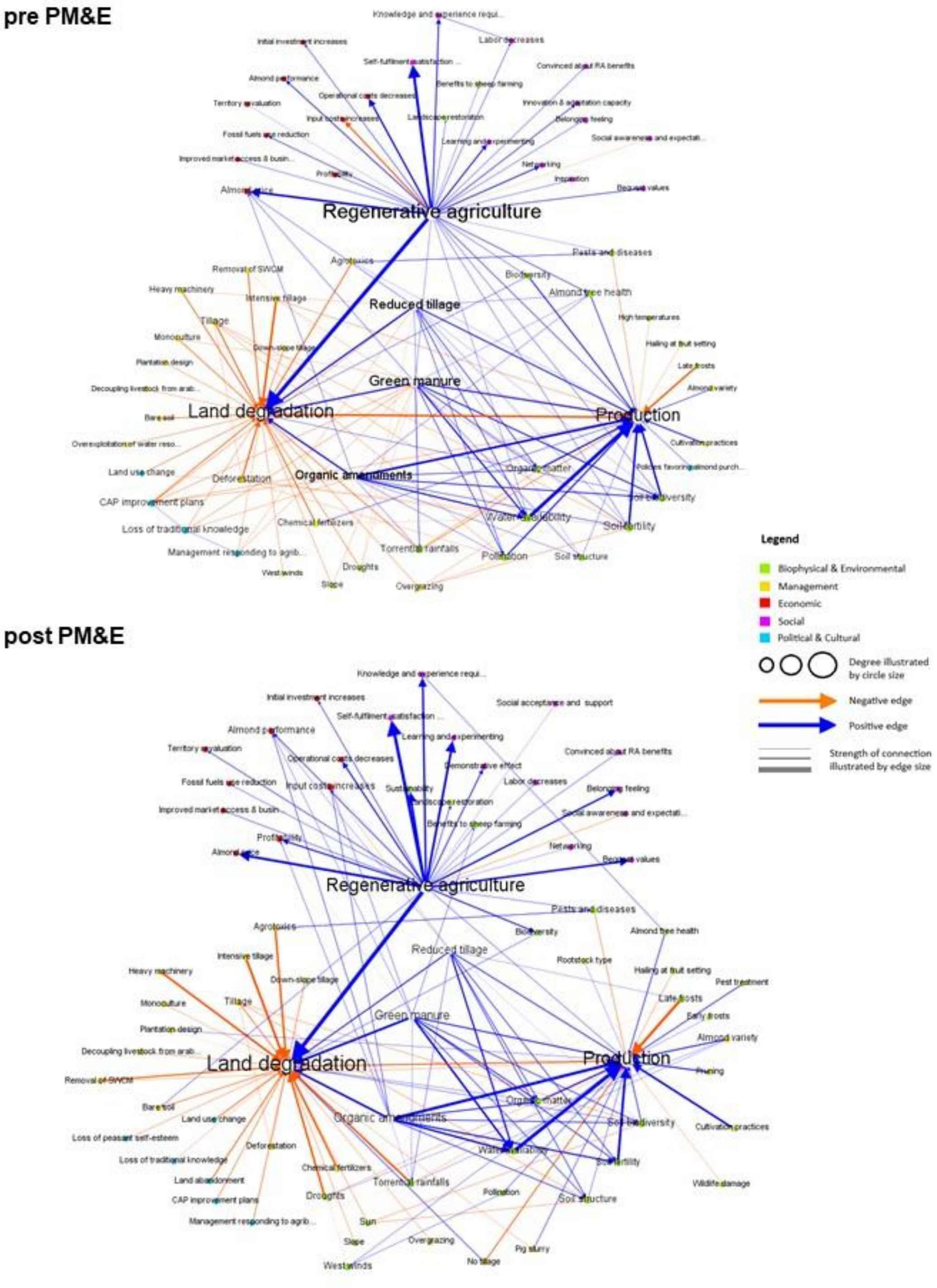

Figure 3 Combined FCMaps of farmers (n=10) before (pre PM&E) and in the 3rd year (post PM&E) of taking part in the participatory monitoring and evaluation project. The size of the circles indicates the relative centrality score of each factor, the thickness of the arrows represents the relative strength of the connection, and arrow colors indicate positive (blue) or negative (orange) connections – influences- of one factor on another factor.

Individually, farmers also mentioned significantly more transmitter (p-value=0.012) and more receiver (p-value=0.005) factors after PM&E, but there was no significant difference between ordinary factors (Table 3). Moreover, there were no significant differences between the amount of "biophysical & environmental" and "political & cultural" factors farmers´ mentioned before and after PM&E, whereas farmers mentioned significantly more "management" (p-value=0.016), "social" (p-value=0.011) and "economical" (p-value=0.042) factors after PM&E (Table 3). Collectively, farmers identified 10 more transmitter factors, and there were little differences in receiver and ordinary factors after PM&E (Table 3).

Table 3 Overview results of FCM indices on farmers´ individual and collective perceptions before and after taking part in the participatory monitoring and evaluation project (PM&E). * Statistical significance at p-value < 0.05

	Individual perceptions					Collective perceptions		
	p-value	z-value	pre PM&E ($\bar{x}$± SE)	post PM&E ($\bar{x}$± SE)	Difference	pre PM&E	post PM&E	Difference
Factors (nr.)	0.006*	-2,762	24,6 ± 1,1	30,0 ± 0,9	5,4	65	73	8
Connections (nr.)	0.022*	-2,296	32,6 ± 2,6	39,0 ± 2,6	6,4	142	128	-14
Transmitter (nr.)	0.012*	-2,505	11,3 ± 1,2	15,5 ± 1,1	4,2	23	33	10
Receiver (nr.)	0.005*	-2,762	8,2 ± 0,6	11,2 ± 0,4	3,0	22	23	1
Ordinary (nr.)	0.280	1,079	4,7 ± 0,9	3,3 ± 0,9	-1,4	20	17	-3
Management (nr.)	0.016*	-2,399	4,7 ± 0,6	7,0 ± 0,6	2,3	16	20	4
Biophysical & Environmental (nr.)	0.173	-1,360	6,7 ± 0,4	7,6 ± 0,6	0,9	18	21	3
Political & Cultural (nr.)	0.522	-0,639	0,8 ± 0,4	1,2 ± 0,4	0,4	5	6	1
Economical (nr.)	0.042*	-2,035	3,3 ± 0,3	4,0 ± 0,3	0,7	9	9	0
Social (nr.)	0.011*	-2,525	3,1 ± 0,3	4,2 ± 0,3	1,1	11	11	0
Green manure Centrality	0.674	0,420	2,8 ± 0,7	2,7 ± 0,5	-0,1	2,62	2,46	-0,2
Organic amendments centrality	0.250	-1,150	2,5 ± 0,5	3,4 ± 0,6	0,9	2,5	3,08	0,6
Reduced tillage centrality	0.843	-0,245	2,3 ± 0,6	2,4 ± 0,4	0,1	1,82	1,7	-0,1

Farmers perceived water availability, soil fertility, organic matter and soil biodiversity as most central factors both before and after PM&E (Figure 3) (Table A5.3). Water availability was mentioned as an influencing factor of crop production by all 10 farmers (Table A5.2), and was the most central factor before and after PM&E (Table A5.3), while soil fertility and organic matter gained importance over soil biodiversity after PM&E (Table A5.3).

Table 4 Results on the influence -strength of relation- of RA practices on Land degradation, production and factors with highest centrality pre and post PM&E

		RT	OA	GM
Land degradation	pre PM&E	0,38	0,38	0,38
	post PM&E	0,26	0,50	0,56
Production	pre PM&E	0,28	0,58	0,34
	post PM&E	0,22	0,72	0,28
Water availability	pre PM&E	0,18	0,36	0,34
	post PM&E	0,38	0,44	0,48
Soil fertility	pre PM&E	0,06	0,14	0,08
	post PM&E	0,18	0,34	0,20
Organic matter	pre PM&E	0,18	0,18	0,12
	post PM&E	0,18	0,26	0,24
Soil biodiversity	pre PM&E	0,04	0,26	0,28
	post PM&E	0,02	0,20	0,18

†Acronyms are as follow: RT= Reduced tillage, OA=Organic amendments, GM=Green manure

Table 4 shows the influence, or strength of relation, of the three most common RA practices on land degradation, production, and the four most central factors as expressed by the farmers. Regarding land degradation, before the PM&E, farmers perceived the impact of all three RA practices as similar (Table 4)(Figure 3).

After PM&E they perceived GM as the RA practice most beneficial to prevent land degradation, followed by OA, and lastly by RT. Regarding production, farmers perceived OA as the most influencing RA practice, followed by GM and RT. This perception remained similar along the PM&E project, however, farmers perceived a higher positive influence of OA and a lower influence of RT and GM on production after PM&E (Table 4)(Figure 3). Regarding the factors with highest centrality, farmers perceived OA as the RA practice with the most positive impact on water availability, soil fertility and organic matter. This perception remained similar, though with a perceived higher positive impact at the end of PM&E. However, after PM&E, farmers perceived GM to be slightly more positively influencing water availability than OA, while the latter was perceived as the practice most positively influencing soil biodiversity, which was initially attributed to GM. Before and after PM&E, RT was perceived as the RA practice with least influence on land degradation, production and all most central factors (Table 4)(Figure 3).

Farmers´ Social Networks

The Social Network Analysis (SNA) shows that the dimension of the PM&E farmers´ network was bigger in the third year of the PM&E project than just before its start, involving 45 more people with whom farmers established 65 new fluxes of information (Figure 4)(Table 5).

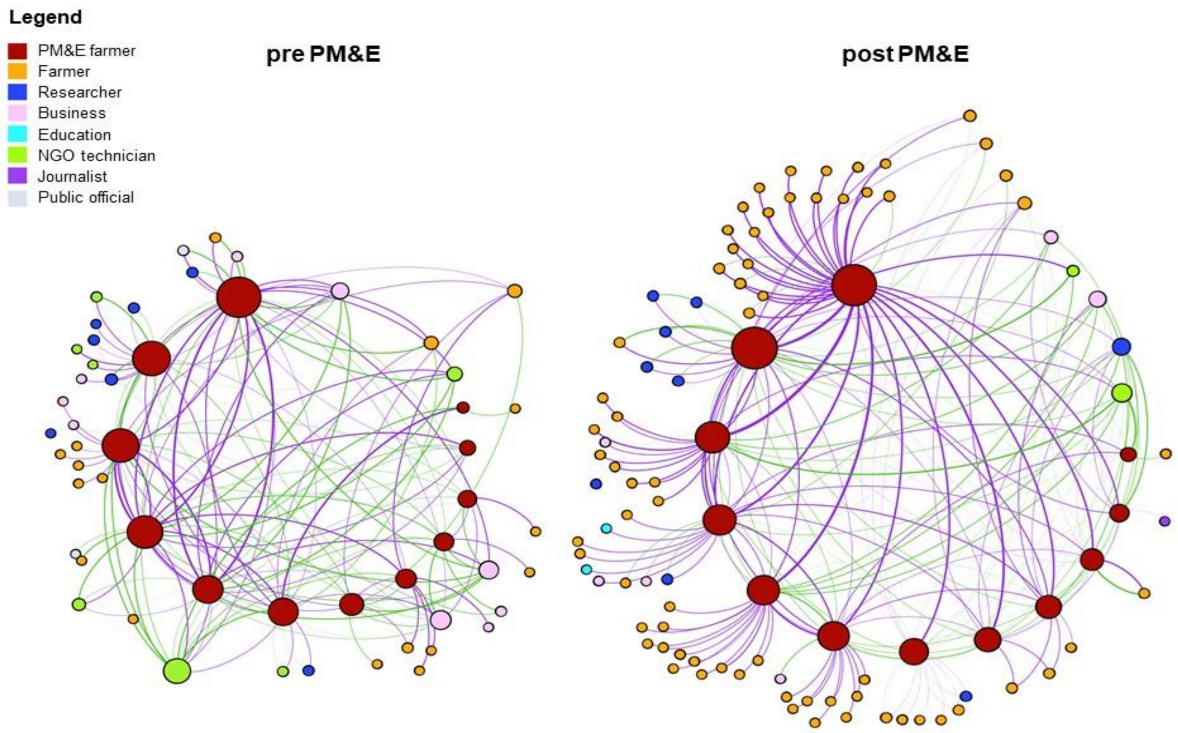

Figure 4 Social networks of farmers participating in PM&E of regenerative agriculture. Regenerative agriculture information fluxes of farmers (n=12) before initiating the PM&E project (pre PM&E), and in the 3rd year of taking part in the PM&E project (post PM&E) (n=12). Centrality is the sum of absolute weights of ingoing and outgoing connections. The size of the circles indicates the relative centrality score of each person, the thickness of the arrows represents the relative strength of the information flux, and arrow colors indicate the direction of the information flux that can be either received (green) or shared (purple) information.

After PM&E, within the group of PM&E farmers, in total 26 more fluxes of RA information were reported (i.e. sent and received) of which 15 more fluxes of information were sent by PM&E farmers, maintaining a similar frequency of communication (i.e. occasionally) with each receiver (Table 5). PM&E farmers received 11 more fluxes of information within the group, but the frequency decreased one point, from occasionally to seldom.

After PM&E, PM&E farmers shared RA information with more people from outside the group (mainly farmers), while they received slightly less fluxes of information from outside the group. There were particularly less NGO technicians providing information, while the main researcher facilitating the PM&E gained centrality (Figure 4). The frequency with which PM&E farmers sent to and received information from outside the group slightly decreased in time, as reflected by a slightly lower indegree centrality, but higher outdegree centrality after the PM&E process. Higher RA information sharing between PM&E farmers and with other non-participating farmers is reflected by the negative homophily index, meaning that RA information sharing occurs mostly between farmers. Lastly, betweenness and two step reach betweenness were higher after PM&E.

Table 5 Comparison of egocentric social networks parameters on information sharing generated from individual interviews pre PM&E and after 3 years of PM&E

Parameter	Information sharing	
	pre PM&E	post PM&E
Dimension	54	99
Information fluxes	175	236
Within PM&E		
Sent (number and frequency)	28 / 3,1	43 / 3,0
Received (number and frequency)	34 / 2,9	45 / 1,8
Outside PM&E		
Sent (number and frequency)	56 / 3,6	97 / 3,1
Received (number and frequency)	57 / 3,4	51 / 2,3
Metrics		
Indegree centrality	31,8	27,0
Outdegree centrality	32,4	42,6
Betweenness centrality	57,5	120,3
Two step reach betweenness (%)	39,3	81,3
Homophily	-0,21	-0,61

DISCUSSION

In the following sections we discuss whether based on our results, PM&E enabled social learning amongst participating farmers, addressing both the social-cognitive (perceptions) and the social-relational (social networks) dimensions. Based on these insights, we further elaborate the discussion on the potential of PM&E to support adoption and out-scaling of innovative SLM such as regenerative agriculture.

Social cognitive dimension

The analysis of the social cognitive dimension on how farmers´ perceptions evolved along the PM&E research project revealed that PM&E enabled social learning regarding regenerative agriculture. More specifically, PM&E facilitated a collective process of individual and collective learning resulting in more converging views and opinions amongst participating farmers on the influence of different RA practices on land degradation and production, and factors influencing and being influenced by them.

Greater and more complex individual knowledge about RA

Considering the evolution of individual perceptions (Appendix 4), the significantly higher number of factors and connections between factors mentioned by farmers in the FCM results (Table 3) after three years of PM&E, indicate that PM&E enhanced farmers´ acquisition of knowledge. The significantly higher number for receiver and transmitter factors mentioned by farmers after PM&E shows that farmers gained insights on influencing and influenced factors regarding RA, land degradation and production. In addition, significant differences show that farmers broadened their comprehension of the importance of management, social, and economic factors playing a role in their agroecosystems and livelihoods. In other words, after almost three years of PM&E research, farmers showed a more complex understanding of the social-ecological system around RA, land degradation, crop production, and related factors.

Farmers´ self-evaluation of SLM experiences has proven to be crucial for individual learning (Tran et al. 2018). The development process carried out through participatory workshops, where participating farmers identified, selected, prioritized and validated local indicators of soil quality, farmers´ monitoring of RA by using the field manual, and the collective sharing and discussion of monitoring results by farmers and researchers, seem to have achieved assisting farmer´s self-evaluation and self-reflection on

RA practices, management and impacts. This reflection process should help them in the decision-making towards SLM (Triste et al. 2014, Ball et al. 2017), and enhance farmers´ ownership and empowerment to adapt and adopt RA (Darnhofer et al. 2008). Learning mechanisms crucial for collective learning such as communication and knowledge exchange with other participating farmers and researchers are intrinsically linked to individual learning (Reed et al. 2010, De Vente et al. 2016). Therefore, individual learning was enabled in the PM&E through individual as well as collective learning processes, such as during facilitated participatory workshops and in the phone chat group. Thus, we state that involving farmers in PM&E enhanced individual learning, complying with the first requirement to achieve social learning (Reed et al. 2010).

More cohesive and broader common understanding of RA

While the individual FCMaps presented significantly more connections between factors after PM&E, the collective FCMap had fewer connections (Table 3) (Figure 3). This indicates that by participating in the PM&E project, farmers showed more complex individual perceptions and more consensus regarding RA impacts on land degradation, production and environmental, social, cultural, economic and political factors involved in their agroecosystems and livelihoods. This "higher consensus" can be observed as well in the higher citation frequency of mentioned factors (Fig A5.1) and the larger number of farmers that linked RA practices to land degradation and production (Table A5.1, Table A5.2). Furthermore, after PM&E, farmers differentiated more between the influence of regenerative practices on land degradation, production and those factors perceived as most central. Farmers´ perceptions on the influence of RA practices on these four most central factors were consistent with the monitoring results obtained by the researchers involved in PM&E on the impact of the different RA practices on soil physical, chemical and biological indicators of soil quality in the monitored farms (Luján Soto et al. 2021). This insinuates that PM&E favored knowledge exchange between farmers and researchers and a broader understanding of RA shared amongst the farmers involved, thereby complying with the second requirement for social learning (Reed et al. 2010). Interaction and deliberation involving different stakeholders in research processes to foster the appreciation of others´ perspectives has been highlighted for having greater potential to favor social learning than when only one type of actors are involved (García-Nieto et al.

2019). Converging perceptions is an expected outcome from knowledge exchange in social learning processes (Scholz et al. 2014). However, it is important to pay attention to the influence that some inputs may have, such as scientific inputs, in influencing the perceptions of participating stakeholders. Managing power dynamics by skilled and structured facilitation allows flattening of the hierarchical relationships between the actors to prevent biased orientation of perceptions of participating farmers towards the direction of actors with higher decision-making power (i.e. researchers, technicians…)(Dessie et al 2012; de Vente et al. 2016).

Moreover, it is worth noting that before starting the PM&E research, participating farmers already had some experience, knowledge and a positive predisposition towards RA. This condition, added to the fact that learning processes take time, might explain that although farmers have deepened their knowledge on RA, just few new factors were added, and we did not find very large changes between pre and post PM&E farmers´ perceptions.

Different participatory research processes have proven to enable social learning for natural resource management, sustainable development and climate change adaptation, such as participatory modeling in multi-stakeholder innovation platforms (Henly-Shepard et al. 2015), community-based management with participatory future scenarios (Johnson et al. 2012), or participatory mapping of ecosystems services (García-Nieto et al. 2019). The design of participatory research processes should be adapted to local contexts and established objectives to maximize their relevance and impact (De Vente et al. 2016, Reed et al. 2018), with facilitation being critical to ensure social learning (Harvey et al. 2013, Suškevičs et al. 2019). Ensor and Harvey (2015) discussed that "minimum sets" of participatory activities and tools are necessary to stimulate social learning in participatory processes, suggesting that the greater the integration of these activities and tools, the greater the opportunities for successful social learning. Our results on farmer perceptions provide substantial empirical evidence to prove that a well-designed PM&E process, combining different participatory activities and tools to facilitate participation, knowledge exchange and engagement between farmers and researchers, accelerates collective understanding and social learning on innovative SLM practices, which are important prerequisites for SLM out-scaling and large-scale adoption. Nevertheless, social learning is influenced by multiple, context dependent, factors (Ernst 2019, Suškevičs et al. 2019) and does not necessarily translate into collective action (Muro and Jeffrey 2008, Nykvist 2014, Newig et al. 2018).

Social relational dimensions

The analysis of the social-relational dimension on how farmers´ social networks on RA information evolved along the PM&E project highlights that PM&E processes boost farmers' number of relations, interactions and knowledge sharing, enabling social learning.

Strengthened farmer networks: empowerment, trust and confidence for RA adoption

Higher exchange of RA information fluxes within the group of PM&E farmers

PM&E enhanced information sharing between participating farmers, increasing the number of information fluxes that farmers shared among them, and maintaining a similar frequency of communication. The increase of information fluxes within the group after 3 years of research, reflects farmer´s larger mutual help, collaboration and proactivity, but foremost, increased access to knowledge on RA experiences. PM&E strengthened the PM&E group cohesion and facilitated farmers´ social learning, as was also evidenced in the analysis of farmers´ perceptions. The increased number of interactions resulted in a denser collaborative network, facilitating the exchange and dissemination of information and knowledge. This result aligned with the findings of Hermans et al. (2017) who showed that knowledge exchange was significantly correlated with the amount of ties in the collaborative network.

Denser networks tend to generate more cohesive groups which are more likely to form their own set of values, beliefs and behaviors in new belief systems (Monge et al. 2008). This is crucial because farmers who are more concerned about land degradation, and SLM practices and their impacts are more likely to adopt them (Marques et al. 2015, Carlisle 2016, Liu and Luo 2018, Teixeira et al. 2018). Since participating farmers were open and willing to share their knowledge, listen and understand each other, we argue that PM&E boosted trust, confidence and empowerment among farmers and about RA, which helped them deal with differences and reach agreement. Trust and confidence are emergent properties of social learning processes that can facilitate SLM adoption (Sol et al. 2013, De Vente et al. 2016). While relational social capital is key to fostering transitions (Darnhofer et al. 2016, Darnhofer 2020), moving from this to collective action goes beyond farmers´ agency, and relies on a diversity of factors and actors in an enabling environment. Thereby, these other factors and actors should also be addressed if we want to achieve large-scale SLM adoption (Pinto-Correia and Azeda 2017, Darnhofer et al. 2019, Pinto-Correia et al. 2019, Darnhofer 2020), for instance, considering innovative ways of participatory governance (Armitage et al. 2012), building multi-stakeholder partnerships, business model innovation, and policy support.

Slightly less information fluxes from outside PM&E farmers

The social network analysis (SNA) shows that PM&E farmers received less information (fluxes and frequency), from outside their group after 3 years of PM&E compared to the beginning of the research project (Figure 4)(Table 5). This can be explained by the fact that they were less dependent on external sources of information, suggesting an increased empowerment of farmers on RA understanding. The PM&E project stimulated them to share empirical information with peer farmers, and provided them access to new scientific information on adopted RA practices from participating researchers (Figure 4)(Table 5). Many organizations working with agroecology, sustainable farming and natural resource management, have emphasized the crucial role of farmers as co-producers of knowledge through the exchange of ideas, experiences and innovations (e.g. Via campesina, The Latin American Scientific Society of Agroecology (SOCLA), CGIAR Consortium of International Agricultural Research Centers, Associação Brasileira de Agroecologia (ABA), World Overview of Conservation Approaches and Technologies (WOCAT)). These organizations frequently use farmer to farmer diffusion of knowledge to strengthen farmers´ networks and to break with hierarchical top-down power relations and dependence on outside experts (Val et al. 2019). Our SNA evidenced that PM&E enabled social learning, since greater individual and collective knowledge sharing occurred through social interactions by the exchange of knowledge within their social network, complying this way with the third requirement for social learning (Reed et al. 2010). Farmer's evaluation of their participation in the PM&E project through individual interviews showed that PM&E 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 (Luján Soto et al. in review). This further validates the causal relation between farmers' participation in the PM&E project, the development of relations, and individual and collective learning.

Enlarged social networks: stimulating RA out-scaling

Farmers shared RA information with a larger number of farmers

After 3 years of PM&E, farmers almost doubled the number of people with whom they shared information about RA, mostly other farmers (Figure 4), as indicated by the homophily indicator. PM&E also enforced farmers' central role in communication and propagation of RA information, as was evidenced by the increase of farmers´ betweenness index. In addition, the larger and more complex social network generated after three years of PM&E favors a faster and easier access to RA information for other farmers and anyone forming part of the network, as demonstrated by the large increase of the two step betweenness indicator, a metric indicating efficiency, independence and empowerment. Therefore, while there may have been other factors involved as well, based on our findings, we argue that PM&E stimulated farmer empowerment, which is reflected in a wider diffusion of RA information between farmers. The dynamics of diffusion processes depend mostly on horizontal communication among farmers (Parra-Lopez et al. 2007, Wood et al. 2014, Tran et al. 2018, Skaalsveen et al. 2020), since new ideas are more easily adopted when they come from others who are considered "similar". This is, for instance, one of the reasons why the peasant-to-peasant method, prompted by social movements like 'La Via Campesina', has been used for decades for horizontal diffusion of knowledge and learning, and to enhance agroecology and SLM out-scaling worldwide (Val et al. 2019). Furthermore, it has been previously documented that farmers who are exposed to a more intense and better informed persuasion by the promoters of innovation are more likely to adopt it (Monge et al. 2008).

As reflected in our results, the developed PM&E research favored the creation of a more collaborative and supportive social network with more interactions between farmers and increased the potential for contagion effect, which may lead to enhanced RA out-scaling. Although post PM&E interviews for developing the SNA were held by phone due to COVID-19 mobility restrictions, the short period of time from the lock down until interviews were held, the questionnaire simplicity, researcher guidance on the interviewee process, and farmers previous experience with the methodology minimized potential limitations of shifting from in person to by phone format. It is important to highlight that multiple other factors also influence farmers' diffusion of information and knowledge, such as the level of education, the gender, the full-time or part-time dedication to the job and the type of job. For instance, Beaman and Dillon (2018) social network analysis showed that women have less access to knowledge on composting than men, and gender intersected with other factors such as the geographic distance to the informant and the power of the actor (betweenness centrality) that shared the information. Furthermore, it is worth noting that social learning goes beyond information and knowledge sharing and has aspects of emotional sharing, relationship building and mutual support (Reed et al. 2010, Johnson et al. 2012, Van Der Wal et al. 2014), aspects that we did not address in this study. As a final remark we would like to highlight that although social learning on innovative SLM can be expedited by well designed PM&E research processes involving farmers and researchers (Luján Soto et al 2020, García-Nieto et al 2019), PM&E is eminently empirical and nourished by on field experimentation. Thus, social learning on SLM is also conditioned by the biophysical and climate conditions of the study region. For instance, in our study context where RA is applied in a semiarid region, water scarcity limits soil biological activity, and soil quality and agroecosystems changes may take time to occur, thereby slowing down learning processes.

PM&E and Living Labs to support out-scaling RA and SLM

Participatory research to support social learning, out-scaling and large-scale adoption of SLM is increasingly promoted by researchers and policy-makers worldwide (Reed et al. 2011, Bouma 2019, Albaladejo et al. 2021), and is also pre-eminent on the EU agenda in the context of agricultural transition in Europe. The European Green Deal and related strategic guidelines (European Commission 2019, 2020), focus much more strongly than before on innovation in farming by joint learning and interaction. For sustainable management of soils and a transition towards RA and agroecology, the science-practice interface is to be supported by a dense network of Living Labs (LL) across all European regions. Living Laboratories (Living Labs) are spaces for co-innovation through participatory, transdisciplinary and systemic research (ENoLL 2020, Veerman et al. 2020). They are expected to foster the co-design, evaluation and assessment of innovative practices beyond current understanding with inputs from citizens, practitioners (e.g. farmers, foresters, landscape managers), advisory services, scientists, planners and policy makers, business, educators and trainers. Accelerating adoption of SLM innovations like RA requires a closer fit between the features of a solution and the needs of its potential adopters (Lahmar et al. 2012, Chinseu et al. 2019). Thus, the user-centric LL approach to develop and co-create innovative solutions in partnership with stakeholders and tested in their real-life context holds great promise for accelerating the transition of the agri-food system towards greater sustainability and resilience (Schuurman and Tõnurist 2017, Zavratnik et al. 2019). Considering the urgency of addressing global land degradation and the increasing importance put on participatory research and PM&E to promote social learning and adoption of SLM in main international agendas, further research on factors that can favor or impede social learning in PM&E is highly needed. Addressing this knowledge gap is of great help to improve the design and development of future PM&E research projects, and nourish and support the development of Living Labs to enhance the long-term adoption of SLM and to favor sound transitions towards sustainable agroecosystems. We consider that the findings from our research can inform more targeted and effective design of the LLs model, adapted to each context. Moreover, promotion of Living Labs integrating participatory monitoring and evaluation and co-development of solutions may provide a very powerful tool to support social learning and out-scaling of SLM in different land use systems.

Reflection on methodologies

Aggregating individual FCMaps into collective FCMaps is a commonly used method that can be helpful to reveal and contrast patterns in the evolution of perceptions of one group of actors (Scholz et al. 2014) or to compare different actor groups (Teixeira et al 2018). Given that collective FCMs are created by merging the factors and summing the connections raised by all farmers in the PM&E group, special attention must be paid in the interpretation of FCMaps to avoid misinterpretations. When merging individual FCMaps into collective FCMaps, obtaining fewer connections in the latter than by summing the connections of individual maps can respond to two different causes. On the one hand, if the connection between two factors is perceived by two individual farmers to have the same sign, then fewer connections in the collective map would indicate more cohesion in collective farmers´ perceptions. On the other hand, one negative connection and one positive connection on two factors perceived by two individual farmers will only be represented by one connection based on the average weight of the two connections, representing one single connection. In this case, fewer connections in the collective map will not indicate more cohesion. Therefore, interpretation of collective FCMaps needs to take into account potential artifacts associated with the merging of individual farmer responses into group responses, and data must be well analyzed, interpreted and discussed by the researchers to avoid misinterpretations. In this study, fewer connections in the collective FCMap after farmers participating in PM&E provided a fair representation of the higher cohesion in individual farmer´s responses. This is confirmed by contrasting farmer´s individual FCMaps and by the higher citation frequency of mentioned factors, the larger number of farmers that linked RA practices to land degradation and production, and by the fact that farmers differentiated more between the influence of different regenerative practices on land degradation, production and the factors perceived as most central after PM&E. Therefore we are confident that the analysis of individual and collective FCMaps provides representative insights on farmers´ more complex and more common understanding on RA and social learning.

The SNA methodology revealed the evolution of farmers´ networks on RA information and knowledge sharing. Some information fluxes between farmers were mentioned by only one of the farmers, which could be attributed to farmers forgetting to mention some connections. This is a common limitation of open data collection methods for conducting SNA interviews (Borgatti et al. 2013). Using open questionnaires and closed lists for the interviewee to select names have other limitations. Restricting is simpler but can induce false quotes; therefore it is preferable to give freedom rather than restriction (Borgatti et al. 2013). By using an open questionnaire, we assumed that all information fluxes mentioned by farmers were real and we took them as valid.

CONCLUSIONS

Well-designed participatory monitoring and evaluation research processes favor the creation of dense collaborative networks, generating the conditions to stimulate enhanced knowledge exchange between farmers and researchers. This significantly contributes to faster and easier access to information on innovative SLM to stakeholders in the network, thus stimulating social learning, to support SLM adoption and out-scaling. This outcome of PM&E was revealed by (i) a broader and more complex understanding by farmers on the potential of regenerative agriculture to counter land degradation and enhance production, including environmental, social and economic factors; (ii) a more cohesive collective perception and higher consensus on the impacts of regenerative agriculture and most common regenerative practices over multiple aspects; (iii) a strengthened and enlarged farmer social network for sharing of regenerative agriculture information, with a more central role of participating farmers as drivers of innovation, thereby increasing the potential for regenerative agriculture adoption and out-scaling. Therefore, we argue that participatory monitoring and evaluation is an effective tool for individual and collective knowledge acquisition, co-creation and dissemination of knowledge, with relevance for the design of Living Labs and similar science-practice co-innovation spaces, to enhance adoption and out-scaling of innovative SLM.

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Appendix 1: Lists of original concepts, transformations and final concepts

ID	Original concept	English concept	Homogenization	Final concept	Is reverse
1	Laboreo intensivo (frecuencia)	Intensive tillage (frequency)	Intensive tillage	Intensive tillage	n
2	Laboreo intensivo (profundidad)	Intensive tillage (depth)	Intensive tillage	Intensive tillage	n
3	Laboreo: el hecho de labrar	Tillage: the fact of tilling	Tillage	Tillage	n
4	Labrar a favor de pendiente	Down-slope tillage	Down-slope tillage	Down-slope tillage	n
5	Lluvias torrenciales	Torrential rainfalls	Torrential rainfalls	Torrential rainfalls	n
6	Sol	Sun	Sun	Sun	n
7	Cambio climático	Climate change	Torrential rainfalls Droughts	Torrential rainfalls Droughts	n n
8	Aumento de sequías	Increment of droughts	Droughts	Droughts	n
9	Sequias	Droughts	Droughts	Droughts	n
10	Pendiente	Slope	Slope	Slope	n
11	Monocultivo	Monoculture	Monoculture	Monoculture	n
12	Deforestación	Deforestation	Deforestation	Deforestation	n
13	Sobrepastoreo	Overgrazing	Overgrazing	Overgrazing	n
14	Cambio usos del suelo: de cereal a leñosos	Land use change: from cereal to woody crops	Land use change	Land use change	n
15	Desvincular la ganadería y la agricultura	Decoupling livestock from arable farming	Decoupling livestock from arable farming	Decoupling livestock from arable farming	n
16	Mecanización	Mechanization	Mechanization	Heavy machinery	n
17	Maquinaria pesada	Heavy machinery	Heavy machinery	Heavy machinery	n
18	Adaptación de la agricultura a la maquinaria	Adaptation of farming to heavy machinery	Heavy machinery	Heavy machinery	n
19	Desaparición de lindes y su vegetación	Elimination of field boundaries and hedgerows	Removal of barriers	Removal of soil and water conservation measures	n
20	Eliminación de barreras	Removal of barriers	Removal of barriers	Removal of soil and water conservation measures	n
21	Eliminación de linderos, ribazos y barreras naturales	Removal of boundaries, hedgerows and natural barriers	Removal of barriers	Removal of soil and water conservation measures	n
22	Eliminación de atochás	Removal of mud barriers	Removal of barriers	Removal of soil and water conservation measures	n
23	Eliminación de terrazas	Removal of terraces	Removal of barriers	Removal of soil and water conservation measures	n

24	Eliminación de terrazas y barreras	Removal of terraces and barriers	Removal of barriers	Removal of soil and water conservation measures	n
25	Falta de cubiertas	Lack of ground covers	Bare soil	Bare soil	n
26	Capitalismo: políticas públicas equivocadas	Capitalism: wrong public policies	CAP subsidies responding agribusiness interests	CAP subsidies responding agribusiness interests	n
27	Incentivar prácticas que responden a intereses empresas y no del agricultor	Promotion of farming practices that respond to agribusiness interests and not to farmers	CAP subsidies responding agribusiness interests	CAP subsidies responding agribusiness interests	n
28	Manejo favorables a intereses económicos de empresas	Farming managements that respond to agribusiness interests	Management responding to agribusiness interests	Management responding to agribusiness interests	n
29	Abandono de la tierra	Land abandonment	Land abandonment	Land abandonment	n
30	Falta de mano de obra (éxodo rural)	Lack of labor (rural exodus)	Land abandonment	Land abandonment	n
31	Subvenciones (PAC - Políticas Públicas)	PAC subsidies - Improvement plans	CAP subsidies responding agribusiness interests	CAP subsidies responding agribusiness interests	n
32	Concentración de tierras	Land concentration	Land concentration	Land concentration	n
33	Pesticidas	Pesticides	Agrotoxics	Agrotoxics	n
34	Fitosanitarios	Agrotoxics	Agrotoxics	Agrotoxics	n
35	Abonos químicos	Chemical fertilizers	Chemical fertilizers	Chemical fertilizers	n
36	Abonos sintéticos	Synthetic fertilizers	Chemical fertilizers	Chemical fertilizers	n
37	Regadío y sobreexplotación de recursos hídricos	Irrigation and overexploitation of water resources	Overexploitation of water resources	Overexploitation of water resources	n
38	Sobrexplotación recursos hídricos	Overexploitation of water resources	Overexploitation of water resources	Overexploitation of water resources	n
39	Purines	Pig slurry	Pig slurry	Pig slurry	n
40	Falta de materia orgánica	Lack of organic matter	Lack of organic matter	Organic matter	y
41	Suelos descubiertos (falta de cubiertas)	Bare soil (Lack of ground covers)	Bare soil	Bare soil	n
42	Falta y pérdida de conocimientos de manejo y prácticas	Lack and loss of traditional/folk knowledge on sustainable farming practices and management	Loss of traditional knowledge	Loss of traditional knowledge	n
43	Pérdida de conocimiento en el manejo "sabiduría popular"	Loss of traditional/folk knowledge on farming managements (farming wisdom)	Loss of traditional knowledge	Loss of traditional knowledge	n
44	Pérdida de autoestima campesina	Loss of peasant self-esteem	Loss of peasant self-esteem	Loss of peasant self-esteem	n
45	Lluvias fuertes época de floración	Torrential rainfalls during blossoming	Torrential rainfalls	Torrential rainfalls	n
46	Altas temperaturas (por	High temperatures (over	High temperatures	High temperatures	n

	encima de 40ºC)	40ºC)			
47	Disponibilidad de agua	Water availability	Water availability	Water availability	n
48	Heladas tardías (congelan la alloza o almendruco)	Late frosts that freeze the green almond nut	Late frosts	Late frosts	n
49	Heladas tempranas	Early frosts	Early frosts	Early frosts	n
50	Granizadas después de que cuaje	Hailing during/after fruit setting	Hailing at fruit setting	Hailing at fruit setting	n
51	Viento de poniente (fuerte y cálido)	West winds	West winds	Warm West winds	n
52	Fertilidad del suelo	Soil fertility	Soil fertility	Soil fertility	n
53	Biodiversidad del suelo	Soil biodiversity	Soil biodiversity	Soil biodiversity	n
54	Equilibrio (parte viva, orgánica y mineral)	Soil balance (organisms, organic and mineral fractions)	Soil balance	Soil balance	n
55	Estructura del suelo	Soil structure	Soil structure	Soil structure	n
56	Materia orgánica	Organic matter	Organic matter	Organic matter	n
57	Nutrición del árbol	Almond tree nutrition	Almond tree nutrition	Almond tree nutrition	n
58	Polinización	Pollination	Pollination	Pollination	n
59	Niebla en floración	Fog at blossoming	Fog	Fog	n
60	Labores culturales	Cultural practices	Cultivation practices	Cultivation practices	n
61	Manejo con abejas	Management with bees	Cultivation practices	Cultivation practices	n
62	Variedad del almendro	Almond variety	Almond variety	Almond variety	n
63	Falta de ganado	Lack of livestock	Lack of livestock	Decoupling livestock from arable farming	n
64	Plagas	Pests	Pests and diseases	Pests and diseases	n
65	Salud del cultivo	Almond tree health	Almond tree health	Almond tree health	n
66	Biodiversidad	Biodiversity	Biodiversity	Biodiversity	n
67	Insumos químicos	Chemical inputs	Chemical fertilizers	Chemical fertilizers	n
68	Poda	Pruning	Pruning	Pruning	n
69	Poda (en verde)	Green pruning	Pruning	Pruning	n
70	Pie franco	Ungrafted rootstock	Rootstock type	Rootstock type	n
71	Pie franco/ hibrido (tipo de pie)	Ungrafted or hybrid rootstock (type)	Rootstock type	Rootstock type	n
72	Plagas y enfermedades (exceso de lluvia en primavera)	Pests and diseases (excessive rainfall in spring)	Pest and diseases	Pest and diseases	n
73	Plagas y enfermedades (tratamiento preventivos con cobre)	Pests and diseases (Preventive pest treatments using copper)	Pest treatment	Pest treatment	n
74	Tratamiento de plagas	Pest treatments	Pest treatment	Pest treatment	n
75	No laboreo	No tillage	No tillage	No tillage	n
76	Daños animales (arruí, jabalí)	Damage caused by arrui and wild pigs	Wildlife damage	Wildlife damage	n

77	Diseño de la plantación	Plantation design	Plantation design	Plantation design	n
78	Pérdida de suelo	Soil loss	Land degradation	Land degradation	n
79	Acceso a mejores mercados	Access to better markets	Access to better markets	Improved market access & business opportunities	n
80	Adaptación a cambios	Adaptation to changes	Adaptation to changes	Innovation & adaptation capacity	n
81	Aumento precio almendra	Almond price increases	Almond price	Almond price	n
82	Sentimiento de pertenencia (arraigo territorio)	Belonging feeling (deep roots in the territory)	Belonging feeling	Belonging feeling	n
83	Rendimiento (calibre de la almendra y peso)	Performance (Caliber and weight of kernel nut)	Almond performance	Almond performance	n
84	Generaciones futuras	Coming generations	Coming generations	Bequest values	n
85	Efecto contagio/demostrativo a vecinos	Contagion and demonstrative effect	Contagion and demonstrative effect	Demonstrative effect	n
86	Contribución al planeta (Sostenibilidad)	Contribute to planet earth (sustainability)	Contribute to planet earth (sustainability)	Bequest values	n
87	Convencido de los beneficios de RA	Convinced about RA benefits	Convinced about RA benefits	Convinced about RA benefits	n
88	Dar que hablar al pueblo	Create a buzz	Demonstrative effect	Demonstrative effect	n
89	Por experimentar y aprender	Eager for learning and experimenting	Learning and experimenting	Learning and experimenting	n
90	Facilidad de manejo por adaptación a ciclos naturales	Easiness in management following natural cycles	Easiness in management following natural cycles	Labor decreases	n
91	Necesidad de experiencia (profesionalización)	Experience requirements (professionalization)	Experience requirements (professionalization)	Knowledge and experience requirement (Professionalization)	n
92	Compartir experiencias	Sharing experiences	Learning and experimenting	Learning and experimenting	n
93	Reducción combustibles fósiles	Fossil fuels use decreases	Fossil fuels use decreases	Fossil fuels reduction	n
94	Felicidad	Happiness	Happiness	Self-fulfillment, satisfaction and personal development	n
95	Favorece a los pastores por alimento al ganado	Helps shepherds because of fodder	Benefits to sheep farming	Benefits to sheep farming	n
96	Aumento de la demanda de las empresas	Companies´ demands increase	Companies´ demands increase	Improved market access & business opportunities	n
97	Incremento solicitud de productos, conocimientos, charlas	Higher demands (products, talks, knowledge)	Higher demands (products, talks, knowledge)	Improved market access & business opportunities	n
98	Mejor rendimiento a largo plazo	Higher economic performance	Profitability	Profitability	n

99	Producción	Production	Production	Production	n
100	Inversión inicial aumenta	initial investment increases	initial investment increases	Initial investment increases	n
101	Coste insumos aumenta a corto plazo	Input costs increases (short term)	input costs increases	Input costs increases	n
102	Reducción costes de insumo	Inputs costs decreases	input costs increases	Input costs increases	y
103	Inspiración	Inspiration	Inspiration	Inspiration	n
104	Necesidad de conocimientos (RA mayor complejidad)	Knowledge requirements (RA higher complexity)	Knowledge requirements	Knowledge and experience requirement (Professionalization)	n
105	Necesidad de conocimiento técnicos	Technical knowledge requirements	Knowledge and experience requirement (Professionalization)	Knowledge and experience requirement (Professionalization)	
106	Reducción de mano de obra	Reduction of working force	Labor decreases	Labor decreases	n
107	Reducción horas de trabajo	Reduction of working hours	Labor decreases	Labor decreases	n
108	Mano de obra aumenta	Labor increases	Labor decreases	Labor decreases	y
109	Belleza del paisaje	Landscape aesthetics	Landscape aesthetics	Landscape restoration	n
110	Recuperación del Paisaje	Landscape recovery/restoration	Landscape restoration	Landscape restoration	n
111	Aprender	Learning	Learning	Learning and experimenting	n
112	Reducción de enfermedades ganado	Livestock diseases decreases	Livestock diseases decreases	Benefits to sheep farming	n
113	Amor a la tierra	Love for the land	Belonging feeling	Belonging feeling	n
114	Necesidad de adaptar la maquinaria	Machinery adaptation requirements	Machinery adaptation requirements	Innovation & adaptation capacity	n
115	Reducción gastos maquinaria	Machinery costs decreases	Machinery costs decreases	Operational costs decreases	n
116	Aumento costes manejo	Operational costs increases	Operational costs increases	Operational costs decreases	y
117	Manejo más complicado	Management is more complex	Management complexity	Knowledge and experience requirement (Professionalization)	n
118	Conocer personas dentro de RA interesantes	Meeting interesting people working with RA	Networking	Networking	n
119	Aprendizaje mutuo	Mutual learning	Mutual learning	Learning and experimenting	n
120	Políticas que incentiven la compra de almendras	Need of policies to promote almond purchases	Need of policies to promote almond purchases	Policies favoring almond market purchases	n
121	Acceso de redes: Contactos	Access to networks: contacts	Networking	Networking	n
122	Networking	Networking	Networking	Networking	n

123	Nuevas oportunidades de negocio (Agroturismo)	New business opportunities (agro-tourism)	New business opportunities (agro-tourism)	Access to better markets & business opportunities	n
124	Apertura a nuevas tecnologías	Openness to new technologies	Openness to new technologies	Innovation & adaptation capacity	n
125	Reducción de costes operacionales	Operational costs decreases	Operational costs decreases	Operational costs decreases	n
126	Desarrollo personal	Personal development	Personal development	Self-fulfillment, satisfaction and personal development	n
127	Disfrute personal de la finca	Personal enjoyment of the farm	Personal enjoyment of the farm	Self-fulfillment, satisfaction and personal development	n
128	Reducción tratamientos fitosanitarios (curas para Plagas)	Pest treatments decreases	Pest treatments decreases	Pest treatment	n
129	Rentabilidad	Profitability	Profitability	Profitability	n
130	Calidad de la almendra	Quality of almond nut (kernel)	Quality of almond nut (kernel)	Almond quality	n
131	Reducción de costes a largo plazo	Reduction of costs (long term)	Reduction of costs (long term)	Operational costs decreases	n
132	Respeto al planeta (Sostenibilidad)	Respect to planet earth (sustainability)	Bequest values	Bequest values	n
133	Satisfacción y desarrollo personal	Satisfaction and personal development	Satisfaction and personal development	Self-fulfillment, satisfaction and personal development	n
134	Ahorro de tiempo	Saves time	Saves time	Labor decreases	n
135	Incremento consciencia social (ayudar a la gente)	Social consciousness increases (help people)	Social consciousness increases (help people)	Social awareness and expectation	n
136	Presión social	Social pressure	Social pressure	Social acceptance and support	y
137	Aumento sensibilización y expectación en la sociedad	Social awareness and expectation increases	Social awareness and expectation increases	Social awareness and expectation increases	n
138	Espiritualidad	Spirituality	Spirituality	Self-fulfillment, satisfaction and personal development	n
139	Sostenibilidad	Sustainability	Sustainability	Sustainability	n
140	Revalorización del	Territory revaluation	Territory revaluation	Territory revaluation	n
141	Reducción de costes de	Tillage cost decreases	Tillage cost decreases	Operational costs	n
142	Validación y apoyo	Validation and social	Validation and social	Validation and social	n
143	Orgullo y éxito personal	Pride and personal success	Self-fulfillment,	Self-fulfillment,	n
144	Degradación de la Tierra	Land degradation	Land degradation	Land degradation	n
145	Enmiendas orgánicas	Organic amendments	Organic amendments	Organic amendments	n
146	Abonos verdes	Green manure	Green manure	Green manure	n
147	Laboreo reducido	Reduced tillage	Reduced tillage	Reduced tillage	n

148	Salud física y mental del agricultor	Farmer´s physical and mental health	Self-fulfillment, satisfaction and	Self-fulfillment, satisfaction and	n
149	Necesidad de maquinaria	Need of machinery	Innovation & adaptation capacity	Innovation & adaptation capacity	n
150	Ver para creer	Seeing for believing	Learning and experimenting	Learning and experimenting	n
151	Sistemas de conservación de agua	Water conservation measures	Removal of soil and water conservation	Removal of soil and water conservation	y
152	Tratamiento con cobre	Pest treatment	Pest treatment	Pest treatment	n
153	Despoblación	Depopulation	Land abandonment	Land abandonment	n

Appendix 2: Lists of concepts in the aggregated map and their meaning

ID	Final concept	Interpretation/definition based on farmers´ interviews
1	Intensive tillage	Tillage frequency higher than 4 times per year, moldboard plowing and/or deep plowing
2	Tillage	The fact of tilling
3	Down-slope tillage	Tillage direction following the direction of the slope, favoring erosion processes and soil loss
4	West winds	Winds coming from the west usually strong and warm. In spring negatively affect pollination
5	Sun	High temperatures, insolation and evapotranspiration
6	Droughts	Periods of water scarcity
7	Slope	Steep slopes
8	Monoculture	Cultivation of one single crop occupying large land extensions
9	Deforestation	Clear cutting or clearing a forest to convert it to farm land
10	Overgrazing	Excessive grazing causing damage to grasslands, such as compaction and fertility loss
11	Land use change	Conversion from cereal to woody crops, mainly to almond trees
12	Decoupling livestock from arable farming	Separation of livestock from arable production. Disappearance of traditional integrated systems based on woody crops, pastures and sheep
13	Heavy machinery	Change from oxen plow to heavy machinery, leading to the intensification of tillage activities and adaptation of farming practices to machinery
14	Removal of SWCM	Removal of soil and water conservation measures and erosion barriers, such as stone walls, hedgerows, vegetation on field borders, and mainly "atochadas", a small barrier made of mud and esparto grass or other woody plants for retaining water within terraces
15	Bare soil	Soil without surface protection due to elimination of ground covers
16	CAP improvement plans	Policies from the 90´s prompted by the EU which initially subsidized the use of chemical fertilizers, agrotoxics, tillage and other farming practices, while in later stages of agricultural surpluses, PAC subsidies were destined for not producing, thereby fostering land abandonment and cessation of farming activities
17	Management responding to agribusiness model	Farm management coupled to the green revolution and agribusiness farming model, which has led to the removal of terraces, contour lines, use of heavy machinery, agrochemicals and agrotoxics
18	Land abandonment	Land abandonment partly due the industrialization of agriculture, and relates services and industry. Less labor is needed, and the lack of opportunities in rural areas led to the flight of people from rural areas to cities (rural exodus)
19	Land concentration	Concentration of land ownership in a few owners due to the reduction of the number of farms and the increment of the farm size
20	Agrotoxics	Pesticides and herbicides used in agriculture to eliminate weeds, insects, fungi or any other living organisms affecting crop performance
21	Chemical fertilizers	Mineral fertilizers including mainly simple and mixed N, P, K fertilizers

22	Overexploitation of water resources	Water extraction rates beyond natural recharge. This includes groundwater extraction from (i)legal drilled wells and water reservoirs to water traditional rain-fed crops, high-yielding horticultural crops, or intensive fruit tree plantations
23	Pig slurry	Watery and nutrient concentrated amendment mixed of feces, urine and water wastes from pig farming, that after treatment is often used as fertilizer
24	Organic matter	Organic matter component of soil, consisting of plant and animal detritus, cells and tissues of soil microbes, and substances that soil microbes synthesize
25	Loss of traditional knowledge	Loss of traditional knowledge of farming practices and management used by farmers before the arrival of "Green Revolution model". Traditional knowledge includes understandings to maintain soil fertility through careful management of organic material; to avoid pest outbreaks through intercropping and natural remedies, and about crop varieties, soil types and their best combination, involving a deep connection to the land and its stewardship
26	Loss of peasant self-esteem	Loss of sense of self, the value of the community and the value of the peasant´s profession, as a result of years of denigration and prejudice fostered by the green revolution model
27	Torrential rainfalls	Extreme and concentrated rainfall events occurring in the southeast, and the Mediterranean coast, of Spain. Usually occur during the beginning of Autumn and Spring with the arrival of the Cold Drop phenomenon. In agricultural lands these events often cause huge soil losses via water erosion affecting crop production due to the fall of flowers and fruits
28	High temperatures	Temperatures over 40ºC. During blossoming bees do not visit flowers at high temperatures, negatively affecting pollination.
29	Water availability	Water supply to meet crop requirements as a crucial factor in drought-prone agricultural areas
30	Late frosts	Frost occurring in spring that freeze blossoms and green almond nuts
31	Early frosts	Frost occurring in early winter which delays blossoming avoiding possible yield losses caused by late frosts
32	Hailing at fruit setting	Hailing during fruit setting damages almond nuts and produces the fall of fruits jeopardizing annual crop production
33	Soil fertility	Natural fertility intrinsic of the different soil types
34	Soil biodiversity	Number and diversity of organisms present in the soil required for soil health, fertility and overall soil functioning
35	Soil balance	Equilibrium between the organic and mineral fractions of the soil and the soil organisms
36	Soil structure	How particles are aggregated in the soil. Good soil structure enhances soil porosity, water holding capacity and decomposition processes fostering nutrient cycling
37	Pollination	Fertilization of almond flowers by bees and other pollinators
38	Fog	Fog. During blossoming negatively affects pollination
39	Cultivation practices	All the processes involved in the production of plant-based systems carried by the farmer, from seedling to harvesting, including fertilization, tillage, planting, pruning, pest treatments…
40	Almond variety	Almond varieties belong to the hard shell type and have different characteristics such as flowering time and sensibility to pests and

		diseases, and include Guara, Ferragnes, Marcona, Vairo, Desmayo Largueta, Marta, Constanti, Antoñeta, Penta and Marinada among others. The variety of almond can highly condition annual yields depending on the biophysical and climatic conditions where it is planted
41	Pests and diseases	Organisms that cause damage to almond trees conditioning yield. Most important pest and diseases include big head worm (*Capnodis tenebrionis*), almond-tree leaf skeletonizer moth (*Aglaope infausta*) and the monilinia fungus (*Monilinia laxa)*
42	Almond tree health	Includes all factors that contribute to a good performance of the almond tree, including the nutritional status of almond trees
44	Biodiversity	Aboveground biodiversity (insects, plants, crops, animals)
45	Pruning	Type, frequency and timing (green or dry) of the pruning
46	Rootstock type	Ungrafted or hybrid. The rootstock type influences the tree life time, performance and susceptibility to pests and diseases
47	Pest treatment	Preventive and in-situ management of pests using copper and other products allowed in organic farming
48	No tillage	Farming without disturbing the soil profile through tillage activities
49	Wildlife damage	Damage caused to almond trees by wild goats (*Ammotragus lervia*), wild pigs and rabbits
50	Plantation design	Factors to take into account for the establishment of an almond plantation such as the planting frame, the contour lines, terraces, almond variety…
51	Almond price	Organic certified almonds have an added value as "regenerative" branded which translates into the increase of price
52	Almond performance	Caliber and weight of kernel nuts, and amount of empty almonds in 1kg of shell almonds. Higher performance implies higher proportion of filled almonds with higher caliber and weight
53	Feeling of belonging	Strong emotional feeling, need or desire of belonging to a community of people, a territory or a place
54	Benefits to sheep farming	Better nutritional status and health of the herd due to the supply of high quality fodder to sheep, which translates into less veterinary costs for the shepherd
55	Bequest values	Value that the current generation places on ensuring the availability of biodiversity and ecosystem services to future generations. This is determined by a person's concern that future generations should have access to resources and opportunities. It indicates a perception of benefit from the knowledge that resources and opportunities are being passed to descendants
56	Convinced about RA benefits	Farmers´ conviction regarding RA restoration capacity based on their own experience or perceptions
57	Demonstrative effect	Effects on the behavior of individuals, mainly neighbors, caused by observation of the results achieved through the adoption of regenerative agriculture
58	Fossil fuels use reduction	Diesel and oil use reduction due to the minimization of tillage activities, the non-use of chemical fertilizers and agrotoxics used in conventional farming
69	Happiness	Feeling of pleasure and joy experienced by a person from doing what she/he beliefs is right
60	Improved market access &	Higher demand of products by companies, and better access to

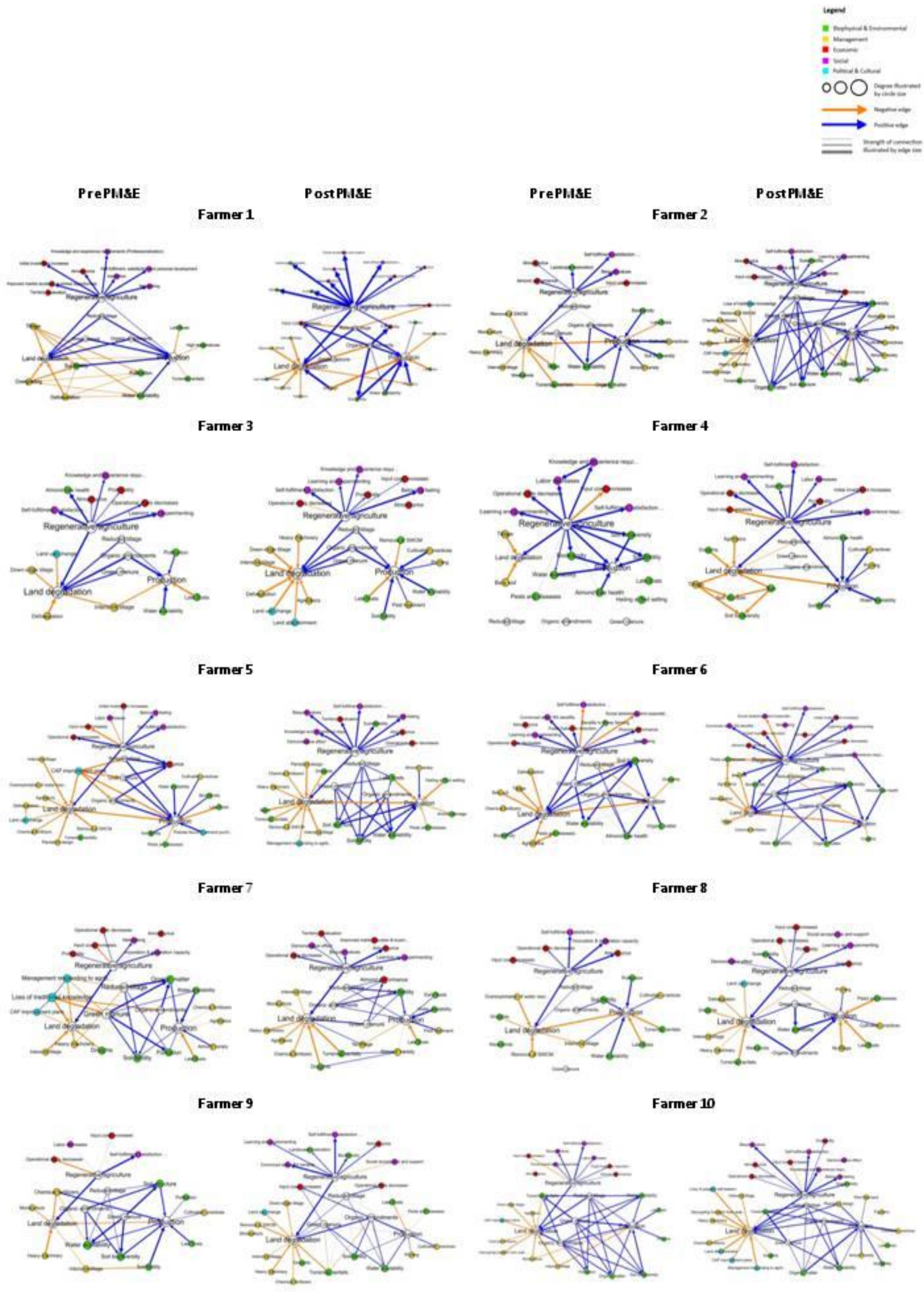
	business opportunities	markets and business opportunities such as agro-tourism, supported by higher media visibility
61	Initial investment increases	Initial investment necessary to adapt a farm to regenerative which entails the implementation of landscape and soil restoration practices such as erosion barriers, swales, key-line design, replanting of hedgerows and borders, composts, green manure, and machinery for RA practices management
62	Innovation & adaptation capacity	Willingness and capacity to innovate in farming, adapt the farming system and farming management, invent or adapt new farming practices and technologies
63	Input costs increases	Cost from compost, green manure seeds, and other RA practices. When input costs decrease is mainly due to diesel saving from reducing tillage operations
64	Inspiration	People's hope, sense of purpose and personal drive to make a difference and contribute to society
65	RA Knowledge and experience requirements	RA is a farming approach that works with natural processes to maximize the provisioning of ecosystem services and requires a farmer´s complex understanding of the biophysical and climatic context, and knowledge and experience on RA practices and management strategies for an effective implementation
66	Labor decreases	Reduction of the need of work force and time dedicated to farming activities as the farming system works more closely to natural processes, making farming activities less labor demanding
67	Landscape restoration	Includes restoration of landscape functioning, including crucial ecosystem processes, aesthetics, and territory revaluation
68	Learning and experimenting	Farmers´ eagerness to learn and experiment from own and shared experiences
69	Networking	Meeting people working with RA, exchanging knowledge and information with people with a common interest
70	Operational costs decreases	Cost reduction of farming activities. Cost reduction in the short term results mainly from the minimization of tillage activities and pest treatments. In the long term other operational costs might decrease as the systems gets restored, benefiting from natural processes and becoming more simple to manage
71	Policies favoring RA almond purchases	Public policies favoring purchases of regenerative almonds to incentivize a large-scale adoption of RA
72	Profitability	Economic performance considering all production economic costs and benefits. Regenerative almond farming might be more profitable than conventional farming in the medium-long term
73	Self-fulfillment, satisfaction and personal development	Fulfillment of one´s objectives and dreams. Enjoyment of the farm, pride and personal success
74	Social awareness and expectation increases	Society becomes more conscious of the damage caused by unsustainable farming practices, and gains awareness of the restoration potential and benefits of RA
75	Spirituality	Sense of connection with something higher than ourselves
76	Sustainability	Maintaining or enhancing the availability of natural resources and well-functioning farming systems in the long term
77	Social acceptance and support	Social support to RA farmers, initiatives and products enhancing RA adoption. Contrary to social pressure against RA.
78	Territory revaluation	Add value to the territory

79	Land degradation	Natural or human-induced processes like soil erosion that disturb ecosystem functioning leading to reduced production potential and loss of functionality
80	Production	Yield
81	Organic amendments	Animal and plant based fertilizers, such as compost, bokashi, sheep manure and excluding green manure
82	Green manure	Leguminous or mixed cereal-leguminous covers that are used to increase soil fertility
83	Reduced tillage	Shallow plowing (less than 20 cm) carried out a maximum of 2 times per year to minimize soil disturbance

Appendix 3: Classification of final terms in groups

Management (technical & productive)	Biophysical & Environmental	Economic	Political & Cultural	Social
• Agrotoxics	• Biodiversity	• Almond performance	• CAP improvement plans	• Belonging feeling
• Almond variety	• Droughts	• Almond price	• Policies favoring almond purchases	• Bequest values
• Bare soil	• Early frosts	• Improved market access & business opportunities	• Land use change	• Convinced about RA benefits
• Chemical fertilizers	• Fog	• Initial investment increases	• Management responding to agribusiness model	• Demonstrative effect
• Cultivation practices	• Hailing at fruit setting	• Input costs increases	• Land abandonment	• Innovation & adaptation
• Decoupling livestock from arable farming	• High temperatures	• Operational costs decreases	• Land concentration	• Inspiration
• Deforestation	• Late frosts	• Profitability	• Loss of traditional knowledge	• Knowledge and experience requirements (Professionalizatio
• Down-slope tillage	• Organic matter	• Territory revaluation	• Loss of peasant self-esteem	• Labor decreases
• Heavy machinery	• Pests and diseases	• Fossil fuels use reduction		• Learning and experimenting
• Intensive tillage	• Pollination			• Networking
• Monoculture	• Slope			• Self-fulfillment, satisfaction and personal
• No tillage	• Soil biodiversity			• Social awareness and expectation
• Overexploitation of water resources	• Soil fertility			• Social acceptance and
• Overgrazing	• Soil structure			
• Pest treatment	• Sun			
• Pig slurry	• Torrential rainfalls			
• Plantation design	• Water availability			
• Pruning	• West winds			
• Removal of SWCM	• Wildlife damage			
• Rootstock type	• Almond tree health			
• Tillage	• Benefits to sheep farming			
	• Landscape restoration			
	• Sustainability			

Appendix 4: Evolution of farmers´ individual perceptions pre and post PM&E



Appendix 5: Most cited factors, centrality and frequency

Table 1 Regenerative practices linked to Land degradation, times cited by participating farmers and strength of influence (weight) before and after PM&E

LAND DEGRADATION	pre PM&E		Post PM&E	
	times cited	weight	times cited	weight
Regenerative practices				
Organic amendments	5	0,38	7	0,50
Green Manure	4	0,38	9	0,56
Reduced tillage	4	0,38	8	0,26

Table 2 Most cited factors and regenerative practices linked to production, times cited by participating farmers and strength of influence (weight) before and after PM&E

PRODUCTION	pre PM&E		post PM&E	
	times cited	weight	times cited	weight
Water availability	10	0,90	10	0,88
Soil fertility	6	0,52	7	0,60
Soil biodiversity	5	0,48	-	-
Late frosts	9	-0,46	8	-0,70
Organic matter	4	0,36	6	0,30
Cultivation practices	-	-	3	0,50
Regenerative practices				
Organic amendments	4	0,58	8	0,72
Green Manure	3	0,34	7	0,28
Reduced tillage	4	0,28	8	0,22
Land degradation		-0,52		-0,30

Table 3 Factors mentioned before and after PM&E organized from higher to lower centrality

pre PM&E		post PM&E	
FACTORS	Centrality	FACTORS	Centrality
Land degradation	7,18	Land degradation	8,58
Production	6,84	Regenerative agriculture	7,66
Regenerative agriculture	6,44	Production	7,20
Green manure	2,62	Organic amendments	3,08
Organic amendments	2,50	Green manure	2,46
Water availability	2,22	Water availability	2,18
Reduced tillage	1,82	Reduced tillage	1,70
Soil biodiversity	1,26	Soil fertility	1,32
Soil fertility	1,20	Organic matter	1,06
Organic matter	0,94	Soil biodiversity	0,90
Pollination	0,92	Soil structure	0,82
Almond price	0,84	Torrential rainfalls	0,80
Intensive tillage	0,72	Self-fulfillment, satisfaction and personal development	0,80
Self-fulfillment, satisfaction and personal development	0,70	Late frosts	0,78
Torrential rainfalls	0,70	Agrotoxics	0,70
CAP improvement plans	0,70	Droughts	0,62
Deforestation	0,66	Intensive tillage	0,62
Tillage	0,60	Almond price	0,60
Almond tree health	0,58	Learning and experimenting	0,58
Agrotoxics	0,50	Knowledge and experience requirements (Professionalization)	0,56
Biodiversity	0,48	Sustainability	0,52
Late frosts	0,46	Heavy machinery	0,52
Chemical fertilizers	0,44	Cultivation practices	0,50
Loss of traditional knowledge	0,40	Bequest values	0,48
Operational costs decreases	0,40	Almond performance	0,46
Knowledge and experience requirements (Professionalization)	0,38	Tillage	0,46
Pests and diseases	0,38	Pests and diseases	0,44
Input costs increases	0,34	Profitability	0,44
Overgrazing	0,32	Chemical fertilizers	0,44
Removal of SWCM	0,30	Removal of SWCM	0,42
Learning and experimenting	0,30	No tillage	0,42
Soil structure	0,30	Almond variety	0,40
Heavy machinery	0,30	Belonging feeling	0,40
Cultivation practices	0,28	Biodiversity	0,38
Networking	0,26	Input costs increases	0,32
Management responding to agribusiness model	0,26	Operational costs decreases	0,32
Monoculture	0,26	Pruning	0,30
Droughts	0,22	Sun	0,30
Labor decreases	0,22	Almond tree health	0,30

Almond performance	0,22
Bare soil	0,20
Land use change	0,20
Bequest values	0,18
Innovation & adaptation capacity	0,18
Fossil fuels use reduction	0,16
Almond variety	0,16
Down-slope tillage	0,16
Slope	0,16
Initial investment increases	0,14
Profitability	0,12
Overexploitation of water resources	0,12
Plantation design	0,10
Policies favoring almond purchases	0,10
West winds	0,10
Belonging feeling	0,10
Convinced about RA benefits	0,10
Improved market access & business opportunities	0,10
Inspiration	0,10
Landscape restoration	0,10
Benefits to sheep farming	0,08
Decoupling livestock from arable farming	0,08
Hailing at fruit setting	0,06
High temperatures	0,06
Social awareness and expectation increases	0,04
Territory revaluation	0,04

Bare soil	0,28
Land abandonment	0,26
Demonstrative effect	0,24
Land use change	0,22
Pest treatment	0,20
Pig slurry	0,20
Pollination	0,20
Management responding to agribusiness model	0,18
West winds	0,18
Benefits to sheep farming	0,18
Initial investment increases	0,16
Landscape restoration	0,16
Territory revaluation	0,16
CAP improvement plans	0,16
Down-slope tillage	0,16
Improved market access & business opportunities	0,12
Deforestation	0,12
Decoupling livestock from arable farming	0,10
Hailing at fruit setting	0,10
Loss of peasant self-esteem	0,10
Plantation design	0,10
Slope	0,10
Convinced about RA benefits	0,10
Fossil fuels use reduction	0,10
Social awareness and expectation increases	0,10
Labor decreases	0,08
Monoculture	0,08
Overgrazing	0,08
Networking	0,06
Early frosts	0,06
Loss of traditional knowledge	0,06
Rootstock type	0,06
Wildlife damage	0,06
Social acceptance and support	0,04

Legend
Biophysical & Environmental
Management
Economic
Political & Cultural
Social
Entry Notes (Given)

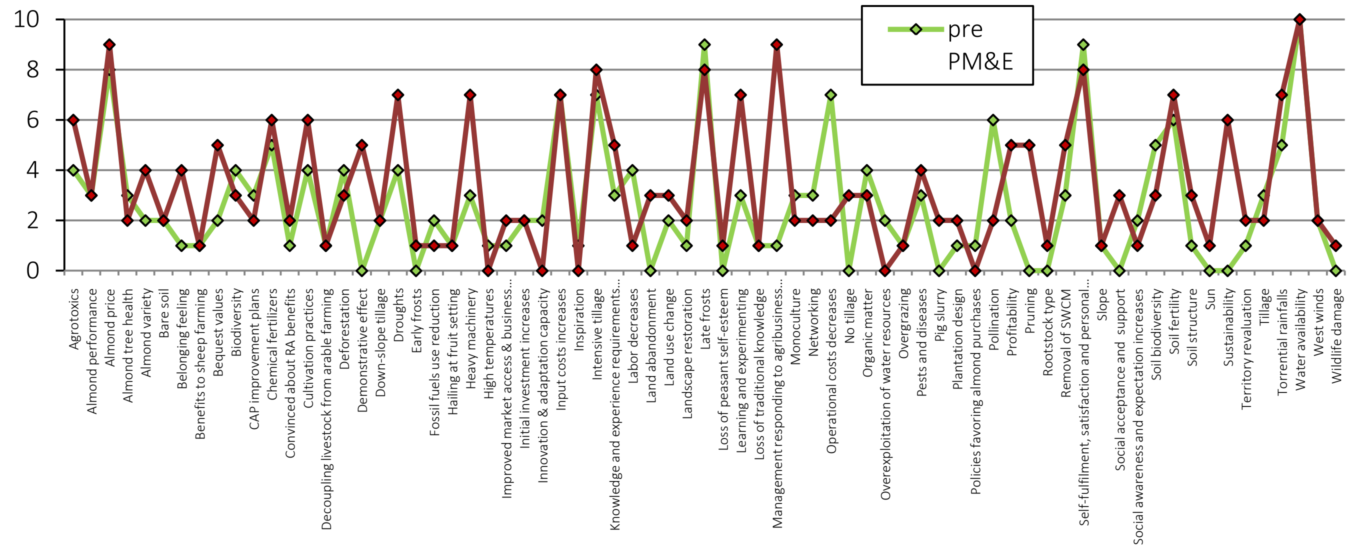


Figure 1 Frequency of citation of mentioned factor pre and post PM&E

Chapter 6

General Conclusions

Conclusions

Participatory monitoring and evaluation (PM&E) involving farmers and researchers contributes to enhance knowledge exchange and social learning, mutual support and capacity building to foster the implementation of sustainable land management to enhance the delivery of ecosystem services and deal with the enormous challenges posed by land degradation. Participatory monitoring systems that combine scientific and local knowledge can play a fundamental role to support the identification and foster the adoption of most effective sustainable land management. The methodological framework developed in chapter 1 facilitated the identification and selection of key technical and local indicators of soil quality to obtain relevant and contextualized monitoring systems and user friendly visual soil assessment (VSA) tools for participatory monitoring of sustainable land management like regenerative agriculture (RA). Monitoring systems of soil quality including local and technical indicators offer the opportunity for farmers and researchers to jointly embark in a monitoring process enhancing knowledge exchange and mutual learning to help the implementation of RA practices that optimize the provisioning of ecosystem services. Technical indicators provided detailed insight into soil supporting services, helping to elucidate the reasons behind land degradation and restoration processes, and complement farmers´ observations with accurate information to enhance the confidence in the effectiveness of RA. Local indicators related more directly to the benefits of RA for a range of supporting, regulating and provisioning ecosystem services providing information hardly accessed by only measuring soil properties used as technical indicators of soil quality. Our monitoring system of soil quality which integrated local and technical indicators of soil quality can help to better understand the impacts of RA than when only local or technical indicators are used. This is crucial to support farmers' implementation and adoption of RA in the face of the lack of empirical data and contrasting scientific results on its effectiveness, and to help farmers see the multiple impacts of their efforts on soil quality restoration, even long before they find a possible positive effect on crop yields.

Our assessment of RA impacts using technical indicators of soil quality, detailed in chapter 3, demonstrated that RA can significantly contribute to the rehabilitation of soil quality of woody agroecosystems in Mediterranean drylands. The RA treatments evaluated improved the physical, chemical and biological quality of soils compared to conventional management. We found that reduced tillage with green manure improved physical soil properties, however additional soil fertility management might be necessary to improve chemical and biological soil properties. Reduced tillage with addition of organic amendments improved chemical and biological soil properties and maintained physical soil properties. Reduced tillage with green manure and organic amendments improved physical, chemical and biological soil quality, showing better soil quality restoration results than each individual practice alone. Furthermore, our results showed that no tillage with permanent natural covers and organic amendments presented the greatest soil quality improvements. We observed that RA treatments combining ground covers and organic amendments presented higher soil quality restoration results and were adopted for longer periods, which makes us expect positive long term soil responses in more recently adopted regenerative treatments and individual practices. Finally, our results on foliar nutrients suggest that the adoption of RA might maintain at least similar nutritional status of the almond trees as conventional management, although additional research on the long term crop yield and total farm operation costs and benefits is required to promote RA adoption. Our findings support the use of RA as a sustainable farming approach to restore soil quality in degraded dryland agroecosystems, maintaining the nutritional status of tree crops, while combinations of multiple practices are expected to be more effective than individual RA practices.

Farmers' visual soil assessment of RA using local indicators of soil quality, reported in chapter 4, also pointed out RA as a promising solution to restore degraded agroecosystems in Mediterranean drylands. Farmers´ VSA results showed small soil quality improvements compared to conventional management but were complementary to our findings using technical indicators of soil quality, stressing the need for longer time and efforts to attain desired restoration objectives. Farmer’s evaluation of the research highlighted the role of PM&E as an educational 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 highlighted the importance of generating spaces for farmer-to-farmer diffusion of knowledge and on-farm experiences as key to expedite testing of sustainable land management and adoption of innovations. Farmers´ insights revealed the need to actively involve them in all decision making phases of VSA tools and support them in initial implementation, in order to develop tools that meet farmers´ needs, to enhance VSA tool adoption, and facilitate reaching restoration goals. Furthermore, farmers´ insights suggest 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 research project for agroecosystem restoration. Some farmers had difficulties in systematically integrating the VSA tool in their farming routine and could not always attend workshops. Therefore, the combination of different forms of in person and online participation and exchange of monitoring information is considered important. As suggested by farmers, the development of a mobile phone application to support VSA can further facilitate farmer 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 evaluate outcomes. Our results stressed that PM&E processes that lead to enhanced social capital, social learning and improved understanding of restoration efforts have as much value as the actual restoration outcomes on the ground.

Social learning is considered a crucial precondition to enhance farmers´ adoption of sustainable land management and farming innovations like RA. In chapter 5 we demonstrated that well-designed PM&E research processes favor the creation of dense collaborative networks, generating the conditions to foster enhanced knowledge exchange between farmers and researchers, facilitating faster and easier access to information on innovative SLM to the stakeholders in the network, stimulating social learning, SLM adoption and out-scaling. This result was confirmed by farmers´ broader and more complex understanding on RA impacts and benefits to counter land degradation, and as a sustainable solution to improve environmental, social and economic factors; by farmers´ more cohesive collective perception and higher consensus on the impacts of RA and most common RA practices over multiple aspects; and by farmers´ strengthened and enlarged social networks for mutual support and sharing of RA information. Furthermore, the evaluation of farmers´ social networks revealed they gained a more central role as drivers of innovation. Since farmer to farmer diffusion of knowledge is one major mechanism to induce farmers´ innovation adoption, involving farmers in PM&E increased the potential for RA adoption and out-scaling. We conclude that PM&E research is an effective tool for individual and collective knowledge acquisition, co-creation and dissemination of knowledge to enhance adoption and out-scaling of SLM and farming innovations like RA.

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, efficient, and sound restoration processes and agroecological transitions towards sustainable and resilient socio-agroecosystems.

Summary
Resumen
Resumo

Summary

The advanced state of land degradation affecting more than 3,200 million people worldwide have raised great international concern regarding the sustainability of socio-ecological systems, urging the large-scale adoption of contextualized sustainable land management. The agricultural industrial model is a major cause of land degradation due to the promotion of unsustainable management practices that deteriorate the quality of soils compromising their capacity to function and deliver ecosystem services. The consequences derived from land degradation are especially devastating in semi-arid regions prone to desertification, where rainfall scarcity and irregularity intensifies crop failure risks and resource degradation, compromising the long term sustainability of these regions.

Regenerative agriculture (RA) has recently gained increasing recognition as a plausible solution to restore degraded agroecosystems worldwide. RA is a farming approach foreseen to reverse land degradation, increase biodiversity, boost production and enhance the delivery of multiple ecosystem services by following a series of soil quality restoration principles and practices. Despite its promising benefits, RA has been limitedly adopted in semiarid regions. Major reasons explaining this seemingly incongruous mismatch are the scarce and contrasting empirical data proving its effectiveness, top-down research approaches and lack of farmer involvement in agroecosystem restoration projects and decision-making, 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.

In the high steppe plateau of southeast Spain, an on-going process of large-scale landscape restoration through adoption of regenerative agriculture was initiated in 2015. The high steppe plateau is one of the European regions most affected by land degradation and desertification processes and represents one of the world´s largest areas for the production of rainfed organic almonds. In 2015, local farmers created the AlVelAl association with the support of the Commonland Foundation, business entrepreneurs, regional governments, and research institutions, and started to apply RA at their farms. The objective was to restore vast extensions of degraded land for increasing the productivity and biodiversity of their agroecosystems, increasing the resilience to climate change, generating job opportunities and enhancing social cohesion in the region, in a time frame of 20 years following Commonlands´ 4-Returns approach.

However, the limited empirical information supporting RA effectiveness, the lack of reference examples in the region, and the slowness with which visible ecological restoration processes usually occur in semi-arid regions were considered major obstacles hindering RA adoption in the region. To effectively address this knowledge gap, support farmers and expedite RA adoption, this research proposed horizontal research fostering the creation of learning communities between farmers and researchers, putting together local and scientific knowledge to improve the understanding of RA.

This thesis presents a participatory monitoring and evaluation research (PM&E) applying a combination of social and ecological methods to evaluate the potential of PM&E to enhance knowledge exchange between farmers and researchers on Regenerative Agriculture in the context of the high steppe plateau. The aim of this thesis is twofold: on one hand, to increase the understanding on RA impacts, on the other hand, to evaluate the potential contribution of PM&E to enable social learning and contribute to the adaptation and long term adoption of RA in the high steppe plateau and semiarid regions in general.

To facilitate PM&E of the impacts of sustainable land management and agricultural innovations like RA, Chapter 2 presents a participatory methodological framework that guides the identification and selection of technical and local indicators of soil quality, generating a monitoring system of soil quality for PM&E by farmers and researchers. The methodological framework includes the development of a visual soil assessment tool integrating local indicators of soil quality for farmers´ monitoring. The framework consists of 7 phases: 1) Definition of research and monitoring objectives; 2) Identification, selection and prioritization of Technical Indicators of Soil Quality (TISQ); 3) Identification, selection and prioritization of Local Indicators of Soil Quality; 4) Development of a visual soil assessment tool integrating LISQ; 5) Testing and validation of the visual soil evaluation tool; 6) Monitoring and assessment of sustainable land management impacts by researchers and farmers using TISQ and the visual soil evaluation tool respectively and; 7) Exchange of monitoring results between all involved participants, and joint evaluation of impacts.

To facilitate PM&E of RA in the steppe highlands, Phases 1 to 5 were applied through a series of participatory methods including a first meeting with AlVelAl board members for the definition of research objectives, farm visits, participatory workshops, and conducting formal and informal interviews, among others. Technical indicators of soil quality were identified, selected and prioritized by researchers through an extensive literature review and ad-hoc expert consultation with expertise in soil quality assessment and monitoring. Local indicators of soil quality were identified, selected, prioritized and validated by farmers in two participatory workshops. The co-developed visual soil assessment tool, named the farmer manual, was tested and validated during the second workshop. Local indicators selected by farmers focused mostly on supporting, regulating and provisioning ecosystem services including water regulation, erosion control, soil fertility and crop performance. Technical indicators selected by researchers focused mostly on soil properties including aggregate stability, soil nutrients, microbial biomass and activity, and leaf nutrients, covering crucial supporting services. The combination of local and technical indicators provided complementary information, improving the coverage and feasibility of RA impact assessment, compared to using technical or local indicators alone. The methodological framework developed in this chapter facilitated the identification and selection of local and technical indicators of soil quality to generate relevant monitoring systems and visual soil assessment tools adapted to local contexts, thus improving knowledge exchange and mutual learning between farmers and researchers to support the implementation of RA and optimize the provision of ecosystem services.

Implementation of RA usually happens gradually due to socioeconomic, informational, practical, environmental and political constraints Thus, RA adoption by farmers, in practice, translates into different combinations of RA practices, with a diversity of management, based on farmer capabilities, environmental conditions, and expected restoration results.

To help the design, adoption and implementation of most effective RA practices to optimize the restoration of agroecosystems, Chapter 3 presents the impacts of the different combinations of RA practices implemented by participating farmers on crucial soil quality and crop performance indicators using previously selected technical indicators of soil quality over a period of 2 years. This chapter corresponds to the application of phase 6 of the methodological framework developed in Chapter 2. RA impacts were assessed in 9 farms on one field with regenerative management and one nearby field with conventional management based on frequent tillage, that were selected together with farmers. Fields were clustered under regenerative management based on the RA practices applied and distinguished 4 types of

RA treatments: 1) reduced tillage with green manure (GM), 2) reduced tillage with organic amendments (OA), 3) reduced tillage with green manure and organic amendments (GM&OA), and 4) no tillage with permanent natural covers and organic amendments (NT&OA). The impacts of RA compared to conventional management were evaluated by comparing physical (bulk density and aggregate stability), chemical (pH, salinity, total N, P, K, available P, and exchangeable cations) and biological (SOC, POC, PON, microbial activity) properties of soil quality, and the nutritional status of almond trees (leaf N, P and K). Our results show that GM improved soil physical properties, presenting higher soil aggregate stability. We found that OA improved most soil chemical and biological properties, showing higher contents of SOC, POC, PON, total N, K, P, available P, exchangeable cations and microbial respiration. RA treatments combining ground covers and organic amendments (GM&OA and NT&OA) exhibited greater overall soil quality restoration than individual practices. NT&OA stood out for presenting the highest soil quality improvements. All RA treatments maintained similar crop nutritional status compared to conventional management. We concluded that RA has strong potential to restore the physical, chemical and biological quality of soils of woody agroecosystems in Mediterranean drylands without compromising their nutritional status. Furthermore, farming management combinations of multiple regenerative practices are expected to be more effective than applying individual RA practices.

In parallel to researchers´ assessment of RA impacts, farmers assessed RA impacts in their farms by using the farmer manual jointly developed in participatory workshops. Chapter 4 presents the RA impact results from farmers´ assessment, and documented farmers´ insights, in the third year of PM&E, on the visual soil assessment process using the farmer manual, and on PM&E outcomes regarding the facilitation of participation and learning processes. This chapter corresponds to the application of phase 6 and phase 7 of the methodological framework developed in Chapter 2. Farmers´ visual soil assessment indicated regenerative agriculture as a promising solution to restore degraded agroecosystems in semiarid Mediterranean drylands, although observed soil quality improvements were relatively small compared to conventional management, and more time and efforts are needed to attain desired restoration targets. The monitoring results on RA reported by farmers were complementary to researchers´ findings using technical indicators of soil quality. Farmers' evaluation of the research project highlighted the PM&E research as an educational 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 of VSA tools and support them in initial implementation, in order to develop tools that meet farmers´ needs, to enhance VSA tool adoption, and facilitate reaching restoration goals. Furthermore, farmers´ evaluation of the farmer manual suggested the need to reinforce the multipurpose usefulness and potential benefits of collectively recording restoration progress in a systematized way, to enhance VSA tool adoption. Farmers´ insights on the PM&E research reinforces the importance of developing learning communities of farmers and researchers that provide a platform for exchange of experiences and support, as a crucial factor to favor social learning and support the adoption of long-term agricultural innovations. 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. We concluded that the process of PM&E that leads to enhanced social capital, social learning and improved understanding of restoration efforts has as much value as the actual restoration outcomes on the ground.

Social learning is considered an important precondition for the adoption of contextualized sustainable land management and farming innovations like RA. The main objective of involving farmers and researchers in PM&E of RA was to enable social learning for enhanced understanding of RA impacts and support adoption of RA. Although there is a growing body of literature asserting the achievement of social learning through participatory processes, social learning has been loosely defined, sparsely assessed, and only partially covered when measured. Confirming that a participatory process has favored social learning implies demonstrating that there has been an acquisition of knowledge and change in perceptions at individual and collective level in the people involved in the participatory process, and that this change in perceptions has been generated through social relations.

Chapter 5 presents an assessment of how the PM&E research process enabled social learning by effectively increasing knowledge exchange and understanding of RA impacts between participating farmers and researchers, and multiple stakeholders of farmers´ social networks. Occurrence of social learning was assessed by covering its social-cognitive (perceptions) and social-relational (social networks) dimensions. This chapter discusses the potential of PM&E to foster adoption and out-scaling of sustainable land management and farming innovations like RA by promoting the generation of information fluxes between farmers and researchers participating in PM&E and the agricultural community of which they form part.

To assess changes in farmers´ perceptions and shared fluxes of information on RA before starting the PM&E and after three years of research, we applied fuzzy cognitive mapping and social network analysis as graphical semi-quantitative methods. Our results showed that PM&E enabled social learning amongst participating farmers who strengthened and enlarged their social networks on information sharing, and presented a more complex and broader common understanding of regenerative agriculture impacts and benefits. This supports the idea that PM&E thereby creates crucial preconditions for the adoption and out-scaling of RA. This study was one of the first studies in the field of natural resource management and innovation adoption proving that social learning occurred by providing evidence of both the social-cognitive and social-relational dimension. Our findings are relevant for the design of PM&E processes, agroecosystem Living Labs, and landscape restoration initiatives that aim to support farmers´ adoption and out-scaling of contextualized farming innovations and sustainable land management. We concluded that 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, efficient, and sound restoration processes and transitions towards sustainable and resilient agroecosystems.

Resumen

El avanzado estado de degradación de la tierra que afecta a más de 3.200 millones de personas en todo el mundo ha suscitado una gran preocupación internacional con respecto a la sostenibilidad de los sistemas socio-ecológicos, instando a la adopción a gran escala de manejos sostenibles de la tierra, adaptados a los diferentes contextos. El modelo agrícola industrial es uno de los principales causantes de la degradación de la tierra debido a la promoción de prácticas agrícolas insostenibles que deterioran la calidad de los suelos, comprometiendo su capacidad de funcionamiento y de prestación de servicios ecosistémicos. Las consecuencias derivadas de la degradación de la tierra son especialmente devastadoras en regiones semiáridas propensas a procesos de desertificación, donde la escasez y la irregularidad de las lluvias intensifican la degradación de los recursos naturales y el riesgo de malas cosechas, comprometiendo la sostenibilidad de estas regiones a largo plazo.

Recientemente, la agricultura regenerativa (AR) ha ganado un reconocimiento cada vez mayor como solución plausible para restaurar agroecosistemas degradados de todo el mundo. La AR es un enfoque agrícola que se prevé puede revertir la degradación de la tierra, aumentar la biodiversidad, incrementar la producción y mejorar la prestación de múltiples servicios ecosistémicos mediante el seguimiento de una serie de principios y prácticas de restauración de calidad del suelo. A pesar de los prometedores beneficios de la AR, este enfoque agrícola ha sido adoptado de forma muy limitada en regiones semiáridas. Las principales razones que explican su limitada adopción son: la escasez de datos empíricos que demuestran su efectividad, la información contradictoria que ofrecen dichos datos, los enfoques verticales (top-down), la falta de inclusión, participación y toma de decisiones de las agricultoras/es en los proyectos de restauración de agroecosistemas, y la generalmente lenta respuesta de los suelos en regiones semiáridas a los cambios de manejo, lo que puede retrasar la aparición de resultados visibles y desalentar a agricultoras y agricultores a adoptar la AR.

En el altiplano estepario del sureste español se inició en 2015 un proceso de restauración de ecosistemas a gran escala mediante la adopción de la AR. El altiplano estepario es una de las regiones europeas más afectadas por procesos de degradación y desertificación de la tierra, y representa una de las mayores extensiones del mundo de producción de almendras ecológicas en secano. En 2015, agricultoras y

agricultores locales crearon la asociación agroecológica AlVelAl con el apoyo de la Fundación Commonland, empresas, gobiernos regionales e instituciones de investigación, y comenzaron a aplicar AR en sus fincas. Su objetivo es restaurar grandes extensiones de tierras degradadas, mejorar la productividad y la biodiversidad, aumentar la resiliencia de sus agroecosistemas al cambio climático, generar oportunidades de empleo y mejorar la cohesión social en la región en el plazo de 20 años, siguiendo el enfoque de 4 retornos de la Fundación Commonland. Sin embargo, la escasez de datos e información que respalden la efectividad de la AR, junto con la falta de ejemplos de referencia en la región y la lentitud con la que los procesos de restauración ecológica suelen ocurrir en regiones semiáridas, fueron considerados grandes obstáculos para promover la adopción de la AR en la región.

Para abordar de manera efectiva la falta de conocimiento sobre los impactos de la AR y apoyar a la comunidad agrícola a mejorar y acelerar su adopción, son necesarios enfoques de investigación horizontales que fomenten la creación de comunidades de aprendizaje entre agricultoras/es e investigadoras/es, aunando el conocimiento local y científico para mejorar el conocimiento sobre la AR.

Esta tesis presenta una investigación de monitorización y evaluación participativa (MEP) donde aplicamos una combinación de métodos sociales y ecológicos para evaluar el potencial de esta metodología de investigación en la mejora del intercambio de conocimientos entre agricultoras/es e investigadoras/es sobre la AR en el contexto del altiplano estepario. El objetivo de esta tesis es doble: por un lado, mejorar el conocimiento de los impactos de la AR y, por otro lado, evaluar la contribución de la MEP en facilitar procesos de aprendizaje social, contribuyendo a una mejor adaptación y adopción a largo plazo de la AR en el altiplano estepario en particular, y en regiones semiáridas en general.

Combinar el conocimiento científico y local se vuelve un imperativo en procesos de MEP para mejorar la adopción de innovaciones agrícolas, siendo especialmente relevante en regiones semiáridas que típicamente responden lento a cambios de manejo, lo que suele dar lugar a bajas tasas de adopción de dichas innovaciones. Para ello es necesario generar sistemas de monitorización de calidad del suelo y sostenibilidad de los agroecosistemas que integren el conocimiento de agricultoras/es e investigadoras/es, y estén adaptados al contexto donde se aplican las innovaciones.

Para facilitar la MEP de los impactos de manejos sostenibles e innovaciones agrícolas como la AR, el Capítulo 2 presenta un marco metodológico que guía la identificación y selección de indicadores técnicos y locales de calidad del suelo, conformando un sistema de monitorización para la evaluación participativa de la AR por parte de investigadoras/es y agricultoras/es. El marco metodológico incluye el desarrollo de una herramienta para la evaluación visual del suelo integrando indicadores locales de calidad de suelo para el monitoreo por parte de las agricultoras/es. El marco metodológico consta de 7 fases e incluye: Fase 1) Definición de objetivos de investigación y monitorización; Fase 2) Identificación, selección y priorización de Indicadores Técnicos de Calidad del Suelo (TISQ); Fase 3) Identificación, selección y priorización de Indicadores Locales de Calidad del Suelo (LISQ); Fase 4) Desarrollo de una herramienta de evaluación visual del suelo integrando LISQ; Fase 5) Puesta en práctica y validación de la herramienta de evaluación visual del suelo; Fase 6) Monitorización y evaluación de los impactos de los manejos implementados por parte de investigadoras/es y agricultoras/es, usando los TISQ y la herramienta de evaluación visual del suelo respectivamente y; Fase 7) Intercambio de los resultados de monitorización entre las participantes y evaluación conjunta de los impactos. Para facilitar la MEP de la AR en el altiplano estepario, se desarrolló este marco metodológico y fueron aplicadas las fases 1 a 5 a través de una serie de metodologías participativas que incluyeron una primera reunión con los miembros de la junta directiva de la asociación AlVelAl para la definición conjunta de objetivos de investigación, visitas a las fincas de las agricultoras/es participantes, el desarrollo de talleres participativos, y la realización de entrevistas formales e informales, entre otras. Las investigadoras/es participantes en la MEP identificaron, seleccionaron y priorizaron indicadores técnicos de calidad del suelo a través de una extensa revisión de literatura científica y la consulta ad-hoc a expertas/os con experiencia en monitorización y evaluación de calidad de suelos. Las agricultoras/es participantes identificaron, seleccionaron, priorizaron y validaron indicadores locales de calidad del suelo en dos talleres participativos. La herramienta de evaluación visual del suelo desarrollada conjuntamente, que denominamos *Cuaderno de Campo*, fue puesta en práctica y validada durante el segundo taller participativo. Los indicadores locales de calidad de suelo seleccionados por las agricultoras/es se enfocaron principalmente en la evaluación de servicios ecosistémicos de apoyo, regulación y abastecimiento, e incluyeron indicadores de regulación hidrológica, control de la erosión, fertilidad del suelo y rendimiento de los cultivos. Los indicadores técnicos de calidad del suelo seleccionados por las investigadoras/es se consistieron en propiedades fisicoquímicas y biológicas del suelo, incluyendo los indicadores: estabilidad de agregados, nutrientes del suelo, biomasa y actividad microbiana, y nutrientes foliares, y cubriendo importantes servicios ecosistémicos de apoyo. La información complementaria generada al combinar indicadores locales y técnicos de calidad de suelo permite ampliar la cobertura, viabilidad y efectividad en la MEP de los impactos de la AR, en comparación con usar de manera individual indicadores técnicos o indicadores locales. El marco metodológico desarrollado en este capítulo facilitó la identificación y selección de indicadores locales y técnicos de calidad del suelo para generar sistemas de monitorización y herramientas de evaluación visual de suelo relevantes y adaptadas a los contextos locales, lo que permite mejorar el intercambio de conocimientos y el aprendizaje mutuo entre agricultoras/es e investigadoras/es para apoyar la implementación de la AR y optimizar la provisión de servicios ecosistémicos.

La implementación de la AR por parte de agricultoras/es generalmente ocurre de forma gradual debido a limitaciones socioeconómicas, informacionales, ambientales y políticas. Por ello, la adopción de la AR por parte de agricultoras/es, se traduce en diferentes combinaciones de prácticas regenerativas y diversidad de manejos determinados por factores socioeconómicos, las capacidades de las agricultoras/es, las condiciones ambientales, y los resultados de restauración que se esperan conseguir.

Para ayudar al diseño, adopción e implementación de las prácticas de AR más efectivas para optimizar la restauración de agroecosistemas degradados en ambientes semiáridos, el Capítulo 3 presenta la evaluación de los impactos de diferentes combinaciones de prácticas regenerativas implementadas por las agricultoras/es participantes en la MEP usando los indicadores técnicos de calidad de suelo y de rendimiento del cultivo previamente seleccionados. Este capítulo corresponde a la aplicación de la fase 6 del marco metodológico desarrollado en el capítulo 2. Este capítulo presenta la evaluación de impactos de la AR realizada durante dos años en 9 fincas, donde fueron seleccionados, junto con las agricultoras/es participantes, un campo con manejo regenerativo y un campo cercano con manejo convencional bajo laboreo frecuente (CT). Los campos bajo manejo regenerativo fueron agrupados en base a las prácticas de AR aplicadas, y se diferenciaron 4 tipos de tratamientos regenerativos: 1) laboreo reducido con abono verde (GM), 2) laboreo reducido con enmiendas orgánicas (OA), 3) laboreo reducido con abono verde y enmiendas orgánicas (GM&OA), y 4) no laboreo con cubiertas naturales permanentes y enmiendas orgánicas (NT&OA). Se evaluaron los impactos de la AR con respecto al manejo agrícola convencional comparando las propiedades físicas (densidad aparente y estabilidad agregada), químicas (pH, salinidad, N, P, K total, P disponible y cationes intercambiables) y biológicas (SOC, POC, PON, actividad microbiana) de la calidad del suelo y el estado nutricional de los almendros (N, P y K foliares). Nuestros resultados mostraron que el tratamiento GM mejoró las propiedades físicas del suelo, presentando una mayor estabilidad de agregados. Encontramos que el tratamiento OA mejoró la mayoría de las propiedades químicas y biológicas del suelo, mostrando mayores contenidos de SOC, POC, PON, N, K, P total, P disponible, cationes intercambiables y actividad microbiana. Los tratamientos regenerativos que combinaron cubiertas naturales o abonos verdes con enmiendas orgánicas (GM&OA y NT&OA) exhibieron una mayor restauración general de la calidad del suelo en comparación con los tratamientos con prácticas individuales (GM y OA). El tratamiento NT&OA destacó por presentar las mayores mejorías en la restauración de la calidad del suelo comparado con el manejo convencional. Todos los tratamientos regenerativos mantuvieron un estado nutricional de los almendros similar al manejo convencional. Concluimos que la AR tiene un gran potencial para restaurar la calidad física, química y biológica de los suelos en agroecosistemas de leñosos en el semiárido Mediterráneo sin comprometer el estado nutricional de los cultivos. Es de esperar que los manejos que incluyen múltiples prácticas regenerativas sean más efectivos en la restauración de la calidad del suelo que los manejos con prácticas regenerativas individuales.

Paralelamente a la evaluación de los impactos de la AR por parte de las investigadoras/es, las agricultoras/es evaluaron los impactos de la AR en sus fincas, utilizando la herramienta de evaluación visual del suelo (*Cuaderno de campo)*, desarrollada conjuntamente en los talleres participativos. El Capítulo 4 presenta los resultados de la evaluación de los impactos de la AR por parte de las agricultoras/es. También presenta las observaciones y la evaluación por parte las/los agricultores, realizadas en el tercer año desde el inicio de la MEP, sobre el proceso de evaluación visual del suelo usando el *Cuaderno de Campo*, así como sobre el impacto de la MEP en facilitar procesos de participación y aprendizaje en las agricultoras/es participantes. Este capítulo corresponde a la aplicación de las fases 6 y 7 del marco metodológico desarrollado en el Capítulo 2. La monitorización por parte las agricultoras/es mostró que la

AR tiene potencial para restaurar agroecosistemas degradados en el semiárido Mediterráneo, aunque las mejoras observadas sobre la calidad del suelo fueron relativamente pequeñas con respecto al manejo convencional, siendo necesario más tiempo y mayores esfuerzos para alcanzar los objetivos de restauración deseados. Las pequeñas mejoras en la calidad del suelo documentadas por las agricultoras/es fueron complementarias a los hallazgos obtenidos por las investigadoras/es usando indicadores técnicos de calidad de suelo. Las agricultoras/es destacaron la MEP como un proceso de aprendizaje que les ayudó a ver sus suelos y sus esfuerzos de restauración de manera diferente, y que facilitó la creación de relaciones de apoyo y el desarrollo de habilidades en ellas/os, los cuales son requisitos fundamentales para fomentar la eficiencia y la adopción de innovaciones agrícolas. Las agricultoras/es confirmaron que la generación de espacios que favorecen el intercambio de conocimientos entre agricultoras/es, así como las experiencias agrícolas en finca (in situ), son un factor clave para fomentar la experimentación y adopción de innovaciones agrícolas por parte de la comunidad agrícola. Además, las observaciones realizadas por las participantes revelaron la necesidad de involucrar activamente a las agricultoras/es en todas las fases de diseño y toma de decisiones en el desarrollo de herramientas de evaluación visual del suelo con el fin de generar herramientas que satisfagan sus necesidades. Junto con ello, se dedujo que el apoyo del equipo investigador a las agricultoras/es en las primeras implementaciones de dichas herramientas puede contribuir a mejorar su adopción, facilitando que las usuarias/os consigan los objetivos de restauración deseados. Asimismo, la evaluación del Cuaderno de Campo por parte de las agricultoras/es indicó la necesidad de reforzar la utilidad multipropósito y los beneficios potenciales de registrar de forma sistematizada y colectiva los progresos de restauración, con el fin de aumentar la adopción de estas herramientas por parte de las usuarias/os a las que van dirigidas. La evaluación de la MEP por parte de las agricultoras/es refuerza la importancia de desarrollar comunidades de aprendizaje entre agricultoras/es e investigadoras/es que proporcionen una plataforma para el intercambio de experiencias y de apoyo en el proceso de investigación, lo cual es considerado un factor crucial para favorecer el aprendizaje social y apoyar la adopción de innovaciones agrícolas a largo plazo. Este capítulo concluyó que el éxito de las investigaciones enfocadas a la restauración de agroecosistemas puede incrementar mediante la integración de fases iterativas en las que agricultoras/es puedan evaluar y ajustar las actividades y los resultados de investigación. Los procesos de MEP, que contribuyen a mejorar el capital social, el aprendizaje social y a generar una mayor comprensión de los esfuerzos de restauración, tienen tanto valor como los propios resultados de restauración sobre el terreno.

El aprendizaje social es considerado un prerrequisito crucial para la adopción de manejos sostenibles e innovaciones agrícolas adaptados a los diferentes contextos. El objetivo principal de desarrollar una investigación de MEP involucrando a investigadoras/es y agricultoras/es en el altiplano estepario fue permitir el aprendizaje social para lograr una mejor comprensión de los impactos de la AR y así mejorar su adopción. Aunque existen cada vez más investigaciones científicas que afirman que los procesos participativos fomentan el aprendizaje social, este concepto ha sido definido de forma muy diversa, ha sido rara vez evaluado, y ha sido abordado de manera parcial sin cubrir su dimensión cognitiva y su dimensión relacional. Establecer que un proceso participativo ha favorecido el aprendizaje social, implica demostrar que se ha generado una adquisición de conocimientos y que se ha producido un cambio en las percepciones, a nivel individual y a nivel colectivo, de las personas implicadas en el proceso, y que este cambio de percepciones ha sido generado gracias al establecimiento de relaciones sociales, de intercambio de información y experiencias.

El Capítulo 5 evalúa cómo la MEP de la AR en el altiplano estepario favoreció el aprendizaje social en las agricultoras/es participantes, mejorando la comprensión de los impactos de la AR al aumentar de manera efectiva el intercambio de conocimientos entre ellas/os, con las investigadoras/es participantes, y con otras personas que forman parte de sus redes sociales. Este capítulo presenta resultados necesarios para probar si la MEP de la AR favoreció el aprendizaje social en las agriculturas/es participantes, evaluando tanto la dimensión social-cognitiva (percepciones) como la dimensión social-relacional (redes sociales) del aprendizaje social. Además, en este capítulo se discute el potencial de la MEP para favorecer la adopción de manejos sostenibles e innovaciones agrícolas a gran escala gracias a fomentar la generación de flujos de información entre las agricultoras/es participantes y la comunidad agrícola de la que forman parte.

Utilizamos el mapeo cognitivo difuso (fuzzy cognitive mapping) y el análisis de redes sociales como métodos gráficos semi-cuantitativos para evaluar los cambios de percepciones y de flujos de información compartidos por las agricultoras/es sobre la AR, antes de empezar la MEP y después de transcurridos tres años de investigación. Nuestros resultados mostraron que la MEP favoreció el aprendizaje social en las agricultoras/es participantes, quienes fortalecieron y ampliaron sus redes sociales de intercambio de información sobre AR, presentando un conocimiento más complejo, común y amplio de los impactos y beneficios de la AR. De esto modo, se demostró que la MEP genera prerrequisitos cruciales para mejorar la adopción de la AR. Este estudio fue uno de los primeros en el ámbito del manejo sostenible de recursos naturales e innovaciones agrícolas que demuestra empíricamente el favorecimiento del aprendizaje social a través de procesos de investigación participativa, proporcionando evidencias tanto en su dimensión social-cognitiva como en su dimensión social-relacional. Nuestros hallazgos tienen una gran relevancia para el diseño de procesos de MEP, como pueden ser los living labs y otras iniciativas de restauración de ecosistemas, que tengan como objetivo apoyar, fortalecer y fomentar la adopción por parte de las comunidades agrícolas de manejos sostenibles e innovaciones agrícolas adaptadas a los diferentes contextos. Las investigaciones de MEP, donde la participación democrática de las/os participantes y las necesidades de las comunidades agrícolas son consideradas centrales en el proceso de investigación, representan una gran oportunidad para generar procesos inclusivos, atractivos, eficientes y transiciones sólidas hacia agroecosistemas sostenibles y resilientes a largo plazo.

Resumo

O avançado estado de degradação da terra que afeta mais de 3.200 milhões de pessoas em todo o mundo tem gerado uma grande preocupação internacional em relação a sustentabilidade dos sistemas sócio-ecológicos, incentivando a adoção em grande escala de manejos sustentáveis da terra adaptados aos diferentes contextos. O modelo agrícola industrial é um dos principais causadores da degradação da terra devido à promoção de práticas agrícolas insustentáveis que deterioram a qualidade dos solos, comprometendo sua capacidade de funcionamento e de prestação de serviços ecossistêmicos. As consequências derivadas da degradação da terra são especialmente devastadoras em regiões semiáridas propensas a processos de desertificação, onde a escassez e a irregularidade das chuvas intensificam a degradação dos recursos naturais e o risco de colheitas ruins, comprometendo a sustentabilidade destas regiões em longo prazo.

Recentemente, a agricultura regenerativa (AR) tem ganhado um reconhecimento cada vez maior como uma solução plausível para restaurar agroecosistemas degradados de todo o mundo. A AR é um enfoque agrícola capaz de reverter a degradação da terra, aumentar a biodiversidade, incrementar a produção, e melhorar a prestação de múltiplos serviços ecossistêmicos mediante o cumprimento de uma série de princípios e práticas de restauração da qualidade do solo. Apesar dos possíveis benefícios da AR, este enfoque agrícola tem sido adotado de forma muito restrita em regiões semiáridas. As principais razões que explicam sua adoção restrita são: a contradição e escassez de dados empíricos que demonstram sua efetividade, os enfoques verticais (top-down) e a falta de inclusão, participação e tomada de decisões das agricultoras/es nos projetos de restauração dos agroecossistemas, e a resposta geralmente lenta dos solos em regiões semiáridas as mudanças de manejos, o que pode retardar o aparecimento de resultados visíveis e desestimular as agricultoras e agricultores a adotarem a AR.

No planalto da estepe do sudeste da Espanha, um processo de restauração de ecossistemas em grande escala foi iniciado recentemente. O planalto de estepe é uma das regiões europeias mais afetadas pelos processos de degradação e desertificação do solo, e representa uma das maiores áreas do mundo de produção de amêndoas ecológicas de sequeiro. Em 2015, agricultoras e agricultores locais criaram a associação agroecologica AlVelAl com o apoio de empresas, governos regionais e instituições de pesquisa,

e começaram implementar a AR em suas propriedades. Seu objetivo: restaurar grandes extensões de terras degradadas, melhorar a produtividade e a biodiversidade, aumentar a resiliência de seus agroecosistemas às mudanças climáticas, gerar oportunidades de emprego, e melhorar a coesão social na região no período de 20 anos seguindo o modelo dos 4 retornos da Fundação Commonland. No entanto, a escassez de dados e informações para respaldar a eficácia da AR, aliada à falta de exemplos de referência na região e à lentidão com que os processos de restauração ecológica tendem a ocorrer em regiões semiáridas, foram considerados grandes entraves para promover a adoção da AR na região.

Para suprir efetivamente a falta de conhecimento sobre AR e apoiar a comunidade agrícola a melhorar e acelerar sua adoção, são necessárias abordagens horizontais de pesquisa, que promovam a criação de comunidades de aprendizagem entre agricultoras/es e pesquisadoras/es, combinando conhecimento local e científico para aprimorar o conhecimento sobre AR.

Esta tese desenvolve uma pesquisa participativa de monitoramento e avaliação (MEP), a partir de uma abordagem de pesquisa-ação-participativa, aplicando uma combinação de métodos sociais e ecológicos para avaliar o potencial do MEP na melhoria da troca de conhecimento entre agricultoras/es e pesquisadoras/es sobre a AR no contexto do planalto da estepe. O objetivo desta tese é duplo: por um lado, melhorar o conhecimento dos impactos da AR e, por outro lado, avaliar a contribuição do MEP na facilitação do aprendizagem social, contribuindo para a melhor adaptação e adoção em longo prazo da AR no planalto da estepe do sudeste da Espanha , e em regiões semi-áridas em geral.

Combinar o conhecimento científico e o local torna-se um imperativo nos processos de MEP para melhorar a adoção de inovações agrícolas, que é especialmente relevante em regiões semiáridas que tendem a responder devagar às mudanças de manejo, o que geralmente resulta em baixas taxas de adoção. Para isso é necessário gerar sistemas de monitoramento de qualidade do solo e sustentabilidade de agroecosistemas que integrem o conhecimento de agricultoras/es e pesquisadoras/es, e sejam adaptados ao contexto onde se aplicam as inovações.

Para facilitar o MEP dos impactos dos manejos sustentáveis e de inovações agrícolas como a AR, o Capítulo 2 apresenta um quadro metodológico que orienta a identificação e seleção de indicadores técnicos e locais de qualidade do solo, formando um sistema de monitoramento para avaliação participativa da AR por parte das pesquisadoras/es e agricultoras/es. O quadro metodológico inclui o desenvolvimento de uma ferramenta de avaliação visual do solo integrando indicadores locais de qualidade do solo para o monitoramento por parte das agricultoras/es. O quadro metodológico consiste em sete fases e inclui: Fase 1) Definição dos objetivos de pesquisa e monitoramento; Fase 2) Identificação, seleção e priorização de Indicadores Técnicos de Qualidade do Solo (TISQ); Fase 3) Identificação, seleção e priorização de Indicadores Locais de Qualidade do Solo (LISQ); Fase 4) Desenvolvimento de uma ferramenta de avaliação visual do solo integrando o LISQ; Fase 5) Teste e validação da ferramenta de avaliação visual do solo; Fase 6) Monitoramento e avaliação dos impactos dos manejos implementados pelas pesquisadoras/es e agricultoras/es utilizando o TISQ e a ferramenta de avaliação visual do solo respectivamente e; Fase 7) Intercâmbio dos resultados do monitoramento entre as participantes e avaliação conjunta dos impactos. Para facilitar o MEP da AR no planalto de estepe, apliquei o quadro metodológico e desenvolvi as fases 1 a 5 por meio de uma série de metodologias participativas que incluíram uma primeira reunião com os membros da diretoria da associação AlVelAl para a definição conjunta dos objetivos da pesquisa, visitas às propriedades das agricultoras/es participantes, o desenvolvimento de oficinas participativas, e a realização de entrevistas formais e informais, entre outros. As pesquisadoras/es participantes do MEP identificaram, selecionaram e priorizaram indicadores técnicos de qualidade do solo através de uma extensa revisão da literatura científica e consultas ad-hoc com especialistas experientes em monitoramento e avaliação da qualidade do solo. As agricultoras/es participantes identificaram, selecionaram, priorizaram e validaram indicadores locais de qualidade do solo em duas oficinas participativas. A ferramenta de avaliação visual do solo desenvolvida coletivamente, que chamamos de Caderno de Campo, foi testada e validada durante a segunda oficina. Os indicadores locais de qualidade do solo selecionados pelas agricultoras/es se concentraram principalmente em serviços ecossistêmicos de apoio, regulação e fornecimento, e incluíram indicadores de regulação hidrológica, controle da erosão, fertilidade do solo e rendimento da produção. Os indicadores técnicos de qualidade do solo selecionados pelas pesquisadoras/es focaram principalmente nas propriedades físico-químicas e biológicas do solo, incluindo os indicadores: estabilidade de agregados, nutrientes do solo, biomassa e atividade microbiana, e nutrientes foliares, abrangendo importantes serviços de apoio ao ecossistema. As informações complementares geradas pela combinação de indicadores locais e técnicos de qualidade do solo permitem ampliar a cobertura, a viabilidade e a eficácia no MEP dos impactos da AR, em comparação ao uso de indicadores exclusivamente técnicos ou locais. O quadro metodológico desenvolvido neste capítulo facilitou a identificação e seleção de indicadores locais e técnicos de qualidade do solo para gerar sistemas de monitoramento e ferramentas de avaliação visual do solo que foram relevantes e adaptadas aos contextos locais, melhorando assim a troca de conhecimento e aprendizagem mútua entre agricultoras/es e pesquisadoras/es para apoiar a implementação da AR e otimizar a provisão de serviços ecossistêmicos.

A implementação da AR pelas agricultoras/es geralmente ocorre de forma gradual devido às limitações socioeconômicas, de informação, ambientais e políticas. Portanto, a adoção da AR na prática se traduz em diferentes combinações de práticas regenerativas e diversidades de manejo com base nas capacidades das agricultoras/es, nas condições ambientais e nos resultados de restauração que se espera alcançar.

Para ajudar a adotar e implementar as práticas de AR mais eficazes para otimizar a restauração de agroecosistemas degradados em ambientes semi-áridos, o Capítulo 3 apresenta os resultados dos impactos de diferentes combinações de práticas regenerativas implementadas pelas agricultoras/es participantes do MEP, ao longo de dois anos, usando os indicadores técnicos de qualidade de solo e rendimento da cultura previamente selecionados. Apresenta os impactos da AR em 9 propriedades onde foram selecionadas, junto com as agricultoras de cada propriedade, uma área com manejo regenerativo e uma área próxima com manejo convencional e lavoura frequente (CT). Agrupei as áreas submetidas ao manejo regenerativo com base nas práticas de AR aplicadas e distingui 4 tipos de tratamentos regenerativos: 1) lavoura reduzida com adubo verde (GM), 2) lavoura reduzida com adubos orgânicos (OA), 3) lavoura reduzida com adubo verde e adubos orgânicas (GM&OA) e 4) não lavoura com cobertura natural permanente e adubos orgânicos (NT&OA). Avaliei os impactos da AR em relação ao manejo agrícola convencional comparando as propriedades físicas (densidade aparente e estabilidade adicionada), químicas (pH, salinidade, N, P, K total, P disponível e cátions trocáveis) e biológicas (SOC, POC, PON , atividade microbiana) da qualidade do solo e estado nutricional das amendoeiras (N, P e K foliares). Nossos resultados mostraram que o tratamento GM melhorou as propriedades físicas do solo, apresentando uma maior estabilidade dos agregados. Verificamos que o tratamento OA melhorou grande parte das propriedades químicas e biológicas do solo, apresentando maiores teores de SOC, POC, PON, N, K, P total, P disponível, cátions trocáveis e atividade microbiana. Tratamentos regenerativos que combinaram cobertura natural ou adubos verdes com adubos orgânicos (GM&OA e NT&OA) exibiram maior restauração geral da qualidade do solo em comparação com tratamentos com práticas individuais (GM e OA). O tratamento NT&OA se destacou por apresentar as maiores melhorias na restauração da qualidade do solo em relação ao manejo convencional. Todos os tratamentos regenerativos mantiveram o estado nutricional das amendoeiras semelhante ao manejo convencional. Concluímos que a AR tem grande potencial para restaurar a qualidade física, química e biológica dos solos dos agroecosistemas de lenhosos no semi-árido Mediterrâneo sem comprometer o estado nutricional das culturas. Espera-se que os manejos que incluem práticas regenerativas múltiplas sejam mais eficazes na restauração da qualidade do solo do que os manejos com práticas regenerativas individuais.

Paralelamente à avaliação dos impactos da AR pelas pesquisadoras/es, as agricultoras/es avaliaram os impactos da AR em suas propriedades por meio da ferramenta de avaliação visual do solo (*Caderno de campo*), desenvolvida em conjunto nas oficinas participativas. O Capítulo 4 apresenta os resultados da avaliação de impacto da AR pelas agricultoras/es e documenta suas observações e avaliações sobre o processo de avaliação visual do solo usando o *Caderno de Campo*, bem como sobre o impacto do MEP em facilitar o processo de participação e aprendizagem das agricultoras/es participantes, no terceiro ano desde o início do MEP. O monitoramento pelas agricultoras/es mostrou que a AR tem potencial para restaurar agroecosistemas degradados no semiárido Mediterrâneo, embora as melhorias observadas na qualidade do solo tenham sido relativamente pequenas em relação ao manejo convencional, exigindo mais tempo e esforço para atingir os objetivos de restauração desejados. As pequenas melhorias na qualidade do solo documentadas pelas agricultoras/es foram complementares aos resultados obtidos pelas pesquisadoras/es usando indicadores técnicos de qualidade do solo. As agricultoras/es destacaram o MEP como um processo de aprendizagem que as ajudou a ver seus solos e seus esforços de restauração de maneira diferente, e que facilitou a criação de relações de confiança e apoio, e o desenvolvimento de habilidades, que são requisitos fundamentais para promover a eficiência e a adoção de inovações agrícolas. As agricultoras/es confirmaram que a geração de espaços que favoreçam a troca de conhecimentos entre as agricultoras/es, bem como as experiências agrícolas nas propriedades (in situ), são um fator fundamental para promover a experimentação e adoção de inovações agrícolas. Além disso, as observações feitas revelaram a necessidade de envolver ativamente as agricultoras/es em todas as fases de planejamento e tomada de decisão para o desenvolvimento de ferramentas de avaliação visual do solo, a fim de gerar ferramentas que atendam às suas necessidades. Aliado a isso, o apoio da equipe de pesquisa aos agricultores/as nas primeiras implementações das ferramentas, contribui para melhorar sua adoção, facilitando para seus usuários o alcance dos objetivos de restauração desejados. Da mesma forma, a avaliação do Caderno de Campo pelas agricultoras/es indicou a necessidade de reforçar a utilidade multipropósito e os potenciais benefícios de registrar de forma sistemática e coletiva os processos de restauração, para aumentar a adoção dessas ferramentas pelas usuárias/os a quem são dirigidas. A avaliação do MEP pelas agricultoras/es reforça a importância do desenvolvimento de comunidades de aprendizagem entre agricultoras/es e pesquisadoras/es que proporcionem uma plataforma para a troca de experiências e apoio no processo de pesquisa, como fator crucial para favorecer a aprendizagem social e apoiar a adoção de inovações agrícolas em longo prazo. Concluímos que o sucesso da pesquisa focada na restauração de agroecosistemas pode ser aumentado pela integração de fases interativas nas quais as agricultoras/es possam avaliar e ajustar as atividades e resultados da pesquisa. O processo de MEP que contribui para aumentar o capital social, a aprendizagem social e gerar uma maior compreensão dos esforços de restauração é tão valioso quanto os próprios resultados da restauração no terreno.

A aprendizagem social é considerada um pré-requisito crucial para a adoção de manejos sustentáveis e de inovações agrícolas adaptadas a diferentes contextos. O objetivo principal do desenvolvimento de uma pesquisa de MEP envolvendo pesquisadoras/es e agricultoras/es no planalto de estepe do sudeste da Espanha foi facilitar a aprendizagem social para alcançar uma melhor compreensão dos impactos da AR e, assim, melhorar sua adoção. Embora haja cada vez mais pesquisas científicas que afirmam fomentar a aprendizagem social por meio de processos participativos, esse conceito tem sido definido de forma muito diversa, raramente é avaliado e tem sido parcialmente abordado sem abranger suas dimensões cognitivas e relacionais. Estabelecer que um processo participativo favoreceu a aprendizagem social implica demonstrar que houve um ganho de conhecimento e mudança de percepções a nível individual e coletivo das pessoas envolvidas no processo, e que essa mudança nas percepções foi gerada através do estabelecimento de relações sociais, troca de informações ou experiências.

O Capítulo 5 avalia como o MEP da AR no planalto de estepe favoreceu a aprendizagem social das agricultoras/es participantes ao aumentar de maneira efetiva a troca de conhecimentos, e a compreensão dos impactos da AR, entre as agricultoras/es e pesquisadoras/es participantes e com outras pessoas que formam parte de suas redes sociais. Avaliei se o MEP favoreceu a aprendizagem social cobrindo tanto suas dimensões sócio-cognitivas (percepções) como sócio-relacionais (redes sociais), e discuti o potencial do MEP para favorecer a adoção em uma escala maior de manejos sustentáveis e inovações agrícolas como a AR ao promover a geração de fluxos de informação entre as agricultoras participantes do MEP e a comunidade agrícola da qual fazem parte.

Usei o mapeamento cognitivo difuso (fuzzy cognitive mapping) e o análise de redes sociais como métodos gráficos semiquantitativos para avaliar as mudanças de percepções e de fluxos de informação compartilhados sobre AR pelas agricultoras/es antes de iniciar o MEP e após três anos de pesquisa. Nossos resultados mostraram que o MEP favoreceu a aprendizagem social das agricultoras/es participantes, que fortaleceram e ampliaram suas redes sociais de intercâmbio de informações sobre a AR e apresentaram um conhecimento mais complexo, comum, e amplo dos impactos e benefícios da AR. Desse modo, demonstrei que o MEP gera pré-requisitos cruciais para o fortalecimento e maior adoção da AR. Este estudo foi um dos primeiros estudos no âmbito da sustentabilidade dos recursos naturais e inovações agrícolas que demonstra empiricamente o favorecimento da aprendizagem social por meio de processos participativos, proporcionando evidências tanto em sua dimensão sócio-cognitiva quanto em sua dimensão sócio-relacional. Nossas descobertas têm grande relevância para o desenho de processos do MEP, bem como living labs e outras iniciativas de restauração de ecossistemas que tenham como objetivo apoiar, fortalecer e fomentar a adoção pela comunidade agrícola de manejos sustentáveis e inovações agrícolas adaptadas a diferentes contextos. As pesquisas do MEP onde a participação democrática das/os participantes e as necessidades das comunidades agrícolas são consideradas centrais no processo de pesquisa representam uma grande oportunidade para gerar processos inclusivos, atrativos, eficientes e transições sólidas para agroecosistemas sustentáveis e resilientes em longo prazo.

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I hope this thesis contributed to the construction and adoption of Regenerative Agriculture in southeast Spain, and I deeply wish it will inspire other researchers to engage in participatory research processes to support agroecological transitions worldwide.

Short biography

My name is Raquel Luján Soto. I was born in Albacete in the spring of 1987. I spent the summers of my childhood in a small village in northern Spain, helping my grandparents in the family orchard, and enjoying the freedom of rural life. In 2006 I enrolled in the degree in environmental science at the University of Valencia. During my university studies, I volunteered in the NGO Engineering Without Borders in the Food Sovereignty and Argentina groups. Together with various activist fellows, in 2010 we created the social center La Alqueria de Fávara, a self-managed space to carry out activities that promote food sovereignty and agroecology, support social organizations, and stimulate critical discussions about the agri-food system. In 2012 I obtained the BSc and MSc degree in environmental sciences from the University of Valencia. After finishing my studies, I gained a Leonardo da Vinci scholarship, completing my studies with a practical traineeship at the Netherland Institute of Ecology (NIOO-KNAW) in the Department of Terrestrial Ecology. At NIOO I worked with natural pest control and soil biodiversity functioning in agroecosystem restoration processes. During the period 2014-2016, I studied a MSc in Organic Agriculture at Wageningen University (Netherlands), and completed my studies at the Federal University of Viçosa (Brazil), developing a MSc thesis on the potential of coffee agroforestry systems to restore degraded soils by using nematodes as soil quality indicators. In 2017 I gained a PhD grant from La Caixa Foundation to develop my PhD research between the Institute of Sociology and Peasant Studies, from the University of Córdoba, and the Center for Soil Science and Applied Biology of the Segura, from the Spanish National Research Council (CEBAS-CSIC). Since then I developed a participatory monitoring and evaluation research to enhance the adoption of regenerative agriculture in semiarid regions.

List of Publications

Peer review journal articles

Luján Soto, R., Cuéllar Padilla, M., and de Vente, J. 2020. Participatory selection of soil quality indicators for monitoring the impacts of regenerative agriculture on ecosystem services. *Ecosystem Services*, *45*, 101157. https://doi.org/10.1016/j.ecoser.2020.101157

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Luján Soto, R., Cuéllar Padilla, M., Rivera Méndez, M., Pinto-Correia, T., Boix-Fayos, C., and de Vente, J. 2021. Participatory monitoring and evaluation of regenerative agriculture to enable social learning, adoption and out-scaling. Ecology & Society.

Journal Citations Report: SCIE (Ecology) 2020: **Q1**. Journal Impact Factor: **4.403**

Conference/Symposium Proceedings

Luján Soto, R. Investigación Acción Participativa en Agricultura Regenerativa. Seminario de Seguimiento de Doctorado- Universidad de Córdoba. Córdoba (Spain) - July 2019

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Appendices

PRIMER TALLER PARTICIPATIVO

SELECCIÓN DE INDICADORES DE CALIDAD DE SUELO

Informe del primer taller participativo desarrollado en Fuente Grande, Comarca de los Vélez (Almería)

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Este Informe forma parte del proyecto de doctorado "Monitorización y Evaluación Participativa en Agricultura Regenerativa: del conocimiento y los impactos locales a la adopción a gran escala". Este proyecto cuenta con el apoyo de la Fundación "la Caixa" (LCF/BQ/ES17/11600008), (ID 100010434)

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Centro de Edafología y Biología Aplicada del Segura (CEBAS-CSIC)

Instituto de Sociología y Estudios Campesinos – Universidad de Córdoba (ISEC-UCO)

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Obra Social
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1. Introducción

Existen múltiples formas de evaluar la calidad del suelo, desde costosos y detallados análisis de laboratorio, a métodos sencillos que se pueden llevar a cabo directamente en campo, que no requieren de recursos económicos o materiales, y que son de más difícil acceso a la mayoría de personas agricultoras. Estos últimos métodos han ido ganando relevancia con el tiempo, teniendo como consecuencia la creación y puesta en práctica de múltiples y diversas herramientas de evaluación rápida de calidad de suelos a las que comúnmente se les ha denominado "cuadernos de campo" o "manuales de campo". Los cuadernos de campo permiten realizar un diagnóstico rápido del estado del suelo en diferentes agroecosistemas y usos del suelo a través de indicadores que son conocidos y utilizados localmente. Los cuadernos de campo permiten además evaluar y contrastar el impacto de diferentes tipos de manejo en el espacio y a lo largo del tiempo, aportando información de gran valor para agricultoras/es, personal científico y técnico, y múltiples organismos que trabajan en el ámbito de la agricultura, el desarrollo rural y temas relacionados con la sostenibilidad.

Al igual que existen múltiples formas para evaluar la calidad del suelo, también existen múltiples formas de determinar qué indicadores resultan más útiles para dichas evaluaciones. La elección de indicadores puede ser completamente individual y unilateral, o puede realizarse a través de procesos participativos de selección y toma de decisiones de forma conjunta. Del mismo modo, la elección sobre los indicadores, cómo evaluarlos, y sobre quién los evalúa, va a estar determinada por los intereses y objetivos que se pretendan alcanzar.

Este taller forma parte del proyecto de doctorado titulado "Monitorización y Evaluación Participativa en Agricultura Regenerativa: del conocimiento y los impactos locales a la adopción a gran escala" donde la autora propone realizar una monitorización conjunta de las prácticas de agricultura regenerativa implementadas en el altiplano estepario del sureste español que comprende las provincias de Murcia, Almería y Granada, y concretamente al territorio donde la asociación AlVelAl trabaja promoviendo la restauración de los agroecosistemas y del paisaje a gran escala en la región.

En este proyecto de doctorado la investigación participativa es considerada esencial para tender puentes y crear sinergias entre la amplia experiencia y el incalculable conocimiento de las agricultoras/es sobre sus agroecosistemas, y el conocimiento y experiencia científico-técnico de las investigadoras/es. Como parte de la investigación participativa, y para que las agricultoras/es participantes puedan realizar la monitorización de las prácticas regenerativas, se ha propuesto realizar un cuaderno de campo creado conjuntamente por y para las agricultoras/es participantes. Pensamos que este cuaderno puede ser de gran ayuda y utilidad para cualquier persona interesada en evaluar la calidad de sus suelos y facilitar el auto-diagnóstico sobre el estado de degradación/restauración de sus agroecosistemas.

Este primer "taller participativo de selección de indicadores de calidad de suelo" es el paso inicial que dará lugar a la creación de nuestro cuaderno de campo.

Los objetivos del taller son:

1) Conocer a las personas que formamos parte de la investigación participativa, sus prácticas y experiencias.

2) Aprender mutuamente e intercambiar saberes puesto que todas las personas tenemos algo que aportar y aprender.

3) Identificar, definir y seleccionar indicadores que permitan evaluar la sostenibilidad de las fincas donde la agricultura regenerativa se ha implementado.

2. Presentación de las personas participantes

La dinámica de presentación de las participantes en el taller está pensada para ser un momento distendido en el que "romper el hielo", que dichas personas se conozcan y se familiaricen con la temática a abordar. Su presentación se realiza a través del "Juego de las tarjetas". La tarjeta sigue un guión que junta aspectos informales y formales sobre las personas participantes y el manejo de sus agroecosistemas.

Objetivo: Conocer a las personas participantes en la monitorización participativa y sus experiencias en agricultura regenerativa.

Metodología: Todas las participantes se sientan en círculo donde se presenta la dinámica. Las participantes forman parejas de presentación eligiendo a la persona del círculo que menos conozcan. Cada persona dispone de un par de minutos aproximadamente para presentarse siguiendo el guión dado en las tarjetas. Una vez terminadas las presentaciones por parejas, las participantes vuelven al círculo donde cada persona presenta su compañera de "juego" al resto del grupo.

Material: Tarjetas.

1. Soy …….. y vengo de………

2. Mi apodo es …………

3. Las prácticas de agricultura regenerativa que hago son……..

4. Algo que me hace feliz cada día….

Imagen 1 Tarjeta utilizada en el "Juego de las tarjetas" (arriba) y fotos de la ronda de presentaciones por parejas (abajo).

3. Instalación artístico-pedagógica

Las instalaciones artístico-pedagógicas son escenarios creados a partir de elementos traídos de diferentes experiencias visitadas. En este caso los elementos fueron recogidos en las fincas que participan en el proyecto de investigación y que fueron visitadas durante la primera fase de trabajo de campo llevada a cabo en la primavera de 2018. Las instalaciones artístico-pedagógicas tienen una dimensión estética y lúdica en el que los diferentes elementos traídos se disponen en el espacio dando lugar a un "escenario interactivo" donde las participantes pueden recorrerlo utilizando los diferentes sentidos (olor, tacto, vista…) para explorar, interactuar y familiarizarse con los elementos que conforman la instalación. Las instalaciones artístico-pedagógicas han de ser construidas preferentemente de forma colectiva, fomentando de esta forma la construcción conjunta de conocimiento sobre las diferentes realidades y vivencias concretas, de forma interdisciplinar y a partir de la interpretación dialogada, la reflexión y el intercambio de las diferentes percepciones de las visitantes de la instalación.

La instalación creada para este taller se compone de:

- Fotografías que muestran diferentes prácticas regenerativas utilizadas por las agricultoras y agricultores de la región de estudio

- Fotografías que muestran síntomas de degradación en los agroecosistemas de estudio

- Fotografías con diferentes propiedades físicas, químicas y biológicas del suelo

- Bolsas con muestras de diferentes tipos de suelo recogidas en las fincas participantes

- Plantas que son utilizadas como abono verde y cubiertas naturales

- Diferentes manuales, cuadernos y cartillas de evaluación de calidad de suelo y salud de los agroecosistemas

Por cuestiones logísticas, los elementos que conforman la instalación artístico-pedagógica de este primer taller fueron recogidos en las visitas de campo por la investigadora principal del proyecto, intentando seleccionar elementos que las y los agricultores destacaron durante las visitas o sobre los que hicieron alguna referencia de especial interés. A estos elementos se les ha unido otros elementos que dotan de contenido a este primer taller participativo, y lo vinculan al objetivo general de la investigación. Esta instalación además está pensada para funcionar como un espacio de devolución no oral del trabajo de campo llevado a cabo en las fincas participantes.

Objetivo: Fomentar el trabajo de reflexión grupal para vincular las prácticas regenerativas implementadas por las participantes a diferentes propiedades del suelo que pueden ser identificadas como indicadores de calidad.

Metodología: Las participantes visitaron la instalación artístico-pedagógica durante 15 minutos pudiendo escoger libremente uno o dos elementos que les llamó especialmente la atención. Al finalizar la visita las participantes se dispusieron en círculo explicando al resto de participantes el por qué de su elección y vinculando el elemento escogido a la pregunta ¿qué te dice ese elemento sobre la calidad del suelo? Las reflexiones y discusiones abiertas durante la instalación artístico-pedagógica fueron recogidas en un papelógrafo por una de las facilitadoras del taller.

Material: Elementos traídos de las fincas, papelógrafo y rotulador.

Imagen 2 Fotos de los difetentes elemetos constituyentes de la instalación artístico-pedagógica y participantes visitando la misma.

Resultados: Durante la dinámica surgieron reflexiones y se abrieron discusiones que abordaron las siguientes cuestiones:

• **Tierras duras / arcillosas:** Se discute sobre las causas que hacen que las tierras estén duras, y se relacionan con la textura del suelo y su contenido en arcillas.

• **Grietas:** A colación del punto anterior se relacionó el alto contenido en arcilla de los suelos a las grandes grietas que se forman cuando los suelos cambian su nivel de humedad, y a las modificaciones que sufren los suelos al perder humedad.

• **Escorrentias, laboreo a favor de pendiente y suelos desnudos:** Una imagen que muestra un suelo con señales de escorrentía superficial es escogida por un agricultor. Éste la relaciona con el manejo de la finca, mencionando que el laboreo a favor de pendiente ha sido una posible causa, ya que favorece la generación de escorrentías superficiales y la pérdida de suelo ante lluvias intensas. La escorrentía superficial es asociada también a suelos "desnudos" refiriendose a suelos desprovistos de cualquier tipo de cubierta.

• **Temperatura, cubierta vegetal y protección del suelo:** Una de las participantes elige una imagen que contiene un suelo con cubierta y un suelo desprovisto de cubierta en el que la diferencia de temperatura entre ambos es de aproximadamente 30 grados centígrados. La diferencia de temperatura en suelos cubiertos y descubiertos había sido mencionada por varios agricultores durante las visitas de campo. Se discute sobre la protección que ofrecen las cubiertas del suelo frente a la exposición al sol. Se habla de la protección que las piedras superficiales también ofrecen, y de la protección que pueden aportar otros tipo de cubiertas como los acolchados a base de restos de paja de la cosecha del cereal puestos en superficie, o los restos de poda de almendro picados y aplicados en forma de mulch.

• **Tierra suelta, raicillas y estructura:** Se comenta sobre el buen aspecto que tienen los suelos con gran presencia de raicillas. Se habla sobre la relación que tiene la presencia de estas raicillas con la buena estructura del suelo, lo que da lugar a una "tierra suelta" refiriendose a suelos no compactados.

• **Olor, contenido de materia orgánica, suelo vivos y muertos:** Se pone de relevancia la diferencia de olor de uno de los suelos presentados en la instalación pedagógica con respecto al resto. El suelo seleccionado es el suelo más oscuro, y los agricultores mencionan que tiene olor a bosque, lo que a su vez es relacionado con el contenido de materia orgánica y con la vida del suelo. El resto de los suelos que no tienen ese olor a bosque son relacionados con suelos sin vida, suelos muertos.

• **Ovejas, almendros, y salud de los sistemas integrados:** Una foto donde aparecen ovejas pastando cubiertas naturales en una finca de almendros es relacionada con un agroecosistema saludable. Se menciona que gracias a integrar animales, cubiertas y árboles se cierran los ciclos de nutrientes y energía, dando lugar a sistemas agroforestales sencillos en componentes pero complejos en funcionalidad y manejo.

• **Leguminosas y aportes de estiercol / materia orgánica, nitrógeno y color del suelo:** Dos prácticas regenerativas como la implementación y mantenimiento de cubiertas vegetales ricas en leguminosas, o abonos verdes, y el aporte de estiercol, son vinculadas a la fijación de nitrógeno y al incremento de materia orgánica en el suelo. Estas prácticas, al incrementar el contenido de materia orgánica del suelo, también son vinculadas a influir en el cambio del color del suelo.

• **Olor, color, textura y armonía:** Se reitera sobre la importancia del olor del suelo y se discute sobre su relación con otras propiedades como el color. Además se habla de la importantcia del equilibrio en los suelos y de la armonía de estos suelos equilibrados, y se relaciona el equilibrio y armonía con la interacción entre la parte mineral del suelo -la textura-, la parte química – nutrientes y materia orgánica- y la biología del suelo -organismos vivos-.

• **Plagas:** Se discute sobre la presencia de plagas tanto en cultivos sanos como en cultivos "no tan" sanos. Varias agricultoras/es mencionan la presencia de plagas en sus cultivos, como el gusano cabezudo, a pesar de ser manejados de forma sostenible. Se menciona que puede que las plagas vayan a árboles que están sanos porque al no estar tratados con agrotóxicos son más "apetecibles". También se comenta que aunque estos árboles sanos sean atacados, puede que el daño no sea muy grande, o que se más fácil "desprenderse" de las plagas debido a la salud de los árboles.

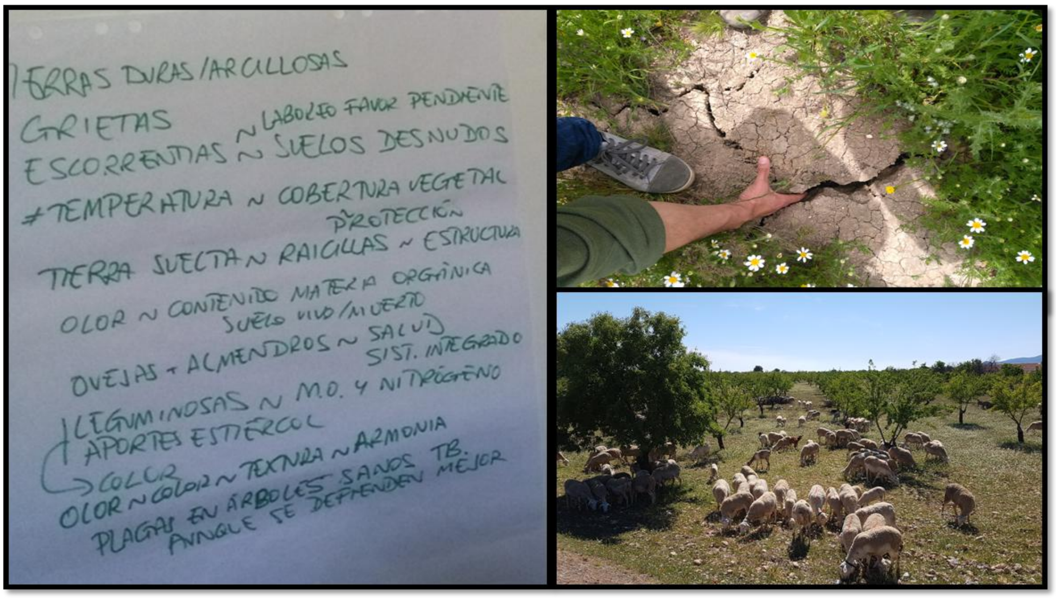

Imagen 3 Reflexiones recogidas durante la instalación artístico-pedagógica (izquierda) y dos fotos tomadas durante el trabajo de campo y que fueron seleccionadas por las participantes en la instalación artístico-pedagógica (derecha).

4. Identificación de indicadores locales de calidad del suelo

Los indicadores se refieren a propiedades o funciones del suelo que nos ofrecen información sobre su estado y nos permiten evaluar si las prácticas regenerativas están dando resultado. Del mismo modo nos informan sobre si se está cumpliendo con los objetivos de regeneración establecidos por las y los agricultores. Los suelos muestran síntomas que nos dan información sobre su estado. La observación de estos síntomas permite hacer un diagnóstico, es decir, relacionar dicho estado con las causas que lo han generado, y con las consecuencias que se derivan de ellas. Por ejemplo, si al pasar la grada para labrar el suelo notamos resistencia (síntoma), puede ser que el suelo esté compactado por estar sufriendo algún proceso de degradación (diagnóstico). Los agricultores pueden corroborar este diagnóstico mediante la observación de algunos signos que muestran dicha compactación, como pueden ser la presencia de una costra superficial o la presencia de grietas (indicadores).

En esta dinámica se recuerda a las personas participantes los indicadores que salieron durante el proceso de reflexión y discusión de la instalación artístico-pedagógica. Seguidamente, se dan nuevas pautas para la identificación participativa de indicadores de "buena/alta" calidad del suelo o suelos en proceso regenerativo, e indicadores de "mala/baja" calidad de suelo o suelos en proceso de degradación.

Objetivo: Identificación por parte de las y los agricultores de indicadores locales de calidad de suelo que utilizan, o pueden ser utilizados, en campo.

Metodología: Las participantes se dividen de forma aleatoria formando 2 grupos de entre 5 - 6 personas:

Los grupos se dividen con dos premisas diferentes:

- *Grupo 1:* Identificación de "Indicadores de mala/baja calidad del suelo o en proceso de degradación"

- *Grupo 2:* Identificación de "Indicadores de buena/alta calidad del suelo o en proceso de regeneración"

A cada grupo se le da una pregunta y una frase guía para facilitar el proceso de identificación de indicadores.

Grupo 1.

¿En qué te fijas para saber si un suelo tiene buena calidad o si las prácticas regenerativas están funcionando?

Para ayudarte puedes pensar en la información que usaban tus padres y abuelos para elegir las áreas donde cultivaban.

Grupo 2

¿En qué te fijas para saber si un suelo tiene mala calidad, está agotado o degradado?

Para ayudarte puedes pensar en la información que usaban tus padres y abuelos para elegir las áreas donde no cultivar, o donde plantaban cultivos menos "valiosos".

Para fomentar la participación de todas las personas del grupo, se pide que cada integrante identifique 3 indicadores de forma individual y los escriba en notas adhesivas, de manera que cada indicador esté escrito en una nota. Una vez realizado el ejercicio de reflexión individual e identificación de indicadores, se hace una puesta en común dentro de cada grupo, y cada integrante explica al resto de participantes los indicadores identificados. Una facilitadora por grupo ayuda a organizar los indicadores en "Indicador", "Respuesta" e "Información". Un ejemplo de la organización de indicadores sería: "Indicador = Color", "Respuesta = Oscuro", "Información = Materia orgánica".

Una vez llegado al acuerdo grupal en los dos grupos de trabajo sobre los indicadores, sus posibles respuestas y la información aportada por cada uno de ellos, una persona por grupo hace de relatora y comparte en plenario los resultados del ejercicio.

Material: Papelógrafo (1 por grupo), notas adhesivas y rotuladores.

Imagen 4 Trabajo grupal para la identificación de indicadores locales de calidad de suelo.

Los indicadores que aparecieron durante el trabajo grupal fueron organizados por las facilitadoras del taller en una tabla formada con varios papelógrafos que será utilizada posteriormente como input para seguir elaborando en la siguiente dinámica propuesta.

Indicador	Respuesta del suelo Degradación Mala Calidad	 Regeneración Buena Calidad	Información	Medición en campo	¿Cuándo?
	Suelos claros	Suelos oscuros	Materia orgánica		
Macrofauna del suelo	Sin lombrices	Con lombrices	Actividad biológica		
Humedad del suelo	Suelos secos				
	Suelos compactados	Suelos no compactados	Profundidad efectiva / capilaridad		
Plantas indicadoras		Diversidad de gramíneas y leguminosas			

Imagen 5 Tabla para la sistematización de indicadores de buena y mala calidad del suelo seleccionados por las participantes durante el trabajo grupal.

Resultados: En esta dinámica se identificaron un total de 14 indicadores, 9 respuestas de mala calidad de suelos, 7 respuestas de buena calidad de suelos, y 2 informaciones derivadas de dos indicadores.

Se generó un proceso de reflexión sobre los indicadores y sus posibles respuestas en los que la plenaria mostró su conformidad y agregó algunas posibles respuestas más. Este fue el caso del tipo de hierbas presentes en suelos de buena calidad, para las cuales, en el trabajo por grupos, no salió toda la información de la que disponía el colectivo.

Tabla 1 Indicadores locales, respuestas e informaciones identificados por las participantes

Indicador	Suelos Degradados - Mala Calidad	Suelos Regenerados - Buena calidad	¿Qué nos dice?
Color	Colores claros / pálidos	Colores oscuros	Contenido de materia orgánica
Contenido de raíces	Pocas o ninguna		
Tipo de hierbas presentes	Mancaperros / Cenizos / Cardo corredor / Poca diversidad	Leguminosas Borraja, alfalfa (mielgas), cardo borriquero, carretones, vállico, culebreras	
Protección del suelo	Signos de erosión /		
Capacidad de infiltración	Nula / Charcos y escorrentías		
Olor	No huele a nada	Huele a bosque	Contenido de materia orgánica
Estructura	Apelmazada / Prensada / Dura	Suelos sueltos	
Presencia de vegetación	Suelo Desnudo / Escasa cobertura vegetal		
Rendimientos en producción		Altos	
Vigor del cultivo / Color de las hojas	Bajo/ Colores pálidos		
Temperatura			
Presencia de macrofauna del suelo (bichos)		Hay lombrices/ mariquitas	
Color de la cubierta		Verde intenso	
Contenido de humedad		Húmedo tras días sin lluvia	

5. ¿Qué nos dicen los indicadores, cómo y cuándo medirlos?

Hasta ahora las dinámicas presentadas nos han ayudado a identificar indicadores locales de calidad de suelo, sus posibles respuestas en función del estado y la calidad del suelo, o estados de regeneración y degradación, y la información que podemos extraer de dichos indicadores. Esta dinámica tiene como finalidad identificar las diversas formas en que los indicadores pueden ser evaluados en campo de forma sencilla, así como el momento más idóneo para evaluarlos. En esta dinámica se completaron los datos ("Indicadores", "Respuestas" e "Información") que faltaban por identificar en la dinámica anterior. La identificación sobre cómo y cuándo medir los indicadores ofrecerá a los agricultores información para hacer un buen diagnóstico sobre el estado de calidad de sus suelos y agroecosistemas. Además esta dinámica sirve de base para abrir procesos de reflexión individual y colectiva sobre tipos de manejo regenerativo que pueden ayudar a frenar o revertir diferentes síntomas que muestren una mala calidad de suelo o procesos de degradación, e impulsar cambios hacia transiciones positivas dentro del amplio gradiente existente de calidades de suelo.

Por ejemplo, en el caso del indicador "macrofauna del suelo", dentro de los posibles organismos que se incluyen en este grupo, las lombrices son los organismos más representativos en climas templados. Si queremos medir la cantidad de lombrices presentes podrían escogerse varios métodos de evaluación, como realizar una estimación visual, realizar un conteo, etc. Igualmente, su momento de medición será aquella época donde resulte más fácil encontrarlas en caso de que estén presentes, como durante los meses de primavera donde las temperaturas son más suaves. Además se evitarán otros momentos que puedan distorsionar los resultados, como por ejemplo, se evitará realizar la evaluación después de un trabajo de labranza porque puede dar lugar a resultados equívocos.

Objetivo: Identificar las diversas formas en que los indicadores pueden ser evaluados en campo de forma sencilla y seleccionar la forma que consideren más adecuada, así como el momento más idóneo para evaluar cada indicador.

Metodología: Se dibuja una tabla grande con 6 columnas en papelógrafos. En cada columna se escribe uno de los siguientes enunciados:

- Indicador
- Respuesta "Suelos de buena calidad"
- Respuesta "Suelos de mala calidad"
- ¿Qué nos dice?
- ¿Cómo lo medimos en campo?
- ¿Cuándo lo medimos?

Se dibujan tantas filas como indicadores se hayan identificado. Se completan las filas y columnas de la tabla correspondientes a indicadores, respuestas e información y se dejan los demás columnas vacías.

Se dividen las personas participantes en 3 grupos y se reparten los indicadores previamente identificados entre los grupos. Se da por terminado el ejercicio en el momento en el que se alcanzaba un acuerdo sobre los datos asignados a cada indicador. Una vez terminado el trabajo por grupos, un relator representante de cada grupo expone en plenario todos los parámetros identificados de cada indicador.

Una vez completada la tabla se discuten en plenaria los aspectos que generen mayor debate durante la presentación de indicadores.

Material: Notas adhesivas, papel de embalaje y rotuladores.

Imagen 5 Participantes presentando en la plenaria grupal los resultados de las diferentes categorías establecidas para los indicadores locales de calidad de suelo.

Resultados: Se identificaron 14 indicadores y se completó la tabla para cada uno de los indicadores con las 6 consignas (tabla 3 – dinámica 6). Además, surgieron los siguientes comentarios y reflexiones que enriquecieron el debate:

• **Tipo de vegetación:** Se mencionan diferentes tipos de cardo, el cardo borriquero y el cardo corredor, como indicadores de diferentes calidades se suelo. Se comenta que tanto en el refranero como en los dichos populares referentes a agricultura de la península ibérica se mencionan plantas bioindicadoras. Se mencionan algunas frases recogidas en la literatura clásica española (ej. el "Lazarillo de Tormes" que data de 1554 y de autoría anónima), dónde ya se hace referencia a la presencia del cardo borriquero (*Onopordum acanthium)* como indicador de tierras fértiles. Se habla de los diferentes nombres comunes que denominan a la misma planta, como en el caso de mielga o alfalfa, nombre utilizado indistintamente por varios participantes para referirse a la especie *Medicago sativa*. Una participante de profesión pastora hace anotaciones sobre diversas leguminosas y otras plantas que son las más apreciadas por sus ovejas como es el caso del vállico (*Lolium rigidum*) y de una planta leguminosa de flores amarillas, posiblemente una especia de *Medicago*, que las ovejas adoran, y que sólo se da en suelos donde ya casi nada crece. Se menciona que el mancaperros, o esmancaperros, (*Salsola Kali*) aparece en suelos degradados, y parece que anuncian la antesala a los desiertos. Mencionan que esta planta no se encontraba antiguamente con tanta facilidad como en la actualidad.

• **Presencia de vegetación:** Se abre una discusión sobre el significado que tiene la presencia de vegetación con respecto a la calidad de los suelos. Se habla de que el hecho de que una cubierta vegetal no esté presente, no significa que ese suelo no tenga la capacidad de generar dicha cubierta. Tras varias reflexiones aportadas por las diferentes personas participantes se llega al acuerdo de que el indicativo de buena, o mala calidad, se refiere a que el suelo pueda generar una cubierta diversa y vigorosa.

• **Textura – estructura:** Durante el ejercicio de devolución del trabajo grupal a la plenaria se generó una discusión sobre qué es la textura de un suelo y la estructura. Tras varios minutos sin llegar a un acuerdo, la facilitadora hace una aclaración sobre lo que en el ámbito científico se entiende como textura, refiriéndose al porcentaje de arena, arcilla y limo de los suelos, y lo que se entiende como estructura, que es una propiedad del suelo derivada de la integración de la textura, el contenido en materia orgánica y los organismos vivos del suelo.

• **Humedad, cómo y cuándo medirla:** Se realizaron varios apuntes sobre los diferentes posibles momentos para su medición, la forma de medirla, y la profundidad del suelo a la que debería ser medida. Se mencionan métodos más sofisticados, como el uso de sensores de humedad (higrómetros), y más rudimentarios, como la apreciación por el tacto. Se llega a la conclusión de que depende del objetivo que se quiera abordar, la medición de la humedad podría ser en un lugar de la finca u otro, y en un momento del día, e incluso del año, u otros. Se acuerda que para que las mediciones sean fiables y consistentes, estas han de ser tomadas siguiendo siempre la misma metodología.

Los resultados de la toma de decisiones de esta dinámica se presentan junto con los resultados de la siguiente dinámica en la Tabla 3.

6. Ranking de indicadores

La dinámica del ranking de indicadores está pensada para establecer el orden de importancia que las participantes atribuyen a los indicadores a la hora de ofrecer información sobre el estado de calidad del suelo. Existen indicadores simples como puede ser la textura del suelo, e indicadores derivados de la agregación de varios indicadores, como puede ser el caso de la estructura del suelo, integrado por el contenido de materia orgánica, la textura y la biología del suelo. Tanto indicadores simples como indicadores agregados, pueden ofrecen información amplia y de calidad a la hora de realizar diagnósticos en las fincas. En esta dinámica se pretende identificar los indicadores locales considerados más relevantes para informar sobre el estado de calidad del suelo en la región de acción de la asociación AlVelAl correspondiente al altiplano estepario del sureste ibérico.

Objetivo: Ordenar los indicadores según su relevancia para aportar información sobre la calidad del suelo (o estado de regeneración/degradación) atribuida por las participantes.

Metodología: A cada participante se le entregan 6 pegatinas que son empleadas en forma de "puntos" con el valor de 1 punto por pegatina. Cada participante puede asignar un máximo de 2 puntos (pegatinas) por indicador, y tiene que escoger un mínimo de 3 indicadores. Cada participante escoge los indicadores que en su percepción considera más importantes siguiendo el criterio de elegir los indicadores que más información, y de mejor calidad, ofrezcan sobre el estado del suelo en función a modificaciones esperadas por las prácticas regenerativas implementadas.

Material: Pegatinas.

Resultados: Se repartieron un total de 60 pegatinas entre 10 participantes para puntuar los indicadores. De los 14 indicadores identificados, dos de ellos finalizaron con un voto de 0 puntos, siendo estos indicadores la "protección de suelo", y el "color de la cubierta".

A 6 de los indicadores se les atribuyó un valor menor de 5 puntos; siendo los siguientes: "contenido de humedad", "temperatura", "presencia de vegetación", "olor", "tipo de hierbas presentes" y "presencia de raíces".

Tres indicadores recibieron 5 puntos, siendo estos "vigor del cultivo", "rendimiento en producción" y "capacidad de infiltración".

Los 3 indicadores con mayor puntuación fueron el "color del suelo" que recibió 7 puntos, la "macrofauna del suelo" también con 7 puntos, y la "estructura del suelo" a la que se calificó como indicador más importante con un total de 10 puntos.

Imagen 6 Participantes asignando sus puntos a los indicadores de calidad de suelo.

La tabla 2 recoge los resultados obtenidos en esta dinámica.

Tabla 2 Puntuación atribuida a los indicadores y valor porcentual relativo calculado

Indicador	Puntuación	Porcentaje
Estructura	10	16,7 %
Color	7	11,7 %
Presencia de macrofauna del suelo (bichos)	7	11,7 %
Rendimientos en producción	5	8,3 %
Vigor del cultivo / Color de las hojas	5	8,3 %
Capacidad de infiltración	5	8,3 %
Contenido de humedad	4	6,7 %
Contenido de raíces	4	6,7 %
Presencia de vegetación	4	6,7 %
Tipo de hierbas presentes	4	6,7 %
Olor	3	5,0 %
Temperatura	2	3,3 %
Protección del suelo	0	0,0 %
Color de la cubierta	0	0,0 %

Finalmente, elaboramos la Tabla 3 donde se recoge toda la información obtenida en este primer "*Taller participativo de selección de indicadores de calidad de suelo*"

Tabla 3 Tabla resumen de los resultados obtenidos a lo largo de las 6 dinámicas que conforman este primer taller participativo de selección de indicadores de calidad de suelo

Indicador	**Suelos Degradados - Mala Calidad**	**Suelos Regenerados - Buena calidad**	**¿Qué nos dice?**	**¿Cómo lo medimos en campo?**	**¿Cuándo?**	**Puntos**
Color	Colores claros / pálidos	Colores oscuros	Contenido de materia orgánica	Visualmente: Con una plantilla de tonalidades y gamas cromáticas	• Cuando el suelo esté en un estado normal de humedad (ni muy seco ni muy húmedo). • Cuando no se haya labrado en tiempo	7
Contenido de raíces	Pocas o ninguna	Muchas raíces	Estructura del suelo	Visualmente: Cogiendo un trozo de tierra de los primeros 10 cm	• En invierno y primavera • Antes de que se sequen y antes de la labranza. Después de las lluvias de otoño	4
Tipo de hierbas presentes	Mancaperros / Cenizos / Cardo corredor / Poca diversidad	•Leguminosas • Borraja, alfalfa (mielgas), cardo borriquero, carretones, vállico, culebreras	• Contenido en nutrientes • Humedad • Estructura	Visualmente	• Durante todo el año • En cada estación	4
Protección del suelo	Signos de erosión / Cárcavas y grietas	• Cubierta semipermanente y permanente • Ausencia de signos de erosión	Nivel - Grado de protección del suelo	Visualmente: • Midiendo su anchura, tamaño y profundidad • Midiendo el nivel de arrastre de sedimentos en ribazos y canales	Durante y después de lluvias torrenciales	0
Capacidad de infiltración	Nula / Charcos y escorrentías	•Capacidad de infiltración • Suelo esponjado •Infiltración alta • Ausencia charcos y escorrentías	• Textura y estructura del suelo • Prácticas de laboreo • Diseño de plantación siguiendo o no las curvas de nivel	Visualmente	Durante las lluvias	5
Olor	No huele a nada	Huele a bosque	Contenido de materia orgánica	Olfato	• Primavera, verano y otoño. • Temprano por la mañana • Evitar momentos de lluvia intensa	3
Estructura	Apelmazada / Prensada / Dura	Suelos sueltos	Buena infiltración	• Sacar un trozo y evaluarlo visualmente • Coger una parte y ver si se rompe •Observar si hay grietas	• Cuando este seco • Varías veces al año.	10

Presencia de vegetación	Suelo Desnudo / Escasa cobertura vegetal	•Mucha cubierta, densa y con diversidad • Suelos con capacidad de generar cubiertas	• Fertilidad • Semillas en el suelo • Mejora de la estructura • Evitar evaporación y escorrentía	• Visual, método del cuadrado y cortar • Pesando la cobertura que hay en una superficie	En primavera (abril) y después de lluvias	4
Rendimientos en producción	Bajos	Altos	Fertilidad	• Recogiendo la cosecha • Midiendo el rendimiento	En la época de cosecha	5
Vigor del cultivo / Color de las hojas	Bajo/ Colores pálidos	Verdes, color de la piel (corteza del árbol)	• Salud del árbol • Fertilidad del suelo • Necesidad de nutrientes	• Visualmente con el color • Tacto hojas y brotes	• Al final del invierno y en primavera • Cuando estén con savia	5
Temperatura	Temperaturas altas	Temperaturas bajas	• Suelos protegidos con cubiertas, piedras, mulch • Vida en el suelo	Termómetro	• En heladas y momentos muy fríos • En cada estación en el momento de más calor e insolación	2
Presencia de macrofauna del suelo (bichos)	Ausencia de bichos	Hay lombrices/ mariquitas	Suelos vivos o muertos	• Visualmente • Mediante captura	Al amanecer y al atardecer	7
Color de la cubierta	Colores pálidos	Verde intenso	• Fertilidad • Nutrientes	Visualmente: Colorímetro	En primavera	0
Contenido de humedad	Suelos más secos / Sin humedad	Húmedo tras días sin lluvia	• Protección •Porosidad • Capacidad de retención de agua	• Con la mano • Con un sensor de humedad	• En el momento de mayor insolación • Al caer la noche • Muchas veces en muchos lugares pero siempre en el mismo momento del día • Entre 10 y 12 cm de profundidad	4

7. Cierre del taller y establecimiento de acuerdos

Una vez completada la tabla y realizado el ranking de indicadores se establecieron acuerdos comunes referentes a los próximos pasos a llevar a cabo una vez culminado este primer taller. Los acuerdos comunes a los que se llegaron en el taller fueron:

Resultados:

1) Los indicadores identificados en el taller formarán parte de un **cuaderno de campo** que crearemos de forma conjunta. En otoño de 2018 se realizará un segundo taller donde se presentará un borrador del manual para ponerlo en práctica y hacer una validación inicial de los indicadores, respuestas, información y metodología de medición. Cada persona tendrá un manual para poder autoevaluar sus propias prácticas y registrar los cambios en el cuaderno.

2) **Las mediciones serán realizadas por ambas partes, es decir,** en el caso de las agricultoras/es se realizará la monitorización usando los cuadernos de campo, y en el caso de las investigadoras/es a través de métodos científicos y de laboratorio.

3) **Visitas 1 o 2 veces al año (primavera – otoño).** El personal investigador nos comprometemos a seguir reuniéndonos junto con las agricultoras/es para hacer próximos talleres, validar el cuaderno de campo y realizar una devolución conjunta de resultados.

Anexo 1: Plantas indicadoras

Plantas indicadoras de mala calidad de suelo

• Mancaperros (*Salsola Kali*)

Foto: Smithsonian Institution

• Cenizo (*Chenopodium álbum*)

Foto: www.riomoros.com

• Cardo corredor – (*Eryngium campestre*)

Foto: Flora de Andalucía Oriental, 2º Edición (izquierda). José Quiles (derecha)

Plantas indicadoras de buena calidad de suelo

• Cardo borriquero (*Onopordum acanthium*)

Foto: A. S. Maldonado

• Borraja (*Borago officinalis*)

Foto: Flora de Andalucía Oriental, 2º Edición

• Alfalfa o Mielga (*Medicago sativa*)

Foto: Flora de Andalucía Oriental, 2º Edición

• Carretón (*Medicago polymorpha, Medicago rigidula*)

Foto: Universidad Nacional de la Pampa (izquierda). Steve Matson (derecha)

• Vállico (*Lolium rigidum*)

Foto: Gibraltar Botanic Gardens (izquierda). Flora de Andalucía Oriental, 2º Edición (derecha)

• Culebrera (Lathyrus clymenum)

Foto: Raquel Luján

Anexo 2: Agenda del taller

9.30 - 10.00 Presentación del taller y de los participantes.

10.00 – 10.30 Instalación artístico-pedagógica

10.30 - 11.30 Identificación de indicadores locales de calidad de suelo

11.30 - 12.15 Pausa café

12.15 – 13.30 ¿Qué nos dicen los indicadores, cómo medirlos y cuándo?

13.30 – 14.00 Ranking de indicadores

14.00- 14.15 Cierre del taller y establecimiento de acuerdos

14.30 - 16.30 Comida

SEGUNDO TALLER PARTICIPATIVO

PUESTA EN PRÁCTICA Y VALIDACIÓN DEL CUADERNO DE CAMPO

Informe del segundo taller participativo desarrollado en la finca Torre de Guajar, Hernán-Valle (Granada)

Autora: **Raquel Luján Soto**

Este Informe forma parte del proyecto de doctorado "Monitorización y Evaluación Participativa en Agricultura Regenerativa: del conocimiento y los impactos locales a la adopción a gran escala". Este proyecto cuenta con el apoyo de la Fundación "la Caixa" (LCF/BQ/ES17/11600008), (ID 100010434)

Sábado 17 de noviembre de 2018

Centro de Edafología y Biología Aplicada del Segura (CEBAS-CSIC)

Instituto de Sociología y Estudios Campesinos – Universidad de Córdoba (ISEC-UCO)

CSIC
Consejo Superior de Investigaciones Científicas

Universidad de Córdoba
Instituto de Sociología y Estudios Campesinos

Obra Social
Fundación "la Caixa"

Agradecimientos

Agradecer a todas las personas participantes en el taller, por su interés y contribución en el desarrollo y validación del Cuaderno de Campo. Especialmente me gustaría agradecer a Fran Martínez Raya y su familia por hospedar el evento en su cortijo, guiar la visita por la finca y el entorno natural aledaño, y por compartir con todas las personas asistentes sus dulces artesanos elaborados con productos locales y agroecológicos.

1. Introducción

Los cuadernos de campo son herramientas de evaluación visual del suelo. Estas herramientas son prácticas y sencillas de usar, facilitan la recopilación y sistematización de observaciones en campo, y ayudan a visualizar los impactos derivados de diferentes manejos agrícolas sobre la calidad del suelo. Además, debido al apoyo visual que estas herramientas ofrecen y al uso de lenguaje coloquial, los cuadernos de campo facilitan el intercambio de información entre diferentes actores y niveles de experiencia.

Los cuadernos de campo nos ayudan a interpretar de forma sencilla el estado de la calidad del suelo a través de la evaluación visual de diferentes indicadores que pueden ser propiedades y funciones del suelo, servicios ecosistémicos, o diferentes aspectos del cultivo. Esto facilita la autoevaluación y la auto-reflexión, a nivel individual y colectivo, sobre la eficiencia de diferentes manejos agrícolas en la restauración de la calidad del suelo y de los cultivos bajo evaluación. Por ello, el uso de estas herramientas puede ayudar a la comunidad agrícola que los utiliza en la toma de decisiones para conseguir los objetivos de restauración, y a realizar un manejo sostenible de sus agroecosistemas sin la necesidad de un apoyo técnico continuado.

Este taller forma parte del proyecto de doctorado titulado "Monitorización y Evaluación Participativa en Agricultura Regenerativa: del conocimiento y los impactos locales a la adopción a gran escala". Este proyecto tiene como pilar central realizar una monitorización conjunta de las prácticas de agricultura regenerativa implementadas en el altiplano estepario del sureste español que comprende las provincias de Murcia, Almería y Granada, y concretamente al territorio donde la asociación AlVelAl trabaja promoviendo la restauración a gran escala de los agroecosistemas y del paisaje en la región.

En este proyecto de doctorado la investigación participativa es considerada esencial para tender puentes y crear sinergias entre la amplia experiencia y el incalculable conocimiento de las agricultoras/es sobre sus agroecosistemas, y el conocimiento y experiencia científico-técnico de las investigadoras/es.

Como parte de la investigación participativa, y para que las agricultoras/es participantes puedan realizar la monitorización de las prácticas regenerativas, se ha propuesto desarrollar un cuaderno de campo creado conjuntamente con las agricultoras/es participantes. Pensamos que este cuaderno puede ser de gran ayuda y utilidad para cualquier persona interesada en evaluar la calidad de sus suelos y facilitar el auto-diagnóstico sobre el estado de restauración/degradación de sus agroecosistemas.

En este segundo taller pondremos en práctica y validaremos el cuaderno de campo desarrollado a partir de indicadores locales seleccionados por las agricultoras/es participantes en el primer taller participativo desarrollado dentro de este proyecto de investigación.

2. Actualización de la investigación participativa y objetivos del taller

Como sabéis hace unos meses empezamos esta investigación participativa que tiene el propósito de unir esfuerzos entre agricultoras/es e investigadoras/es y evaluar de forma conjunta el impacto de las diferentes prácticas regenerativas y manejos que estáis implementando en la diversidad de fincas que forman AlVelAl.

Para la evaluación de impactos podemos elegir diferentes caminos: podemos realizar la evaluación con indicadores locales usados comúnmente por la comunidad agrícola en la región; podemos optar por la evaluación con indicadores técnicos a través de análisis de laboratorio; o, en nuestro caso, elegimos andar ambos caminos de forma paralela. Por mi parte, como ya sabéis, estoy tomando muestras de vuestros suelos para realizar análisis en laboratorio, tanto en las parcelas regenerativas como en las parcelas convencionales a las que llamamos "control". Los análisis de laboratorio ofrecen una parte de la información que necesita ser complementada con conocimientos prácticos y con experiencias en campo. Es decir, necesita de vuestras observaciones y experiencias ya que vosotras/os conocéis vuestras fincas mejor que nadie. Los análisis de laboratorio y las observaciones en campo ofrecen información complementaria, por lo que combinarlas puede ser de gran utilidad.

Además, para ver cómo de efectivos son los manejos y prácticas regenerativas podemos analizar como evoluciona la calidad del suelo en el tiempo, realizando una evaluación en el momento actual, otra el año que viene, y así sucesivamente. Otra opción es comparar la calidad del suelo de nuestra parcela regenerativa con una parcela con manejo tradicional "convencional" donde no se están haciendo prácticas regenerativas, y hacer así una comparación en "espacio". En nuestro caso vamos a realizar una evaluación en tiempo y espacio, evaluando parcelas regenerativas y comparándolas con parcelas convencionales durante varios años. El cuaderno de campo que hemos desarrollado a partir de los indicadores locales que seleccionasteis en el primer taller participativo, permite recoger esta información de forma estructurada.

En próximos talleres nos juntaremos a compartir nuestras experiencias de monitorización, donde se incluirán los resultados recogidos en los cuadernos de campo y los resultados obtenidos en los análisis de laboratorio. Esto nos ayudará a conocer mejor la relación práctica-manejo-impacto y nos permitirá adaptar nuestras prácticas y manejos para obtener una mayor eficiencia en la restauración de la calidad del suelo, sus funciones y los beneficios que obtenemos de ellos.

Objetivos del taller:

1. Poner en práctica el cuaderno de campo en suelos con diferentes manejos para familiarizarnos con él y solventar posibles dudas.

2. Validar el cuaderno y realizar las modificaciones que se consideren precisas.

3. Presentación del cuaderno de campo

Realizar una explicación detallada sobre cómo utilizar el cuaderno de campo previa a su puesta en práctica va a facilitar un uso más eficaz y fluido. El cuaderno de campo se compone de dos secciones, una primera sección con información detallada sobre cómo realizar la evaluación visual de la calidad del suelo, y una segunda sección que incluye los indicadores a evaluar.

Objetivo: Presentar el cuaderno de campo, su estructura y explicar su uso para facilitar su puesta en práctica. Explicar el objetivo de utilizar el cuaderno de campo y cómo interpretar los resultados obtenidos de la evaluación visual del suelo.

Metodología: Todas las personas asistentes se disponen en círculo y la facilitadora explica cómo se estructura el cuaderno, y donde pueden encontrar la información sobre cómo realizar la evaluación de cada indicador. Además se hace un recorrido por todos los indicadores locales que integran el cuaderno, y se explica el uso de los termómetros que servirán para medir el indicador "temperatura del suelo".

Material: Cuadernos de campo y termómetros infrarrojos portátiles

Resultados: Se presentó el cuaderno de campo al las personas participantes al taller, se explicó su estructura, cómo realizar las evaluaciones de los indicadores y donde apuntar los resultados de dichas evaluaciones. Posteriormente se entregó un cuaderno de campo a cada agricultor/a y se fue recorriendo junto con ellos/as, indicador por indicador para resolver posibles dudas. Durante el descanso del almuerzo, las agricultoras/es siguieron ojeando el cuaderno de campo y realizando observaciones.

Imagen 1 Presentación del cuaderno de campo a las participantes del taller

4. Visita a la finca y parcelas regenerativas

Algunos de los principios de la agricultura regenerativa incluyen minimizar la perturbación del suelo, mejorar su fertilidad e incrementar la biodiversidad para mejorar la calidad del suelo. Estos principios pueden ser aplicados de forma generalizada independientemente del clima y del lugar. Sin embargo, las prácticas regenerativas y manejos que siguen estos principios han de ser adaptados a las condiciones biofísicas y climáticas de cada finca, y a los objetivos y necesidades de cada agricultor/a. Es por ello interesante conocer el paisaje circundante y los factores y procesos que han influido e influyen en su formación, ya que nos permitirá entender mejor que prácticas y manejos pueden ser más eficientes en la restauración de nuestros agroecosistemas teniendo en cuenta los recursos disponibles.

Objetivo: Vincular los factores naturales y procesos de formación del paisaje con el manejo agrícola. Mostrar las potencialidades de restauración del suelo observando la naturaleza y trabajando con ella bajo determinadas condiciones. Mejorar el pensamiento creativo de las participantes.

Metodología: Visita a la finca guiada por el agricultor anfitrión.

Material: No se precisan materiales.

Resultados: El agricultor anfitrión nos mostró el paisaje de *badlands* que rodea la finca y nos explicó sus observaciones sobre el paisaje. Nos mostró cómo las caras sur de las formaciones que dan lugar a los *badlands* están más expuestas al sol, desprovistas de vegetación, y muy erosionadas. Por el contrario, las caras norte tienen menos exposición al sol, crece más vegetación, y están menos erosionadas. En el corte donde acaba la planicie y comienza la zona de *badlands*, el agricultor señaló la capa de roca que se sitúa a tan solo 15 o 20 cm de la superficie, explicándonos la escasa profundidad de suelo que tienen para realizar agricultura y la importancia de optimizar y maximizar su uso. Nos mostró algunas especies de gramíneas que producían mucha biomasa con una raíz muy escasa. Además nos explicó como gramíneas y leguminosas eran las plantas pioneras en aparecer en zonas sombrías, incluso a la sombra que generan las piedras. Nos explicó que en la finca intentan aplicar lo que observan que funciona en el paisaje. Por ello favorecen el crecimiento de cubiertas naturales ricas en leguminosas y gramíneas invernales para mantener el suelo cubierto todo el año. Además manejan estas cubiertas con un roller crimper y no labran desde hace más de 10 años para evitar la pérdida de materia orgánica y compactación del suelo.

Imagen 2 Agricultor explicando al grupo los procesos de formación del paisaje

5. Puesta en práctica del cuaderno de campo

Cualquier herramienta de evaluación visual del suelo ha de ser validada en campo. La validación nos permite verificar que los indicadores seleccionados, los rangos establecidos de calidad, así como la metodología seleccionada para su medición ofrecen una información precisa y veraz. Gracias a la puesta en práctica del cuaderno de campo en parcelas con diferentes manejos podremos realizar ajustes precisos para realizar un buen diagnóstico de la calidad del suelo. Además, la puesta en práctica del cuaderno de campo de forma grupal ayuda a familiarizarnos con su uso, y nos permite solventar posibles dudas con las/os compañeras y la persona facilitadora.

Objetivo: Familiarizar a las participantes con el cuaderno de campo. Validar el cuaderno de campo para evaluar y discernir entre diferentes calidades del suelo mediante su puesta en práctica en parcelas agrícolas con diferentes manejos.

Metodología: La agricultora o agricultor anfitrión presenta el manejo de las diferentes parcelas a evaluar. Las participantes con el apoyo de una persona facilitadora, ponen en uso el cuaderno de campo y realizan anotaciones en la plantilla de observaciones.

Material: Cuadernos de campo y termómetros infrarrojos portátiles. Plantillas para anotar observaciones.

Resultados: Nos dividimos en dos grupos, cada grupo acompañado por una persona facilitadora. Cada grupo dispuso de aproximadamente 45 minutos para realizar la evaluación visual del suelo y realizar anotaciones. Durante la puesta en práctica del cuaderno de campo se solventaron dudas sobre algunos indicadores y su metodología de evaluación. Las facilitadoras del taller también realizaron anotaciones sobre las observaciones realizadas en campo por las/os agricultores.

Imagen 3 Parcela con manejo regenerativo (izquierda) evaluación visual del indicador lombrices (derecha)

6. Validación de indicadores y del Cuaderno de Campo

Tras la puesta en práctica del cuaderno de campo para su validación, se recogen y realizan las modificaciones necesarias en los indicadores. Con el transcurso del tiempo es conveniente actualizar el cuaderno de campo y realizar nuevas validaciones. Este cuaderno de campo está concebido como una herramienta dinámica, con el fin de mejorarlo y enriquecerlo a partir de los conocimientos y experiencias de sus usuarias/os.

Objetivo: Validar los indicadores, rangos de calidad, metodología, momento y lugar de medición de todos los indicadores. Llegar a un consenso grupal sobre las modificaciones de los indicadores.

Metodología: Trabajo en grupos. Se divide a las participantes en dos grupos diferentes. Cada grupo trabaja una mitad de indicadores. Sobre esa mitad de indicadores cada grupo tienen que establecer si los rangos de calidad, la forma de medición, y el momento de medición son adecuados, y añadir cualquier sugerencia que consideren que pueda mejorar la medición del indicador. En plenaria un portavoz por grupo presenta las modificaciones y sugerencias al resto de compañeras/os. Se aceptan las modificaciones propuestas si todo el mundo está de acuerdo y, en caso contrario, se facilita una discusión grupal hasta llegar a un acuerdo común.

Material: Papelógrafo, rotuladores y plantillas con las observaciones.

Resultados: Algunas de las modificaciones más importantes propuestas fueron:

- **Sustitución de indicadores**: Las agricultoras/es asistentes hicieron un número de ajustes en los indicadores, su metodología y frecuencia de medición. Las participantes cambiaron el indicador “producción de cultivos” medida a través del rendimiento, por los indicadores "carga de almendras y longitud de brote" y "escandallo". Estos dos nuevos indicadores se consideraron más fáciles, precisos y con menor consumo de tiempo y trabajo en su medición en comparación con la medición de los rendimientos en función del manejo de cada parcela de la finca. Las participantes argumentaron que el rendimiento de los cultivos depende en gran medida de las condiciones climáticas, pero cuando los suelos son fértiles y con suficiente humedad, tienen la capacidad de proporcionar suficientes nutrientes para que el almendro produzca abundantes almendras y brotes largos, además de tener mejores escandallos.

- **Modificación de metodología de medición**: Durante el uso del cuaderno de campo en las diferentes parcelas de la finca, las participantes no pudieron encontrar algunas de las especies de planta que propusieron en el primer taller para evaluar la calidad del suelo a través del indicador “plantas bioindicadoras”. Algunas de estas plantas fueron el cardo borriquero (Onopordum acanthium) y la alfalfa (Medicago sativa). Sin embargo, los agricultores consiguieron realizar la evaluación del indicador basándose en las familias de plantas a las que pertenecían algunas de las plantas presentes. Como resultado, se propuso evaluar las plantas bioindicadoras incluyendo las principales familias de plantas (ej. gramíneas, leguminosas, crucíferas…) para ayudar a la interpretación.

- **Eliminación de indicadores:** Mientras que los indicadores "plagas y enfermedades" y "erosión eólica" se incluyeron durante el primer taller participativo, los agricultores decidieron eliminarlos del conjunto final, argumentando que las plagas y enfermedades podrían estar presentes tanto en fincas regenerativas como en convencionales. Simplemente, los árboles sanos en fincas más sostenibles difícilmente sufrirían un gran daño o la plaga se eliminaría más fácilmente que en árboles débiles. Además argumentaron que aunque la erosión eólica puede evaluarse fácilmente mediante la acumulación de polvo en las lindes de los campos y al observar si hay piedras con su base hueca debido al viento, es un fenómeno poco común y relevante a nivel de territorio.

- **Puntuación de indicadores:** Se enfatizó la necesidad de asignar puntuaciones intermedias entre categorías de calidad para abarcar la complejidad observada en el campo. Por lo tanto, incluimos y enfatizamos en el cuaderno de campo la posibilidad de realizar puntuaciones con decimales.

- **Momento de las mediciones:** Puesto que algunos indicadores pueden tardar más en variar que otros, como el color del suelo debido a incrementos de materia orgánica, se llegó al acuerdo de realizar la evaluación visual del suelo 4 veces al año, una por estación, a excepción de los indicadores donde no fuese posible, como por ejemplo la carga de almendra, solo posible de realizar en verano.

7. Presentación de resultados de los análisis físico-químicos del suelo

Los análisis fisicoquímicos nos ofrecen información sobre múltiples propiedades físicas, químicas y biológicas del suelo. Muchas de estas propiedades, como los nutrientes del suelo, su estructura y la cantidad de materia orgánica, son utilizadas por las comunidades agrícolas, personal técnico y científico, como indicadores técnicos de calidad de suelo. Los análisis físico-químicos, pueden ser de gran ayuda para entender el impacto de diferentes manejos y prácticas regenerativas en nuestros agroecosistemas y complementar las observaciones realizadas en campo, ya que nos ofrecen información sobre la calidad de nuestros suelos difícilmente perceptible a simple vista.

Si no se está familiarizado con este tipo de análisis, la información aportada puede ser difícil de interpretar. Una explicación detallada y acompañada de material de apoyo visual, facilita una mejor compresión de este tipo de informes y ayuda a su interpretación.

Objetivo: Presentar los indicadores técnicos de calidad de suelo a las participantes como la mitad complementaria del los indicadores locales que integran el cuaderno de campo, y que completa el sistema de monitorización. Presentar los indicadores técnicos y los resultados preliminares obtenidos con ellos en las parcelas regenerativas y convencionales seleccionadas conjuntamente entre agricultoras/es e investigadoras/es para su monitorización.

Metodología: Presentación en plenaria y discusión de resultados.

Material: Informes fisicoquímicos individuales y dosier para la interpretación de resultados.

Resultados: Cada agricultor/a recibió un informe que incluía: imágenes de satélite de la parcela regenerativa y de la parcela convencional con las zonas de muestreo señaladas; resultados obtenidos en los análisis de laboratorio sobre los indicadores técnicos de calidad de suelo; tablas y dosier explicativo para la interpretación de los resultados.

La facilitadora, con el permiso de un agricultor, utilizó su informe para explicar en grupo cómo se estructuraba el contenido y dónde podían encontrar información para interpretar los resultados. La facilitadora fue recorriendo uno a uno todos los indicadores, explicando la información obtenida por cada uno de ellos y comentando los resultados obtenidos. Al mismo tiempo, cada persona interpretaba sus propios resultados. Tras la explicación e interpretación de cada indicador se abrió un espacio para solventar posibles dudas. Al terminar la dinámica se recordó la posibilidad de contactar con el equipo científico por email o por teléfono para solventar cualquier otra duda de los informes que pudiera surgir una vez acabado el taller.

Imagen 4 Devolución de resultados obtenidos con los indicadores técnicos de calidad de suelo

Imagen 5 Foto de grupo de las personas participantes en el segundo taller participativo.

Anexo 1: Agenda del taller

10.00 – 10.20 Presentación del taller y recapitulación del proceso de monitoreo participativo

10.20 – 10.50 Presentación del cuaderno de campo

10.50 - 12.15 Visita a la finca y puesta en práctica del cuaderno

12.15 – 12:30 Almuerzo

12.30 - 13.45 Validación de indicadores.

13.45 – 14.30 Presentación de resultados de indicadores técnicos de calidad de suelo

14.30 - 16.30 Comida

TERCER TALLER PARTICIPATIVO

COMPARTIENDO EXPERIENCIAS DE MONITORIZACIÓN EN AGRICULTURA REGENERATIVA

Informe del tercer taller participativo desarrollado en Chirivel (Almería)

Autora: **Raquel Luján Soto**

Este Informe forma parte del proyecto de doctorado "Monitorización y Evaluación Participativa en Agricultura Regenerativa: del conocimiento y los impactos locales a la adopción a gran escala". Este proyecto cuenta con el apoyo de la Fundación "la Caixa" (LCF/BQ/ES17/11600008), (ID 100010434)

Sábado 15 de junio de 2019

Centro de Edafología y Biología Aplicada del Segura (CEBAS-CSIC)

Instituto de Sociología y Estudios Campesinos – Universidad de Córdoba (ISEC-UCO)

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1. Introducción

Esta investigación tiene como eje vertebral la monitorización participativa de diferentes prácticas regenerativas implementadas en el territorio AlVelAl. La monitorización participativa es un método de investigación colaborativo donde agricultoras/es junto con investigadoras/es recogemos conjuntamente información sobre el impacto de diferentes prácticas y manejos regenerativos sobre la mejora de la calidad del suelo. La monitorización participativa tiene como gran ventaja que permite aunar conocimiento local y científico, aportando información detallada sobre el funcionamiento de los agroecosistemas, y permite contrastar observaciones de campo con datos técnicos. Además de proporcionar información de alta calidad, la monitorización participativa mejora el conocimiento individual y comunitario sobre la agricultura regenerativa, aumentando el aprendizaje y la conciencia social, y contribuyendo a impulsar la adopción de la agricultura regenerativa en el entorno local.

Monitorizar los impactos observados y anotar los resultados tanto en el cuaderno de campo como a través de análisis fisicoquímicos y biológicos de suelo, nos permite tener un registro sobre el estado de nuestros suelos al que podemos volver cada vez que queramos y ver los avances realizados, es decir, ver dónde estábamos y dónde estamos ahora. Esto nos permite, saber si los cambios se están dando en la dirección deseada, y en caso contrario, ajustar las prácticas y manejos. Una monitorización frecuente nos permite detectar con mayor rapidez los avances obtenidos. Por ello, anotar los resultados y recogerlos de forma sistematizada es importantísimo, especialmente cuando estamos juntos en un grupo, ya que servirá para compartir los resultados en el grupo y generar una memoria común. Documentar los cambios observados es muy útil para nosotras mismas, pero también puede serlo para otras/os agricultoras o grupos de personas con interés en el tema. Por ejemplo, para optar a proyectos que apoyen modelos de agricultura sostenible necesitamos tener una buena documentación.

En este tercer taller participativo compartiremos las experiencias de manejo, y los primeros resultados obtenidos en la monitorización participativa a través de indicadores locales, recogidos en los cuadernos de campo, e indicadores técnicos que incluyen propiedades físico-químicas y biológicas del suelo, obtenidos mediante análisis de laboratorio.

• Objetivos del taller:

- Compartir los diferentes manejos y prácticas regenerativas implementadas por las participantes y las observaciones realizadas con los cuadernos de campo.

- Revisar el cuaderno de campo y aportar mejoras en base a la experiencia de su puesta en práctica.

- Presentar de forma detallada los indicadores técnicos utilizados en el monitoreo.

- Establecer vínculos entre las prácticas de manejo y los resultados obtenidos con indicadores técnicos a través de análisis de laboratorio.

2. Presentación de las personas participantes

Esta dinámica está pensada para "refrescar" la memoria y presentar a las personas participantes que no han coincidido en talleres previos y, por lo tanto, no se conocen personalmente. La presentación de las personas participantes en el taller se realiza de forma individual a todo el grupo, siguiendo tres pautas con un patrón similar al primer taller: 1) Nombre, 2) De dónde vengo, y 3) Qué prácticas regenerativas utilizo en mi finca.

Objetivo: Presentar a los participantes que aún no se conocen y sus experiencias en agricultura regenerativa

Metodología: Todas las participantes se sientan en círculo y cada una dispone de un par de minutos aproximadamente para presentarse siguiendo las 3 pautas establecidas.

Material: No se precisan materiales

Resultados: Las personas que participamos en el proyecto de monitorización participativa nos presentamos siguiendo las pautas. Muchas de las personas se conocen de talleres previos o de actividades realizadas por AlVelAl. Al finalizar la dinámica y comenzar la siguiente dinámica las participantes se quedan algunos minutos charlando informalmente con las/los compañeros presentes.

Imagen 1 Agricultor y facilitadora del taller durante una charla informal tras la presentación del manejo.

3. Recapitulación del proceso de monitoreo participativo

Con el trascurso del tiempo es conveniente hacer una recapitulación del proceso de investigación y monitorización participativa. Esta recapitulación nos permite ver los principales hitos conseguidos y nos ayuda a establecer metas futuras.

Objetivo: Situar a las participantes en el momento actual de la investigación, haciendo un recorrido sobre los hitos conseguidos y objetivos a alcanzar.

Metodología: Técnica de la línea del tiempo

Material: No se precisan materiales

Resultados: En esta dinámica, la investigadora que facilita el taller, realizó una línea del tiempo, y destacó los eventos más importantes acontecidos desde el inicio de la investigación, entre ellos:

1. Visita a las fincas y selección de las prácticas regenerativas a monitorizar.
2. Taller de indicadores locales
3. Selección de indicadores técnicos y muestreo de suelo en las fincas
4. Taller de cuaderno de campo
5. Recogida de datos de campo

En el momento del taller 3 nos encontramos en la evaluación de las prácticas a través de los resultados obtenidos con indicadores locales y técnicos, y evaluación del cuaderno de campo.

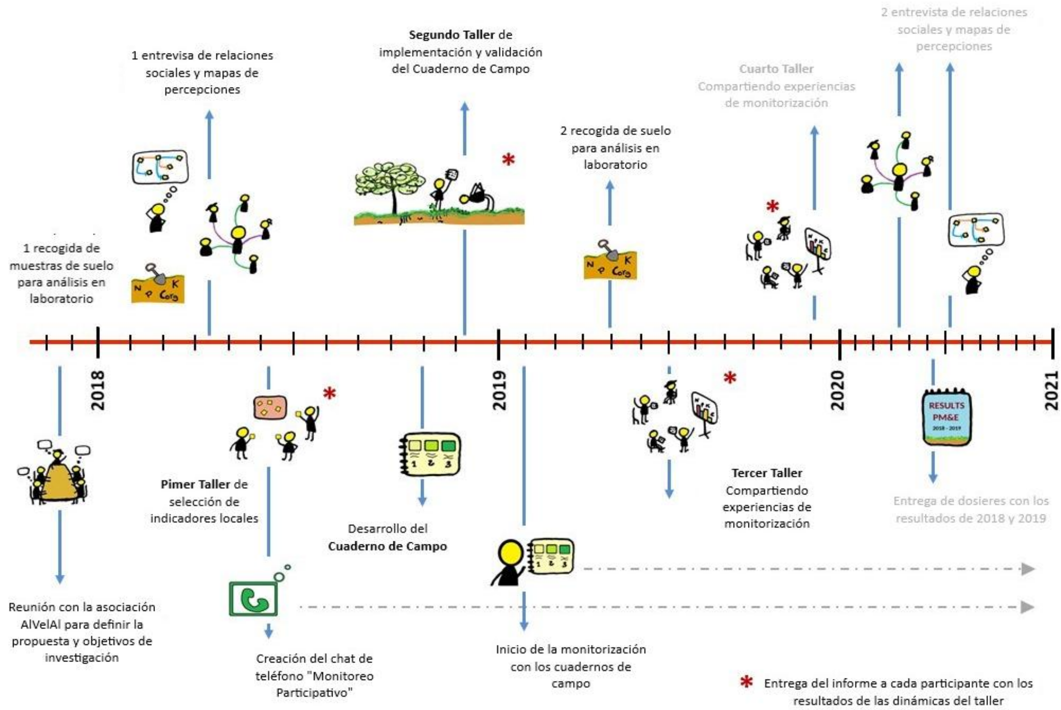


Imagen2 Línea del tiempo situando el taller 3, eventos realizados anteriormente, y eventos futuros.

4. Cambio más significativo

Es esta dinámica se utilizó una variante de la técnica conocida como "el cambio más significativo". Esta técnica permite evaluar intervenciones complejas con un enfoque cualitativo y participativo en el que se evalúa el impacto de las intervenciones de las/los agricultores. Esta técnica facilita la generación de historias de cambio significativas por parte de las/los agricultores que están implementando prácticas regenerativas y registrando los cambios con el Cuaderno de Campo. Cada agricultor/a tiene que seleccionar los cambios más significativos observados durante la monitorización de las prácticas y manejos regenerativos y discutir sobre sus causas. Seguidamente cada agricultor/a tiene que exponer cuáles son los cambios más esperados y, en trabajo grupal, discutir cómo conseguirlos.

Objetivo: Dar a conocer las diferentes prácticas y manejos regenerativos. Compartir los cambios más significativos observados, los cambios que se esperan observar y generar ideas sobre cómo conseguirlos.

Metodología: Generar 1 o 2 grupos en función de las personas. Cada agricultor tiene que escribir su manejo, definir 2 cambios más significativos observados en las parcelas regenerativas. Seguidamente los agricultores tendrán que expresar los cambios que esperan ver en un futuro y compartir, en base a sus experiencias, maneras de cómo conseguir "los cambios más esperados". En las maneras de cómo conseguir dichos cambios cada agricultor ha de empezar con: "A mí me funciona…"

Material: Papelógrafos y rotuladores

Resultados:

Tabla 1 Resultados de la dinámica del cambio más significativo

Finca	Manejo	Cambios observados	Cambios esperados	Como conseguirlos
La Oliverica	Poda anual de almendros variedad guara, 1 o 2 labranzas al año, la primera en abril y la segunda superficial con grada en junio. Aporte de estiércol	Resultados algo mejor que en la parcela convencional. Hay muchas mariquitas.	Retener más humedad y labrar sólo una vez al año. Evitar la erosión.	Con terrazas para evitar la erosión. Labrando sólo una vez. Seguir aportando estiércol y abono verde. Con cubiertas para aportar biomasa al suelo
El Madroño	Aplicación de compost. En enero se da una labranza. En verano dos pases superficiales de rastra para eliminar la vegetación	EL suelo de la parcela regenerativa ha mejorado.	Aplicar un poco más de compost. En la poda de noviembre triturar la poda fina para aplicar al suelo.	Esperando a los resultados que vayan saliendo y las observaciones
Matián	2 labranzas al año poda bianual, aplicación de compost bianual y aporte de restos de poda triturada	Hemos mejorado un poco el suelo con el compost bokashi pero es proceso muy laborioso.	Seguir haciendo varias prácticas regenerativas para saber cuál es la que mejor funciona	Esperando a que los resultados que vayan saliendo y a las observaciones

Cortijo Chirivel-sierra de María	Laboreo superficial 2 o 3 veces al año, dependiendo de las lluvias. Swales por toda la finca. Este año he empezado a implementar abonos verdes	El suelo necesita más materia orgánica. Los swales recogen agua pero algunos están colmatados de sedimentos.	Que vaya mejorando el suelo cada vez más y que ello repercuta en la producción. Los árboles aún son muy jóvenes para ver cambios	Seguir implementando medidas regenerativas. Intentar ampliar el uso de abono verde a más partes de la finca. Intentar labrar menos.
Finca Alamedilla	No laboreo. Cultivo de pistachos. Cubiertas con varias especies leguminosas y cereales. Manejo de las cubiertas con ovejas del pastor vecino. Plantación siguiendo las curvas de nivel	La finca está mucho más bonita. Se recoge mucha agua. Los pistachos están funcionando muy bien y es una posible alternativa para mejorar la economía de la región	Mejorar la biodiversidad y funciones del suelo.	Con el manejo utilizado hasta ahora y tiempo.
Torre Guajar	No laboreo y cubierta natural permanente.	Exceso de temperatura en el suelo Falta de nutrientes	Disminuir la temperatura del suelo y mejorar los nutrientes	Aportar compost con disco (esparcido) y cubrir la totalidad del suelo con cubiertas naturales. Intentar realizar riegos de apoyo por aspersión.
Cortijo de Paco	2 labranzas (una en abril y otra en octubre) Siembra de abono verde (veza, yeros y cebada)	Hay zonas de suelo donde las cubiertas no nacen. En zonas de vaguada La cubierta es más abundante	Mejora de la estructura de la tierra, de la porosidad e incremento de la materia orgánica	Tumbar abono verde o desbrozar para cada vez labrar menos. Tender a introducir cubiertas naturales permanentes.

5. Experiencias de monitoreo con el cuaderno de campo

Los cuadernos de campo son herramientas de fácil uso que permiten hacer un diagnóstico rápido y de forma visual sobre el estado de los suelos y agroecosistemas. Existen múltiples herramientas, como tarjetas, cuadernos, cartillas, y aplicaciones móviles que permiten hacer un diagnóstico rápido del suelo. A pesar de la facilidad de su uso, es necesaria cierta práctica previa para una correcta implementación. Además, el uso continuado de estas herramientas, hace que el diagnóstico cada vez sea más preciso por parte del usuario o usuaria. La adopción de estas herramientas por parte de los agricultores puede ser variable dependiendo de muchos factores. Para mejorar su adopción es necesario que estas herramientas se ajusten a las necesidades y objetivos de las personas usuarias. Es por ello imprescindible saber sus opiniones sobre la herramienta en uso, sus dificultades en implementarla, la utilidad que le ven, así como sugerencias de mejora.

Objetivo: Impulsar la adopción del cuaderno de campo por parte de las participantes

Metodología: Se le pide a cada participante que comparta:

- Si tiene dudas sobre cómo utilizarlo, si por el momento les parece útil, y si hay indicadores que necesitan ser modificados o añadidos de forma.

Material: papelógrafos y rotuladores

que permita registrar los "cambios más significativos" o "los cambios más esperados".

Resultados: Las agricultoras/es que han traído sus cuadernos muestran los resultados recogidos. La facilitadora observa si las anotaciones se han hecho correctamente y se procede a resolver las dudas planteadas. Algunas personas realizaron únicamente la evaluación d la parcela regenerativa y no de la convencional. Se remarca la importancia de hacer las mediciones en una parcela sin prácticas regenerativas para tenerla como referencia y poder medir mejor las mejoras que genera implementar agricultura regenerativa.

Tabla 2 Percepciones de las agricultoras y agricultores sobre el cuaderno de campo

Dudas	Utilidad	Modificaciones/adaptaciones
¿Cada cuándo es necesario usar el cuaderno de campo?	*Medir la temperatura es un indicador interesante para ver el efecto de protección de las cubiertas.*	*A veces es difícil llevar al campo y hacer anotaciones si tienes trabajo que hacer. Hacemos las observaciones aunque no las anotemos.*
¿Cómo realizamos las medidas de temperatura?	*Ayuda a ver el suelo de forma diferente.*	*Sería interesante añadir una sección con recomendaciones para mejorar los indicadores*
El color del suelo varía mucho con la humedad. Puede ser confuso.		

6. Presentación de indicadores técnicos

Para poder realizar intercambios de información técnica y local entre investigadoras/es y agricultoras/es de forma fluida es necesario generar un lenguaje común a todas las partes participantes en la investigación. El lenguaje técnico que se utiliza en el ámbito científico raramente llega al público al que se destina o del que se pretende un cambio. Para ello es necesario explicar en detalle y con un lenguaje inclusivo, la información que nos ofrece cada indicador.

Objetivo: Que agricultoras/es se familiaricen con los indicadores técnicos para facilitar una mejor comprensión de los análisis de suelo.

Metodología: Explicación de cada indicador utilizando apoyo visual.

Material: Fichas visuales de cada indicador.

Resultados: La facilitadora del taller fue explicando uno a uno cada indicador con el apoyo visual de una ficha que representaba gráficamente algún aspecto o función que se analiza con dicho indicador. Agricultoras/es fueron preguntando y resolviendo sus dudas sobre cada indicador. Se generaron debates sobre los siguientes aspectos:

-**pH:** Se habla sobre como condiciona el pH la disponibilidad de nutrientes en algunas de las fincas. Se discute sobre cómo se puede bajar el pH a través de prácticas de manejo porque en la mayoría de las fincas el pH es superior a 8.0. Un agricultor comenta que él solía tener problemas de clorosis férrica ya que aunque sus suelo tienen alto contenido en hierro, debido al pH alto del suelo, las plantas eran incapaces de asimilarlo porque el elemento no estaba disponible. Al aumentar la cantidad de materia orgánica al suelo mediante la utilización de cubiertas naturales, aportes de compost y no laboreo había conseguido eliminar el problema de clorosis férrica.

- **Salinidad:** Algunos agricultores comentan que la salinidad no es un gran problema en sus fincas ya que no utilizan riego ni fertilizantes químicos. Los agricultores que utilizan compost expresan que en los análisis químicos los valores están dentro de niveles considerados bajos.

- **Carbono orgánico del suelo:** Se habla directamente de materia orgánica y se comenta que aunque todas saben de su importancia, incrementar su contenido en los suelos es uno de los mayores retos debido a la dificultad de generar biomasa con el clima característico de la región, ya que las lluvias son muy escasas y concentradas en el tiempo.

- **Nutrientes del suelo y foliares:** Se relacionan los nutrientes del suelo con el aspecto físico de los árboles. Se habla de la importancia de medir el escandallo a parte de saber el estado nutricional de los árboles. Medir la producción se considera muy importante para poder fomentar el uso de prácticas regenerativas.

7. Conectando manejo, indicadores técnicos y locales

Los cambios visibles en la mejora de la calidad del suelo debido a cambios de manejo suelen tardar tiempo en aparecer, especialmente en regiones de climas áridos y semiáridos. En estas regiones la escasez de lluvias limita la actividad microbiana del suelo, ralentizando múltiples de sus funciones, así como la producción de biomasa. Es por ello que la monitorización participativa en estos climas cobra una gran importancia en los procesos de restauración de agroecosistemas, ya que permite aunar conocimientos científicos y locales e incrementar el conocimiento sobre los impactos de distintos tipos de manejos y practicas regenerativas para así optimizar y maximizar los esfuerzos de la comunidad agrícola.

Objetivo: Facilitar la integración y relacionar el manejo de los agroecosistemas de estudio con las observaciones realizadas por agricultoras/es y los análisis fisicoquímicos realizados por el equipo científico en laboratorio, así como validar y contrastar ambos tipos de datos.

Metodología: se forman 1 o 2 grupos de agricultoras/es acompañados de una facilitadora por grupo para ayudar en la interpretación de indicadores técnicos de calidad de suelo y facilitar su relacionamiento con el manejo regenerativo y con las observaciones recogidas en los cuadernos de campo. Otras observaciones realizadas por las participantes, aunque no hayan sido sistematizadas en los cuadernos, son bienvenidas para la discusión de resultados.

Material: Informes individuales con los resultados de los análisis fisicoquímicos realizados en 2018. Fichas con apoyo visual sobre indicadores técnicos. Cuadernos de campo.

Resultados: Las/os agricultores proponen repasar uno a uno cada indicador técnico de calidad del suelo y que cada persona comente como han salido los resultados en su parcela regenerativa y convencional. Dimos a cada agricultor/a su análisis fisicoquímico y procedimos a realizar la dinámica de la forma propuesta. Además, se propuso vincular los resultados obtenidos en los análisis con el tipo de manejo que realizó cada agricultor/a y con las observaciones realizadas en campo.

Algunas de los puntos más relevantes que surgieron en esta dinámica fueron los siguientes:

- **Queda mucho por mejorar.** En muchos de los análisis los resultados d las parcelas regenerativas no fueron mucho mejor que las parcelas convencionales. Se comenta que para que las mejoras alcancen los resultados deseados es necesario realizar un manejo regenerativo durante años. Los resultados no son concebidos como negativos, sino como un aliciente para seguir implementando manejos regenerativos y seguir mejorando la calidad del suelo.

- **Leguminosas de cubiertas verdes.** Los agricultores comentan que algunos abonos verdes funcionan mejores que otros. Un agricultor que ha probado diferentes tipos de leguminosa comenta que prefiere la veza (*Vicia sativa*) a los yeros (*Vicia ervilia*) ya que produce mayor biomasa, pero su coste económico es también mayor. Ha observado que los carretones (*Medicago polymorpha*) que nacen de forma espontánea en su finca, generan una cubierta densa y que no alcanza mucho tamaño, por lo que toda la superficie del suelo queda cubierta y no dificulta las labores culturales en la finca, como la poda o recogida de la almendra.

- **Compost y otras enmiendas orgánicas:** Las participantes comentan el tipo de enmienda orgánica que utilizan en sus fincas. Estas dependen del precio, de la distancia de transporte a la finca y de la mano de obra. Se comenta que el compost bokashi, a pesar de tener una calidad muy buena, requiere mucho trabajo ya que tiene que voltearse dos veces al día y requiere de una persona estar con el tractor y la pala para realizar esta operación. El estiércol de oveja y de cabra no es tan bueno, pero suele conseguirse con facilidad del propio agricultor, pastores vecinos o agricultores con ganado. Otros tipos de enmienda orgánica como los abonos orgánicos en forma de pellet (5N, 5P, 5K) son fáciles de transportar y esparcir por la finca, aunque su efecto fertilizante y de generación de materia orgánica es mucho menor que otras enmiendas orgánicas.

- **Aperos para el manejo de cubiertas.** Se habla de las diferentes maquinarias y aperos para incorporar las manejar los abonos verdes y cubiertas naturales. Algunos agricultores prefieren la desbrozadora de cadena a la de martillos, ya que con la desbrozadora de martillos se quedan marcas de compactación del suelo al paso de la desbrozadora y volatiliza más la materia orgánica al triturarla en partes más pequeñas que la de cadenas. Un agricultor habla del roller crimper como apero alternativo al desbroce para el manejo de cubiertas permanentes con no laboreo.

- **¿Es posible implementar todas las prácticas en todas las fincas?** Se genera el debate sobre si es posible aplicar todas las prácticas y manejos regenerativos en todas las fincas. Se llega a la conclusión de que dependiendo de las condiciones biofísicas y climáticas de cada finca algunas prácticas y manejos regenerativos pueden ser más convenientes que otros.

- **Poda:** Triturar e incorporar la poda del almendro como acolchado del suelo se ve positivo de forma generalizada. Sin embargo, algunos agricultores que no tienen forma de triturar los restos de poda prefieren quemar esas ramas antes de dejarla entera en el suelo ya que puede atraer plagas como el barrenillo. Este punto abre la discusión sobre la necesidad de aperos y maquinarias, y sobre la ventaja de poder tener un banco colectivo de herramientas, maquinaria y aperos.

Anexo 1: Agenda del taller

10.00 - 10.30 Presentación del taller y de los participantes.

10.30 - 11.00 Recapitulación del proceso de monitorización participativa

10.30 - 12.00 Cambio más significativo. Prácticas de manejo y resultados observados a través de indicadores locales de calidad de suelo.

12.00 - 12.30 Almuerzo

12.30 – 13.00 Compartiendo experiencias de monitoreo con el Cuaderno de campo

13.00 – 13.20 Presentación de indicadores técnicos de calidad de suelo

13.20- 14.30 Conectando manejo, indicadores técnicos y locales

14.30 - 16.30 Comida

Anexo 2: Ejemplo de informe de análisis fisicoquímico

Agricultora: MANUELA GARCÍA LOPEZ		**Parcelas**	
INDICADORES	**Información**	**Regenerativa**	**Convencional**
Propiedades Físicas			
Densidad Aparente (g/cm3)	Compactación del suelo	0,95	1,27
Estabilidad de agregados (mm)	Resistencia a la erosión	0,96	0,72
Propiedades Químicas			
pH	Alcalinidad o acidez del suelo	8,48	8,83
Conductividad (µS/cm)	Sales	198	120
Nutrientes			
Nitrógeno Total (N) (%)	Crecimiento árbol y fotosíntesis	0,12	0,09
Potasio Total (K) (ppm)	Formación de yemas y llenado de almendra	7125	4576
Fósforo Total (P) (ppm)	Maduración de flores y fruto	258	256
Fósforo disponible (P) (ppm)	Disponible para las plantas	23,80	23,90
Relación Carbono - Nitrógeno	Disponibilidad de Nitrógeno - Fertilidad	10,45	9,86
Carbonatos Cálcicos (%)	Forma activa - clorosis férrica	85,09	99,51
Materia Orgánica			
Materia orgánica (%)	Despensa de nutrientes	1,23	0,85
Carbono de la Mat. Orgánica (%)	Calidad de la materia orgánica	3,54	1,13
Nitrógeno de la Mat. Orgánica (%)	Calidad de la materia orgánica	0,83	0,25
Cationes intercambiables			
Sodio (ppm)	Fertilidad	52	51
Potasio (ppm)	Fertilidad	521	218
Magnesio (ppm)	Fertilidad	89	49
Calcio (ppm)	Fertilidad	2033	1892
Nutrientes Foliares			
Nitrógeno foliar (N) (%)	En deficiencia las hojas pierden verdor y amarillean	3,03	2,73
Fósforo foliar (P) (%)	En deficiencia las hojas oscurecen o son purpuras	0,24	0,24
Potasio foliar (K) (%)	En deficiencia se quema y arruga el borde de la hoja	1,23	1,33

NIVELES DE REFERENCIA

TABLAS PARA LA INTERPRETACIÓN DE RESULTADOS

Tabla 1 Parámetros físico químicos y niveles de referencia en suelos agrícolas				
Parámetro	**Interpretación**	**NIVEL**		
		Bajo	**Medio**	**Alto**
PROPIEDADES FÍSICAS				
Densidad Aparente	Mejor niveles medios	< 0,7	0,7 – 1,3	> 1,4
Estabilidad de agregados	Mejor niveles altos	-	-	-
PROPIEDADES QUÍMICAS				
pH	Mejor entre 7,0 y 8,5	< 5,5	5,5 – 8,4	> 8,4
Conductividad	Mejor niveles medios		< 500	> 500
Nutrientes				
Nitrógeno Total	Mejor niveles medios o medios altos	0,06 – 0,10	0,11 – 0,20	0,21 – 0,40
Potasio Total (K)	-	-	-	-
Fósforo Total (P)	-	-	-	-
Fósforo disponible (P)	Mejor niveles altos	< 9	10 – 17	> 18
Relación Carbono-Nitrógeno	Mejor niveles medios	< 10	10 – 12	> 12
Carbonatos cálcicos	Suelos calcáreos son siempre altos	5 – 10	10 – 20	> 20
Materia orgánica				
Materia orgánica (%)	Mejor niveles altos	1 – 1,9	2 – 2,5	2,5 – 3
Carbono de la Mat. Orgánica (%)	Mejor niveles altos	-	-	-
Nitrógeno de la Mat. Orgánica (%)	Mejor niveles altos	-	-	-
Cationes intercambiables				
Sodio (ppm)	Mejor niveles medios	-	< 90	> 90
Potasio (ppm)	Mejor niveles altos	50 – 100	100 – 175	175 – 300
Calcio (ppm)	Mejor niveles altos	500 – 1000	1000 – 1600	1600 – 2400
Magnesio (ppm)	Mejor niveles altos	20 – 40	40 – 80	80 – 180
Nutrientes Foliares				
Nitrógeno foliar (N) (%)	Mejor niveles medios	< 2	> 2	-
Fósforo foliar (P) (%)	Mejor niveles medios	< 0,1	0,1 – 0,3	-
Potasio foliar (K) (%)	Mejor niveles medios	< 1	> 1	-

- La información contenida en las tablas 1 y 2 ha sido extraída del Manual del Almendro publicado por la Junta de Andalucía (2013), a excepción de los parámetros marcados con asterisco (*)

- La información recogida en la tabla 3 son niveles de referencia mínimos y máximos establecidos por Bowie & Thornton (1985), Schachtschabel et al. 1992, y por Normativas Europeas para la no intervención por suelos contaminados.

INFORMACIÓN PARA INTERPRETAR LOS ANÁLISIS QUÍMICOS DEL SUELO

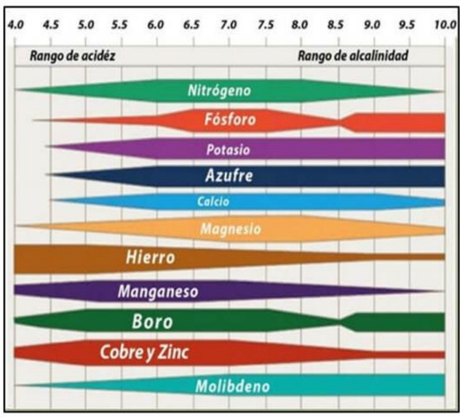
• DENSIDAD APARENTE (Compactación)

Nos informa sobre el nivel de compactación del suelo**.** Los suelos agrícolas suelen tener una densidad aparente **entre 0,7 y 1,3 (g/cm³)** lo que está dentro de valores que llamaríamos **normales. Valores por encima de 1,6** (g/cm³) son indicativos de **suelos compactados**, en los que se pueden ocasionar problemas de crecimiento en las raíces de nuestros cultivos. **La estructura** del suelo **está relacionada con la densidad aparente**. Los suelos con buena estructura tienen niveles más bajos de densidad aparente, y los suelos compactados y tienen niveles más altos de densidad.

• PH (SUELOS ÁCIDOS O BÁSICOS)

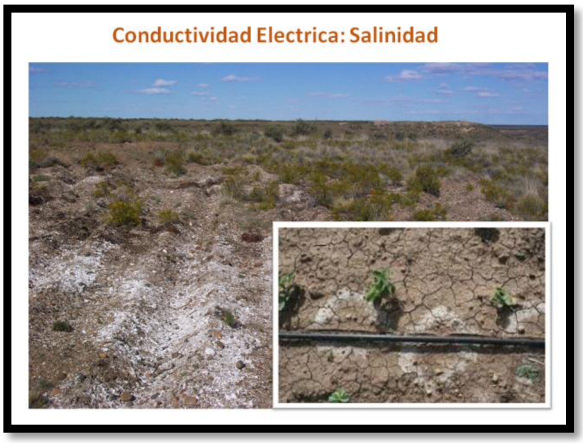
Nos informa sobre si los **suelos son ácidos o básicos**. El pH del suelo suele estar entre **5,5** (suelos más **ácidos**) y **8,4** (suelos **básicos o calcáreos**). El tipo de roca que forma nuestros suelos tiene una gran influencia en el pH del suelo. Los suelos calizos, como es el caso de la mayoría de suelos de AlVelAl, tienen pH altos, entre 7,5 y 8,5. El pH influye en la disponibilidad de nutrientes, es decir, en suelos muy ácidos o muy básicos, aunque tengamos nutrientes presentes en el suelo, estos pueden quedar retenidos en el suelo y las plantas no pueden acceder a ellos. Incrementar los niveles de materia orgánica ayuda a regular el pH y favorece que los nutrientes queden disponibles para las plantas.

pH: Disponibilidad de nutrientes



• CONDUCTIVIDAD (Salinidad)

Se refiere al nivel de salinidad del suelo. La conductividad es buena para la mayoría de cultivos con niveles menores a 500 micro siemens (salinidad baja). Las sales en el suelo tienen pueden están por origen natural, por ejemplo, las sales propias del suelo, el aporte de sales por el agua de lluvia, etc. Los humanos también aportamos sales al suelo, por el agua de riego y por los fertilizantes minerales. Los fertilizantes químicos son sales, por lo que su uso indiscriminado puede crear problemas de salinidad en el suelo. Si la salinidad es muy alta, nuestros cultivos tendrán problemas para tomar agua pro sus raíces, viéndose afectada nuestra producción.



• MATERIA ORGÁNICA

Se puede considerar la despensa de macro y micronutrientes del suelo. La materia orgánica además es importantísima porque desempeña múltiples funciones. Contribuye a mejorar la salud y el crecimiento de los cultivos, mejora la estructura del suelo, incrementa la infiltración de agua y alberga la mayor parte de la vida en el suelo que se encarga del reciclado de nutrientes, entre otras. Niveles de materia orgánica por debajo del 2% suelen considerarse bajos, entre el 2% y el 2,5% son niveles medios, y más del 2,5% son niveles altos. Conseguir niveles altos de materia orgánica en nuestro suelo es muy recomendable.

• RELACIÓN CARBONO/NITRÓGENO (C/N)

Se refiere a la relación entre carbono y nitrógeno que hay en el suelo. Los valores por debajo de 10 significan que tenemos menos carbono y más nitrógeno disponible para las plantas. Los valores por encima de 12 indican que tenemos mucho carbono y poco nitrógeno disponible para las plantas. En general, es conveniente tener un equilibrio entre carbono y nitrógeno, entre 10 y 12, aunque esto puede variar, dependiendo de la época del año.

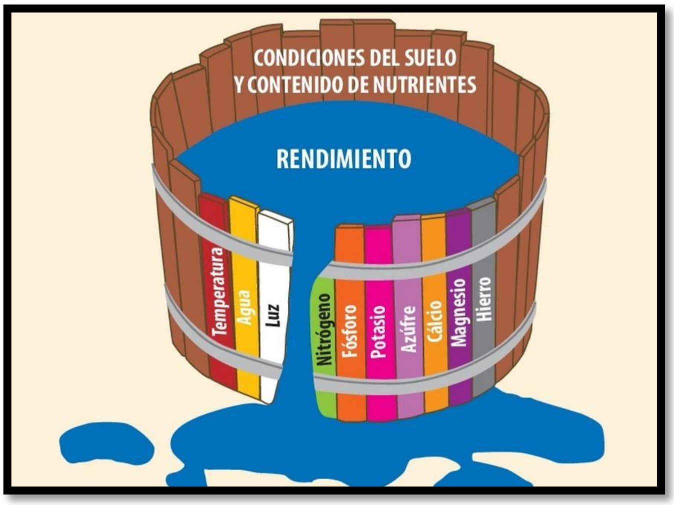
En primavera, momento de crecimiento vegetativo del árbol, la planta demanda mucho nitrógeno para la creación de ramas, frutos y hojas, por lo que deberemos asegurarnos de que disponen de nitrógeno suficiente y valores bajos en la relación C/N, es decir, menos carbono y más nitrógeno, serán más deseables. Si no realizamos aportes extra de nutrientes hasta el otoño, es normal que conforme la planta va tomando nitrógeno, los valores de C/N vayan siendo más altos, es decir, que vaya consumiéndose el nitrógeno con el tiempo, y predomine el carbono. En otoño, con el aporte de compost, estiércol o cubiertas ricas en leguminosas, aumentaremos el contenido de Nitrógeno y la relación C/N volverá a bajar, teniendo nuevamente nitrógeno disponible para el nuevo periodo. Los restos de poda, la paja de cereal, y otros materiales leñosos, tienen mayor proporción de carbono que de nitrógeno. El estiércol, los purines y las cubiertas ricas en leguminosas, son más ricos en nitrógeno. Por ello, un aporte equilibrado de carbono y nitrógeno lo encontramos en cubiertas que incluyen gramíneas naturales o sembradas, como los cereales, y leguminosas (mielgas, yeros, trébol…), y en otras posibles combinaciones de residuos orgánicos ricos en carbono, y ricos en nitrógeno.

• **CARBONATOS CÁLCICOS ($CaCO_3$)**

Es otra forma de llamar a la caliza, por lo que los suelos calcáreos tienen niveles altos. En su forma activa, el exceso de calcio provoca que las plantas no puedan absorber hierro, que es un micronutriente esencial para el cultivo, dando lugar a problemas de clorosis férrica que se observa en el amarilleamiento de las hojas del árbol. Cuando el pH del suelo es alto, mayor a 8,5, también se favorece la aparición de clorosis férrica. Aumentar el contenido en materia orgánica disminuye los valores de pH y ayudara a corregir los problemas de clorosis férrica.

• **MACRONUTRIENTES Y MICRONUTRIENTES**

La cantidad de nutrientes que contiene el suelo va a determinar su potencial para alimentar a los cultivos. Macronutrientes y micronutrientes **son igual de importantes para el crecimiento, nutrición y buen desarrollo de las plantas**. La única diferencia entre ellos es que los macronutrientes son tomados en mayor cantidad que los micronutrientes. La falta de alguno de ellos, aunque los demás nutrientes estén presentes, pueden afectar al crecimiento y desarrollo de la planta (se nos sales el agua del bidón). Cada macronutriente, y cada micronutriente, desempeña una función diferente en la planta.



• MACRONUTRIENTES

NITRÓGENO (N)

El nitrógeno interviene en el **crecimiento de árbol y en la fotosíntesis**, vital para la respiración y nutrición de las plantas. Si el suelo aporta suficientes cantidades de nitrógeno al árbol, estos crecerán correctamente y las hojas tendrán **color verde intenso.** Si los árboles no pueden tomar del suelo en nitrógeno que necesitan, las hojas tendrán **colores verdes pálidas y amarillentos, y se paraliza el crecimiento del árbol.** Por ello es recomendable evitar los niveles bajos de nitrógeno, por debajo del 2%. Por encima del 3% pueden producirse problemas por la proliferación de hongos.

FÓSFORO (P)

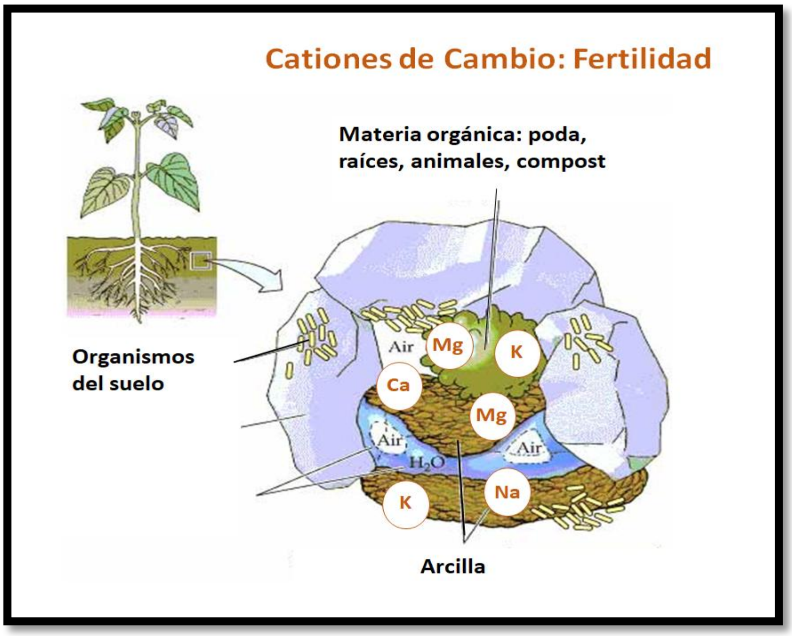
El fósforo forma parte de la estructura del árbol. **El fósforo ayuda a la maduración de las flores y los frutos, y al desarrollo de raíces**. Su escasez está relacionada con el cansancio del suelo. Su **carencia** provoca que las **hojas tomen colores verdes oscuros apagados y tonos purpura,** además de provocar una escasa floración y fructificación. La materia orgánica y las micorrizas son muy importantes para asegurarnos de que nuestros árboles están bien nutridos, ya que la materia orgánica aporta fósforo y las micorrizas contribuyen a su absorción por el árbol. Los niveles adecuados han de estar entre 0,1 y 0,3 %.

POTASIO (K)

Se encuentra de forma natural en el suelo y podemos aumentarlo con materia orgánica rica en este elemento. El potasio interviene en el llenado de la almendra, por lo que su deficiencia afecta a la producción. Por el contrario, arboles con aportes suficientes en potasio tendrán mayor floración y formarán tejidos más resistentes a plagas, sequías y heladas. Su deficiencia se observa en la punta y bordes de las hojas que se secan después de haber amarilleado. Los niveles de potasio no deben de estar por debajo del 1% y se recomiendan niveles entre 1 y 1,4 %.

• LOS CATIONES DE CAMBIO (FERTILIDAD)

Los cationes de cambio están relacionados con la fertilidad: **son el Potasio (K), el Sodio (Na), el Magnesio (Mg) y el Calcio (Ca)**. Los niveles altos en cationes de cambio están relacionados con suelos con altos contenidos en arcilla y/o en materia orgánica. **Niveles altos en cationes de cambio les da a los suelos mayor capacidad para retener nutrientes**, es decir, los hace más fértiles. En general no suelen haber deficiencias en Magnesio y Calcio.



Sodio (Na): El sodio está relacionado con **la expansión y contracción de las arcillas en el suelo** que se observa pro la **formación de grandes grietas en el suelo cuando este se seca.** Si los valores se encuentran **por encima de 90 ppm, podemos tener problemas** de expansión y contracción de suelos, que no permitan la infiltración de agua y que impidan el correcto crecimiento de raíces.

MICRONUTRIENTES

Los micronutrientes más importantes son: Boro (B), Zinc (Zn), Hierro (Fe), Cobre (Cu), Manganeso (Mn) y Molibdeno (Mo). **Son esenciales en pequeñas cantidades, pero en grandes cantidades pueden ser tóxicos,** además **el rango entre necesidad y toxicidad es muy pequeño**. Hay dos cosas a tener en cuenta con los micronutrientes:

1) Es la cantidad que tenemos en nuestro suelo, que es consecuencia del tipo de roca formadora (caliza, pizarra) y que **no podemos modificar** con el manejo, y
2) Es la cantidad en qué están disponibles para las plantas, **que si podemos mejorar con el manejo**. La disponibilidad está condicionada en gran medida por el pH. Por ello la materia orgánica tiene una influencia importantísima, porque además de regular el pH, es una reserva de

nutrientes, e influye en la disponibilidad de estos micronutrientes para los cultivos. Incrementando los niveles de materia orgánica estaremos mejorando la disponibilidad de estos micronutrientes para los cultivos.

Los resultados de los análisis muestran la cantidad en el suelo. A continuación, se ofrece una explicación breve de la función de cada elemento en la planta.

Boro (B): El boro es un micronutriente esencial para el crecimiento de las plantas y desempeña una función **esencial en la polinización y cuaje de los frutos**. El Boro mejora el tamaño y la fertilidad de los granos de polen, por lo que los polinizadores pueden sentirse más atraídos y visitar más las flores de los almendros con suficiente Boro. Si el Boro es deficiente podremos observar una abundante caída de frutos en el inicio del verano, las hojas jóvenes se deforman, son más pequeñas y curvadas y se ondulan hacia arriba.

Hierro (Fe): El hierro interviene en la fotosíntesis, por lo que su carencia a afecta a la producción y se puede observar en el amarilleamiento de las hojas del almendro, lo que se conoce como clorosis férrica. La mayoría de suelos suelen tener grandes reservas de hierro, el problema es que su disponibilidad para los cultivos es limitada en suelos con pH alto, mayores a 8.5, como es el caso de la mayoría de casos de los suelos de AlVelAl. Incrementar los niveles de materia orgánica ayuda a reducir el pH y mejora la solubilidad del hierro para que esté disponible para los cultivos.

Zinc (Zn): EL zinc, como el boro, también interviene en la cuaja del fruto, así como en su maduración y en la producción de semillas. Al igual que el boro, también favorece en la formación y la fertilidad del polen. Su deficiencia provoca que las hojas crezcan pequeñas y estrechas, o en forma de roseta. Además, se puede producir mal desarrollo de frutos, y aparición de clorosis invernal.

Cobre (Cu) y Manganeso (Mn): Son también esenciales para el buen desarrollo del almendro. Su carencia provoca efectos similares a los de la falta de hierro, es decir, fenómenos de clorosis que afectarán al rendimiento. La falta de manganeso provoca la caída prematura de las hojas.

Molibdeno (Mo): Sus carencias se asemejan a los síntomas de la falta de nitrógeno, con hojas de colores verdes pálidos y amarillentos.

CUARTO TALLER PARTICIPATIVO

COMPARTIENDO EXPERIENCIAS DE MONITORIZACIÓN EN AGRICULTURA REGENERATIVA

Informe del cuarto taller participativo desarrollado en el cortijo Ciruelos Altos, comarca de los Vélez, Almería

Autora: **Raquel Luján Soto**

Este Informe forma parte del proyecto de doctorado "Monitorización y Evaluación Participativa en Agricultura Regenerativa: del conocimiento y los impactos locales a la adopción a gran escala". Este proyecto cuenta con el apoyo de la Fundación "la Caixa" (LCF/BQ/ES17/11600008), (ID 100010434)

Viernes 6 de diciembre de 2019

Centro de Edafología y Biología Aplicada del Segura (CEBAS-CSIC)

Instituto de Sociología y Estudios Campesinos – Universidad de Córdoba (ISEC-UCO)

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1. Introducción

Esta investigación tiene como eje vertebral la monitorización participativa de diferentes prácticas regenerativas implementadas en el territorio AlVelAl. La monitorización participativa es un método de investigación colaborativo donde, agricultoras y agricultores junto con investigadoras e investigadores, recogemos conjuntamente información sobre el impacto de diferentes prácticas regenerativas sobre la mejora de la calidad del suelo. La monitorización participativa tiene como gran ventaja que permite aunar conocimiento local y científico, aportando información detallada sobre el funcionamiento de los agroecosistemas, y permite contrastar observaciones de campo con datos técnicos. Además de proporcionar información de alta calidad, la monitorización participativa mejora el conocimiento individual y comunitario sobre la agricultura regenerativa, aumentando la conciencia social y contribuyendo a impulsar la adopción de prácticas regenerativas en el entorno local.

Monitorizar los impactos observados y anotar los resultados tanto en el cuaderno de campo como a través de análisis fisicoquímicos y biológicos de suelo, nos permite tener un registro sobre el estado de nuestros suelos al que podemos volver cada vez que queramos y ver los avances realizados, es decir, ver dónde estábamos y dónde estamos ahora.

Necesitamos saber dónde estábamos y comparar con el estado actual, para saber si los cambios en la calidad del suelo y de nuestros agroecosistemas se están dando en la dirección hacia donde queremos que se den. Por ello, anotar los resultados y recogerlos de forma sistematizada es importantísimo, especialmente cuando estamos juntos en un grupo, ya que servirá para compartir los resultados en el grupo y generar una memoria común. Documentar los cambios observados es muy útil para nosotros mismos, pero también para compartir los resultados con otros agricultores o grupos de persona con interés en el tema. Por ejemplo, para optar a proyectos que apoyen modelos de agricultura sostenible también necesitamos tener una buena documentación. Una monitorización frecuente nos permite además detectar rápidamente los avances obtenidos, así como detectar si hay cambios en la dirección equivocada y tomar medidas para solventarlos.

Este cuarto taller forma parte del proyecto de doctorado titulado "Monitorización y Evaluación Participativa en Agricultura Regenerativa". En este proyecto la investigación participativa es considerada esencial para tender puentes y crear sinergias entre la amplia experiencia y el incalculable conocimiento de las agricultoras sobre sus agroecosistemas, y el conocimiento y experiencia científico-técnico de las investigadoras.

En este cuarto taller participativo compartiremos las experiencias de manejo regenerativo y los resultados obtenidos de la monitorización participativa durante el año 2019, a través de indicadores locales recogidos en el cuaderno de campo, e indicadores técnicos que incluyen propiedades físico químicas y biológicas del suelo, obtenidos mediante análisis de laboratorio.

2. Bienvenida y presentación de los objetivos del taller

Se recibe a las participantes al taller y se pregunta individualmente cómo ha ido la temporada y la cosecha. En grupo se hace una recapitulación de los talleres anteriores y se ubica este cuarto taller en una línea del tiempo imaginaria, para visualizar dónde estamos en el proceso de monitorización participativa. Se presenta la estructura del taller, las dinámicas a realizar durante la mañana y los objetivos a alcanzar durante el taller.

• Objetivos del taller:

- Compartir como han ido los manejos regenerativos desde el último taller.
- Intercambiar los resultados recogidos en los cuadernos de campo y en los análisis de suelo del año 2019.
- Establecer objetivos y acciones futuras.
- Recoger propuestas que permitan mejorar la adopción de los cuadernos en la rutina de las participantes.

Material: Papelógrafo

Imagen 1 Presentación de la estructura y ejercicios a desarrollar durante el taller

3. Devolución de resultados de los análisis de suelo de 2019

Los análisis fisicoquímicos de suelo nos aportan información puntual sobre el estado físico y químico de nuestros suelos. Estos análisis aportan datos que nos permiten contrastar los resultados de las observaciones recogidas en los cuadernos de campo y pueden ayudarnos a entender mejor el impacto de las prácticas regenerativas que estemos implementando. Del mismo modo, podeos contrastar los diferentes tipos de manejo, con las observaciones realizadas en campo y los resultados obtenidos en los análisis fisicoquímicos. De esta forma podremos entender mejor los posibles procesos que se están controlando/fomentando gracias a la implementación de dichas prácticas, como puede ser el control de escorrentía superficial y de pérdida de suelo.

Para ayudar a una mejor compresión de los resultados, los análisis fisicoquímicos son presentados en forma de informe en el que se muestran 2 tablas. En la primera tabla se presentan los resultados obtenidos por cada indicador (propiedad del suelo) en la parcela regenerativa en estudio, y en la parcela convencional usada como parcela control. En la segunda tabla, se presentan valores de referencia para estados de calidad bajo, medio y alto del suelo. Acompañando a esta segunda tabla se adjunta un pequeño dossier con información sobre cada indicador analizado y una foto que sirve de referencia visual.

Objetivo: Contrastar los resultados observados por los agricultores con los resultados obtenidos en los análisis de suelo y ofrecer propuestas para la mejora de resultados.

Metodología: Metodología grupal en el que cada agricultor tiene su informe. La facilitadora, con la ayuda visual de una ficha que representa a cada indicador técnico (Anexo 1), presenta un indicador, la información que nos aporta y su importancia. Seguidamente todos los agricultores van a la tabla de resultados y vamos comentando uno por uno los resultados

Material: Fichas plastificadas con indicadores técnicos, informes de análisis fisicoquímicos individuales y dosieres para ayudar a interpretar los resultados.

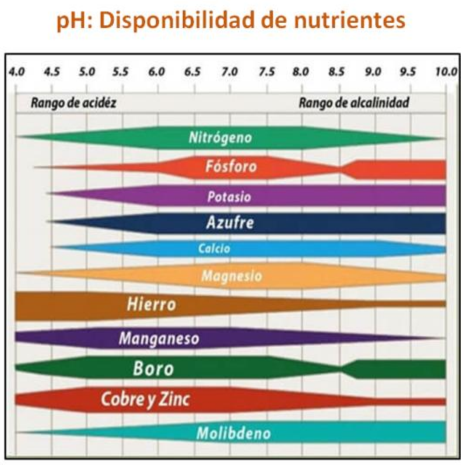

Imagen 2 Ejemplo de ficha utilizada como soporte visual para explicar el indicador pH

Resultados:

Durante esta dinámica las y los agricultores destacaron los siguientes puntos.

- **Importancia de los indicadores:** Se habla de la relación que tienen la mayoria de indicadores con la materia orgánica y que, por lo tanto, a través de incrementar los niveles en materia orgánica se pueden mejorar los resultados de muchos de los indicadores.

- **Nutrientes foliares y producción:** Se discute sobre la relación entre las mejoras en calidad de suelo y cómo puede repercutir esto a la producción de la almendra. Se comenta la variedad de factores, más alla del manejo, que repercuten en la cosecha. Varios agricultores comentan la importancia de generar buenos suelos como un seguro de producción a largo plazo.

- **Manejo:** Se comenta que además del tipo de práctica regenerativa que se emplee, un buen manejo es lo que va a determinar la eficiencia de dicha práctica en la mejora de la calidad del suelo. Es decir, no es sólo implementar un abono verde, sino tambien saber que densidad de semillas usar, que especies, cúando incorporar el abono verde al suelo, que apero utilizar, etc… Un agricultor comenta: "Lo importante es el manejo, no la práctica".

- **Comparación entre fincas:** Hay indicadores en el que los resultados son muy dispares entre fincas, como puede ser el contenido en carbonatos cálcicos. Por ello las y los agricultores señalan la importancia de que las comparaciones se hagan entre la parcela regenerativa y la control y no entre fincas, debido a la gran diversidad de suelos y condiciones biofísicas de las fincas.

- **Realización de análisis en el futuro:** Se señala la importancia de continuar realizando análisis en un futuro ya que la variación interanual entre los valores de los indicadores es muy grande y sólo realizando más análisis se podrán ver tendencias generales.

4. Visita a parcelas regenerativas

Las visitas grupales a las parcelas regenerativas permiten realizar observaciones sobre la calidad del suelo in situ. Además, a través del intercambio de observaciones entre las personas participantes de la visita, se generan discusiones con múltiples enfoques y niveles de experiencia sobre el impacto del manejo actual y de posibles manejos futuros. Del mismo modo, la visita permite realizar un estudio visual del paisaje y entender diferentes procesos que se pueden generar o fomentar debido al manejo de las prácticas implementadas.

Objetivo: Conocer la experiencia regenerativa de la finca que acoge el taller y poner en práctica el cuaderno nuevamente para aclarar posibles dudas.

Metodología: Se realiza una visita grupal a la finca. La agricultora cuya experiencia se está visitando cuenta el histórico de las parcelas y del manejo implementado en ellas además de las observaciones realizadas a lo largo del tiempo. Se comentan nuevamente los factores que pueden estar dando lugar a los resultados obtenidos.

Material: No se precisa material

Resultados: Durante la visita, la agricultora señala las parcelas en las que se obtienen las mejores cosechas en comparación con otras parcelas. Comenta que los árboles son de la variedad Ferragnes y que la producción media llega a unos 1200kg/ha, tres veces superior a la media. Habla del manejo histórico de la finca, y de que el uso de abonos verdes se lleva realizando durante décadas por la necesidad de alimentar a su ganado, y no tanto pensando en que se estaba realizando una mejora de la calidad del suelo. Se visita la parcela de la finca vecina, en la que se realiza un manejo convencional con hasta 6 pases de labor por año. Se observa que dicha parcela esta labrada a favor de pendiente, y la agricultora comenta que después de las lluvias se suelen generar grandes cárcavas. Los agricultores comentan que el hecho de labrar a favor de pendiente puede dar lugar a que en eventos de lluvia haya una deposición de nutrientes pendiente abajo, y este hecho podría explicar que en las partes bajas de la parcela convencional visualmente el suelo presenta mejor calidad que en la parte alta.

La agricultora nos comenta su interés en realizar un manejo con no laboreo y cubiertas naturales permanentes en una parte de la finca, y nos enseña la parcela "experimental" donde están probando este tipo de manejo. Agricultores con experiencia en el manejo con no laboreo y cubiertas naturales permanentes ofrecen algunos consejos para el buen funcionamiento de la práctica. Algunos de estos consejos son:

- **Fomentar la aparición de gramíneas invernales**. Si no aparecen de forma natural, intentar fomentar su aparición, o bien, dejando de labrar en Otoño después de la cosecha, o bien sembrando la cubierta con las especies que nos interesen. Las gramíneas invernales mantendrán el suelo cubierto por periodos más largos de tiempo y ayudarán a la aparición posterior de especies de leguminosas.

- **Manejo de las cubiertas:** Dependiendo de la forma de manejo (con pastoreo, desbrozadora o roller crimper), existirán unos pasos u otros a seguir. Si se realiza pastoreo durante el invierno, se fomentará el rebrote de la cubierta. Si la primavera es lluviosa no existirán problemas de competencia por agua con los almendros, pero en primaveras poco lluviosas habrá que manejar las cubiertas nuevamente a finales de mayo o principios de junio, chafándolas con el roller crimper, o rulo, o segándolas con una desbrozadora de cadena o martillo, lo que evitará las pérdidas de agua por evaporación.

Imagen 3 Fotos de la visita a parcelas regenerativas con laboreo reducido y abono verde.

5. Devolución de resultados de los cuadernos de campo de 2019 y establecimiento de acciones futuras

Reflexionar individual y colectivamente sobre las observaciones realizadas e información sistematizada con los cuadernos de campo nos permite discutir sobre la efectividad de las prácticas implementadas y generar propuestas para mejorar los resultados obtenidos. Concretar los objetivos individuales que cada agricultora y agricultor quiere alcanzar a corto y medio plazo y socializarlos en grupo ayuda a definir acciones concretas para la consecución de dichos objetivos. Cada experiencia sobre el manejo de las fincas puede aportar información de interés al resto de agricultoras y agricultores, que pueden valerse de ideas y sugerencias que le ayuden a mejorar la eficiencia de sus prácticas o a implementar nuevas prácticas.

Objetivo: Compartir las experiencias de monitorización y las observaciones de cada agricultora y agricultor sobre sus prácticas y manejos.

Metodología: Se forman dos o tres grupos de 3-4 personas en función del número de asistentes. Cada persona tiene 10 minutos para contar y escribir en qué consisten sus prácticas y manejos regenerativos en su grupo, y las observaciones más destacables que han recogido con el cuaderno. Por ejemplo, yo hago labranza reducida, y los cambios más significativos, las observaciones más significativas que he visto son… En el siguiente cuadro han de escribirse los objetivos a alcanzar con los manejos regenerativos, por ejemplo, para el año que viene me gustaría mejorar... Por último, y con la ayuda de las demás participantes del grupo, se aportarán sugerencias sobre cómo conseguir dichos objetivos. Por último, en plenaria, se presentan los datos recogidos al resto del grupo.

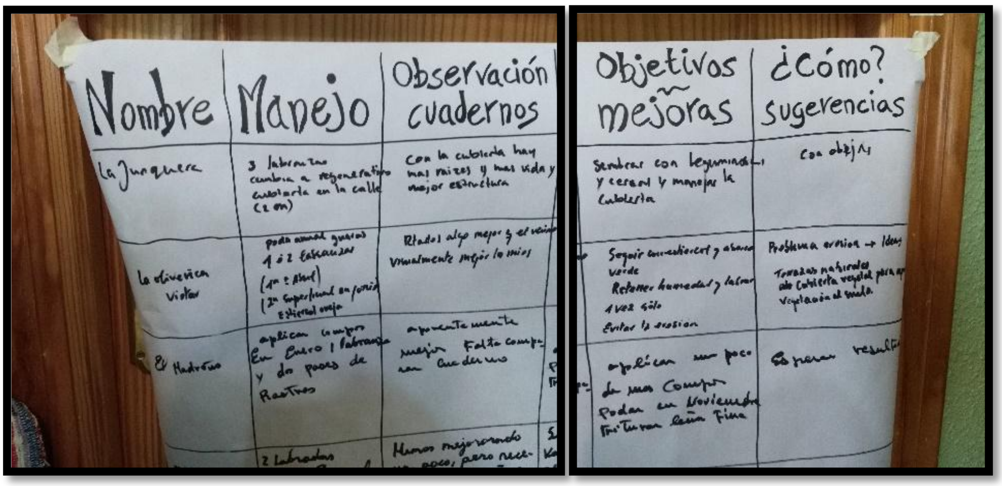

Imagen 4 Información recogida durante la devolución de resultados de cuaderno de campo

Material: Papelógrafos y rotuladores

Resultados:

Nombre finca	Manejo	Observaciones con Cuaderno	Objetivos / Cosas a Mejorar	¿Cómo conseguirlos? Sugerencias
La Junquera	3 labranzas y cubiertas naturales sin labrar en el centro de la calle en franjas de 2 metros	Con las cubiertas hay más raíces, más vida y mejor estructura	Sembrar con leguminosas y cereal y manejar las cubiertas	Manejar las cubiertas con ganado
La Oliverica	Poda anual de almendros variedad guara, 1 o 2 labranzas al año, la primera en abril y la segunda superficial con grada en junio. Aporte de estiércol	Resultados algo mejor que en la parcela convencional. Visualmente están mejor los almendros en parcelas regenerativas	Retener más humedad y labrar sólo una vez al año. Evitar la erosión.	Con terrazas para evitar la erosión. Labrando sólo una vez. Seguir aportando estiércol y abono verde. Con cubiertas para aportar biomasa al suelo
El Madroño	Aplicación de compost. En enero se da una labranza. En verano dos pases superficiales de rastra para eliminar la vegetación	Aparentemente esta mejor la parcela regenerativa. Falta registrar los datos y comparar con el cuaderno.	Aplicar un poco más de compost. En la poda de noviembre triturar la poda fina para aplicar al suelo.	Esperando a los resultados que vayan saliendo y las observaciones
Matian	2 labranzas al año Poda Bianual, aplicación de compost bianual y aporte de restos de poda triturada	Hemos mejorado un poco el suelo pero necesita más materia orgánica para que sean asimilables los nutrientes.	Seguir haciendo varias prácticas regenerativas para saber cuál es la que mejor funciona	Esperando a que los resultados que vayan saliendo y a las observaciones
Ciruelos Altos	2 labranzas al año. Aporte de estiércol cada dos años. En otoño siembra de abono verde (gramíneas y leguminosas). Manejo con ovejas en invierno y principio de primavera. Incorporación a finales de primavera de los restos de cubierta	En la regenerativa, menos temperatura y más humedad en el suelo, y mejor aspecto de los árboles. En la convencional, más escorrentía superficial y cárcavas, peor color de las hojas y aparecen muchos esmancaperros.	Aumentar nutrientes, Mejorar rendimiento, evitar la pérdida de suelo. Probar con no laboreo y cubiertas naturales	Aporte de estiércol anual o a su falta, aporte de abonos orgánicos. Dejar cada vez los suelos más cubiertos. Dejar un trozo de cubiertas sin labrar y chafarlas con rulo para experimentar. Pasar las ovejas antes de las primeras lluvias (Septiembre), para traer semilla autóctona, principalmente gramíneas invernales.
Torre Guajar	No laboreo y cubierta natural permanente.	Exceso de temperatura en el suelo Falta de nutrientes	Disminuir la temperatura del suelo y mejorar los nutrientes	Aportar compost con disco (esparcido) y cubrir la totalidad del suelo con cubiertas naturales
Cortijo de Paco	2 labranzas (una en abril y otra en octubre) Siembra de abono verde (veza, yeros y cebada) Aporte de abono orgánico pelletizado	Este verano los arboles tenían aspecto débil, por déficit hídrico. Hay zonas del suelo donde no nace hierba.	Mejora de la estructura de la tierra, de la porosidad e incremento de la materia orgánica	Tumbar abono verde o desbrozar para cada vez labrar menos. Tender a introducir cubiertas naturales permanentes.

6. Implementación del cuaderno de campo

La adopción de herramientas de diagnóstico de calidad del suelo en la rutina de las y los agricultores, como es el cuaderno de campo, puede darse de forma inmediata o puede darse de forma gradual debido a una gran diversidad de factores. La adopción de los cuadernos de campo puede mejorarse si las participantes ven la utilidad de registrar y documentar cambios individuales para así poder contar con un registro común. A pesar de que se vea utilidad en su uso, pueden existir dificultades que limiten su aplicación. En el siguiente ejercicio se hace una lluvia de ideas que nos permita recoger la visión de las participantes sobre la utilidad del cuaderno de campo, las dificultades encontradas y aportar sugerencias sobre cómo mejorar su adopción.

Objetivo: Mejorar la utilización y adopción del cuaderno de campo en la rutina de las y los agricultores.

Metodología: Lluvia de ideas**.** Preguntar por el interés de utilizar el Cuaderno de campo (qué necesitáis para ponerlo en marcha, qué dificultades encontráis). Recopilar su utilidad, dificultades y sugerencias para facilitar su puesta en práctica. Lluvia de ideas.

Cada agricultor tiene 6 notas adhesivas:

- 2 notas adhesivas amarillas para escribir porqué lo encuentra útil
- 2 notas adhesivas azules para escribir las dificultades
- 2 notas adhesivas verdes para escribir sugerencias que le ayudarían a ponerlo en práctica. (que fuese una app digital, que tuviese un apartado de recomendaciones, mejores explicaciones de cómo usarlo).

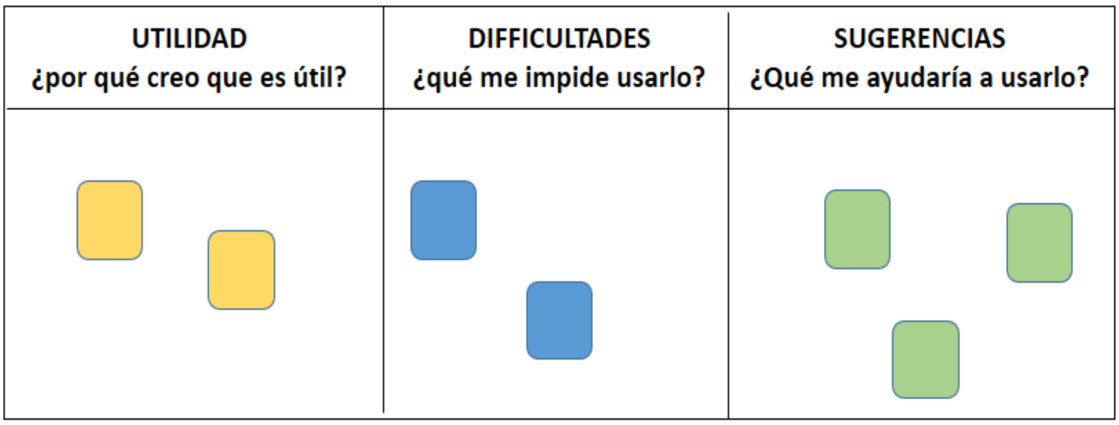

Imagen 5 Representación de la estructura de la dinámica para recoger ideas que mejoren la puesta en práctica del cuaderno de campo

Material: Papelógrafo y notas adhesivas.

Resultados:

Utilidad

- Permite ver el suelo de otra forma y prestar atención a parámetros que antes no se prestaba atención
- Permite recoger y sistematizar información
- Se asemeja a los indicadores que en el día a día se observan en el campo
- Lo utilizamos en visitas para mostrar la mejora en la calidad de nuestros suelos

Dificultades

- Se olvida muchas veces
- A veces es tedioso llevar el cuaderno y apuntar los datos
- Ya tengo registrados los datos de mi forma personal y es doblegar esfuerzos
- Algunos indicadores cambian muy rápido y otras tardan mucho en cambiar por lo que a veces es difícil interpretar los resultados

Que me ayudaría a usarlo

- Que se mande un recordatorio cada vez que haya que usarlo
- Desarrollar una app para el móvil que permita a los agricultores registrar los cambios directamente en el teléfono. Señalando en un mapa el lugar donde se está realizando el diagnóstico.
- Que tuviese un apartado de recomendaciones sobre cómo mejorar los resultados de los indicadores

Anexo 1: Agenda del taller

10.30 - 11.00 Presentación del taller y recapitulación del proceso de monitorización participativa

11.00 – 12.00 Devolución de los resultados de los análisis fisicoquímicos realizados en 2019

12.00 - 12.30 Visita a las parcelas regenerativas de la finca

12.30 - 13.30 Devolución de los resultados recogidos con los cuadernos de Campo y establecimiento de acciones futuras

13.30 – 14.00 Implementación del Cuaderno de Campo

14.30 - 16.30 Comida