DIGITAL BOOK OF PROCEEDINGS

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FARMING SYSTEMS FACING CLIMATE CHANGE
AND RESOURCE CHALLENGES

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THEME 6 – LANDSCAPE INTEGRATION OF FARMING

Governance actors, networks and their mutual interactions are key drivers of the (past, present and future) trajectories of change in land-use and farming systems. This process is enacted across a wide range of spatial-temporal scales and institutional levels. Alas, the divergences in the interests and aspiration of these different actors and institutions (both public and private) make it difficult to reach consensus on directions for achieving more productive agronomical and forestry-systems that can be integrated with other land-uses and related socio-political objectives, including; biodiversity conservation, economic diversification and climate change mitigation and adaptation. To tackle these challenges, many theoretical and operational frameworks and tools have been proposed, including Ecosystem Services and an Ecosystems Approach, and Social-Ecological Systems and Resilience. Nonetheless, few aspects of these frameworks have been translated from theory into real-world management. Furthermore, existing land management systems that are intrinsically multi-functional and thus can foster sustainability (e.g. Mediterranean silvo-pastoral systems, such as Dehesas and Montados) are currently in decline. This is largely due to inadequate governance frameworks and market inefficiencies.

In such a context, Landscape Approaches can seemingly provide with an opportunity to link diverging land-use actors and objectives to converge through more innovative governance and decision-making structures, ultimately contributing to integrate agriculture and forestry alongside with other rural land-uses. This is a context where biodiversity conservation and carbon sequestration are largely menaced from a rapid and uncontrolled expansion of agriculture, and thus where landscape functional and ecological capacities can help address problems of connectivity and sustainable farming production. Alas, they have also been proposed in regions with a long history of human intervention where both cultural and natural values have long co-existed with, or even at times depended, on agriculture and forestry (e.g. the Mediterranean), and thus, where Landscape naturally provide the much-required bridge between food production and other benefits and services to be potentially obtained from the land, such as cultural ones. Last, Landscape is also considered as a spatial-temporal scale, and more concretely, as a scale to which decision-makers and land-managers operating on the ground can relate, thus being useful for land-management coordination and cooperation.

SPECIALIZATION, ABANDONMENT AND PERIURBANIZATION TRAJECTORIES ON MEDITERRANEAN LAND SYSTEMS. A PARTICIPATORY ANALYSIS FOR THE CASE STUDY OF THE COMTAT VENAISSIN (SOUTHERN-EAST FRANCE)

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Abstract: The Mediterranean is at the same time a region of stark social and ecological contrasts and a global biodiversity hotspot, where complex local evolving land use patterns compose the region's landscapes. In this context, we aimed to identify key drivers of land system dynamics and future possible scenarios to increase territory resilience in a local case study of the south-east of France (Comtat Venaissin, Vaucluse department) involving territorial stakeholders. The choice of this case study is based on global previous quantitative analysis of land system dynamics at Mediterranean basin scale, from which we operated a downscale and pursue a local analysis based on qualitative approach and stakeholders' knowledge.

Through a methodology based on both participatory approach and semi-structured interviews, we analysed stakeholders perception about ongoing dynamics and their drivers in farming and land systems, but also within the same farming systems, in terms of farming practices. In particular, we implemented a "Territory game" methodology, pushing stakeholder to work on a spatialization exercise, identifying territorial dynamics perceived as positives or negatives, and to formulate territorial issues linked with land, farm and food systems. Stakeholders' foreseen and desired futures for their lands completed this characterization of current dynamics, and will be compared to actual patterns and tendencies.

We identified two main changes in land and farming systems that involve several dynamics. The first one is a process of specialization, at territory scale but also within farming systems, which is strongly linked with vineyards expansion dynamic and has a landscape homogenizing effect. Farmers' choices, that are determined by an objective of profitability and depend, inter alia, on food sector functioning, on sanitary pressure and quality label areas, mostly explain this dynamic. The second one is agricultural decline as a result of periurbanization and land speculation, but also linked with agricultural vitality loss. Those dynamics raised various territorial issues, such as the fostering of land access or the conservation of agricultural and landscape diversity, to which we can respond by consolidating some modest dynamics perceived positively by stakeholders.

The implemented approach allows us to verify global assessed land system typology and dynamics, and to deeply understand the process behind them.

TRAJECTORIES OF CHANGE IN OLIVE GROVE EXPANSION AND INTENSIFICATION IN ALENTEJO (PORTUGAL): DISCUSSING A LANDSCAPES APPROACH TOWARDS MORE SUSTAINABLE FUTURES

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Abstract

Olive groves in Alentejo (Portugal) have exponentially increased their extent and intensive character over the past 15 years. This has been driven by the rise in global demand for olive oil, in the availability of water for irrigation and by a strong political and social support. As a result of this, whilst in 1998 olive groves in the Alentejo occupied 144,759 hectares (15.38 % of which were irrigated), in 2015 they occupied 169,869 hectares (28.86% of which were irrigated, including 18.32 % located in the Alqueva irrigation system) (EDIA 2016 & 2017). In parallel, the traditional farm structure in olive groves is shifting towards land concentration in areas with access to irrigation, and towards property fragmentation and abandonment in marginal lands. Nonetheless, the existing governance framework is fragmented and has gaps, with policy tools focusing on individual aspects of the system, such as preventing the cutting of olive trees (Despacho Normativo 1/2002) or regulating the price of water (Despacho Normativo 3025/2017). This is all largely underpinned by technological-innovation discourses, with governance and social innovation largely missing from the discussion. A much-needed overarching governance strategy and vision for more sustainable futures of the sector remains absent. In response to such pressing challenges, this paper will discuss the hypothesis of whether a landscape approach can contribute to build novel governance frameworks that drive olive-groves towards scenarios of increased sustainability. The main goal of the paper is to discuss how these gaps in governance can be filled by designing and testing a landscape approach (Sayer et al, 2013; 2015; 2016) that can ultimately foster the co-construction of a more sustainable land-use system. To achieve this, the paper begins by identifying and characterizing the current mosaic of olive groves and land-management models and their current trends. This is then followed by an analysis of the governance actors, networks, levels and institutions driving change in the sector, including the discourses that underpin key challenges, such as sustainable intensification, and the role potentially played by a landscape approach. Scenarios of future change (business-as-usual vs others) are then discussed with a view on the next CAP cycles (2020-2032), including one underpinned by adopting a landscape approach. Research in this paper is based on a trans-disciplinary approach, ultimately aiming to contribute to knowledge co-construction.

Olive groves (and olive oil) in Alentejo (Portugal): socio-territorial and social-ecological dynamics of change

A prevailing opinion persists among the key policy, economic and social actors in Portugal on the pertinence to advance agricultural intensification if an expanding global demand and international market competitiveness are to be satisfied (Silveira et al, 2018). In parallel, growing concerns are raised about the impacts and externalities to potentially arise, calling for more sustainable forms of agricultural intensification. However, this is a term that remains largely unresolved (Garnett et al. 2013; Röckstrom et al, 2017), being frequently used to justify private strategies of growth.

In this context, the Alentejo seems to be clearly following a pattern of rapid, and largely unsustainable, agricultural intensification, despite of the constraints posed by its dry Mediterranean climate and a tradition of extensive, multi-functional agricultural systems

(Marques & Carvalho, 2017). A key factor driving intensification in the region is the long-standing public investment in the Alqueva irrigation system that has counted with legal and financial support from policy makers, and that has been facilitated by private financial investment in agriculture. The construction of the Alqueva dam was concluded in 2002, becoming the largest artificial water body in Europe. Although extensive and intensive olive groves continue to coexist in the region, the transition from traditional and extensive towards increasingly intensive farming systems has been extremely fast.

In 2016, land used for irrigated olive groves (intensive and super-intensive) was of 57% in the Alqueva area of influence (EDIA, 2017). As a result of this, whilst in 1998 olive groves in the Alentejo occupied 144,759 hectares (15.38 % of which were irrigated), in 2015 they occupied 169,869 hectares (28.86% of which were irrigated, including 18.32 % located in the Alqueva irrigation system) (EDIA 2016) (figures 1 and 2).

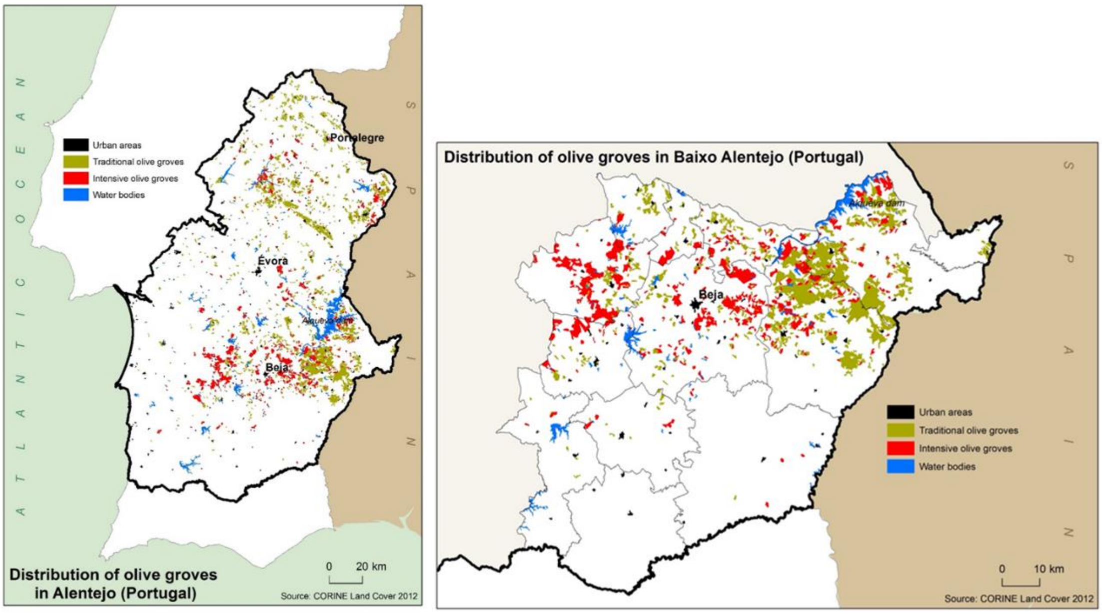

Figure 1: Distribution of olive groves in the region of Alentejo (NUTS II) and the district of Beja (NUTS III), differentiating amongst traditional/extensive and intensive/super-intensive olive groves. The location of the artificial water reservoirs in the region in their role as main material factor for the expansion and intensification of olive groves, especially the Alqueva damn, are also represented.

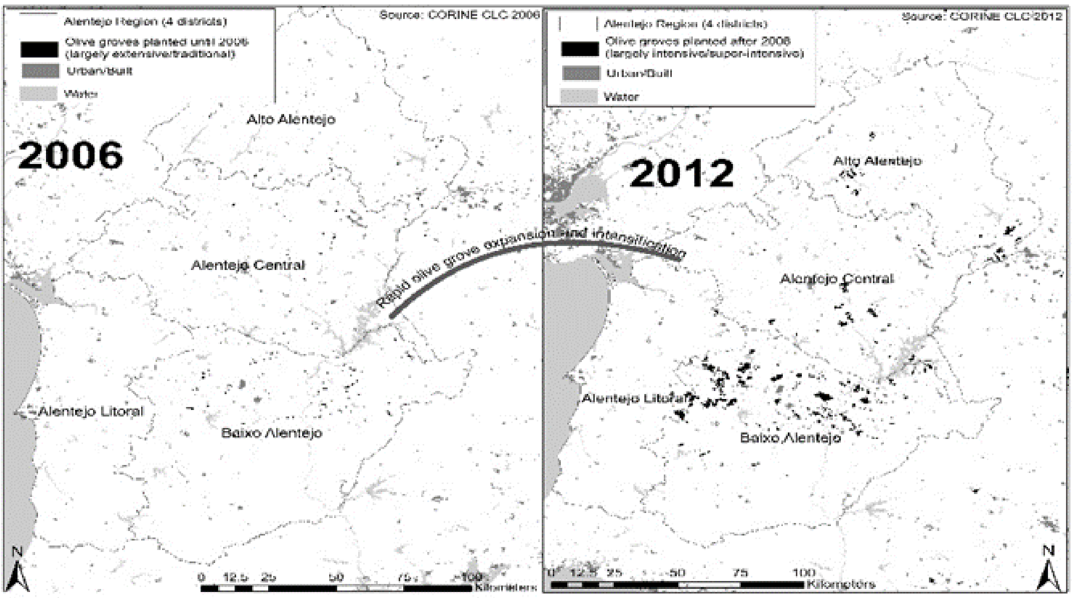

Figure 2: Map showing the rapid increase in intensive and super-intensive olive groves across central Portugal in the period between 2006 and 2012. It is relevant to indicate that the most acute period of increase in olive grove expansion and intensification started in reality immediately after the latest date represented in this figure, thus portraying a more extensive and impacting change that the one hereby shown.

In parallel, the traditional farm structure in olive groves is shifting towards land concentration (table 1) in areas with access to irrigation, and towards property fragmentation and abandonment in marginal lands, where agricultural productivity is lower.

Table 1: Change in the number of farms of olive groves and olive oil production of different sizes in the Alentejo during the period between 1999 and 2013. The parallel process of increase in the number of bigger farms and decrease in the number of smaller farms is clearly indicative of the land property concentration process which is inherently linked to the intensification trend. As with indicated for figures 1 and 2, the process of land concentration has become increasingly acute following the reflected in this table, when the irrigation perimeter of the Alqueva has become fully operational.

Size	2013	2009	1999
Total	19449	19745	22513
<0.5 Hectares	949	1101	1682
0.5<1 Hectares	4155	3598	4578
1<2 Hectares	4300	4829	5266
2<5 Hectares	4692	5101	5105
5<20 Hectares	3804	3575	4095
20<50 Hectares	896	886	942
50<100 Hectares	403	413	309
>100 Hectares	250	243	136

Governance challenges: scales, actors and networks

In the context of such rapid and acute change, the regulatory and planning framework remains fragmented, with policy tools focusing on individual aspects of the olive grove system, such as preventing the cutting of olive trees (Despacho Normativo 1/2002) or regulating the price of water (Despacho 3025/2017). This is all largely underpinned by technological-innovation discourses, with governance and social innovation largely missing from the discussion. A much-needed overarching governance strategy and vision for more sustainable futures of the sector remains absent.

In response to similar challenges in other crops and farming systems, several alternative theoretical and operational frameworks for improving governance structures and mechanisms have been proposed, although the olive sector in Portugal has so far remained quite impermeable to such proposals. The experience in the neighboring region of Andalucía (Infante-Amate, 2014), which is the largest olive oil producing region worldwide, has so far been mainly focused on top-down planning and regulatory instruments aiming to achieve better coordination and cooperation across scales and actor-networks, having mostly failed. These failures in the policy sector has encouraged a more innovative discussion on how to progress towards more sustainable and inclusive agro-ecological alternatives (Guzmán et al, 2017), which are in direct conflict with the currently dominant agro-industrial framework.

Inspired by such agro-ecological approaches, in the Alentejo some initial hints have been lately devised looking at gaining more critical understandings of the governance gaps, limitations and opportunities of the system, following rationales such as the one that is shown in figure 3. Findings indicate to a vicious circle of actor-network dynamics of de-territorialization, where the transition between an bio-economy and an eco-economy governance model (Silveira et al, 2018) that is threatening sustainability is not being properly tackled.

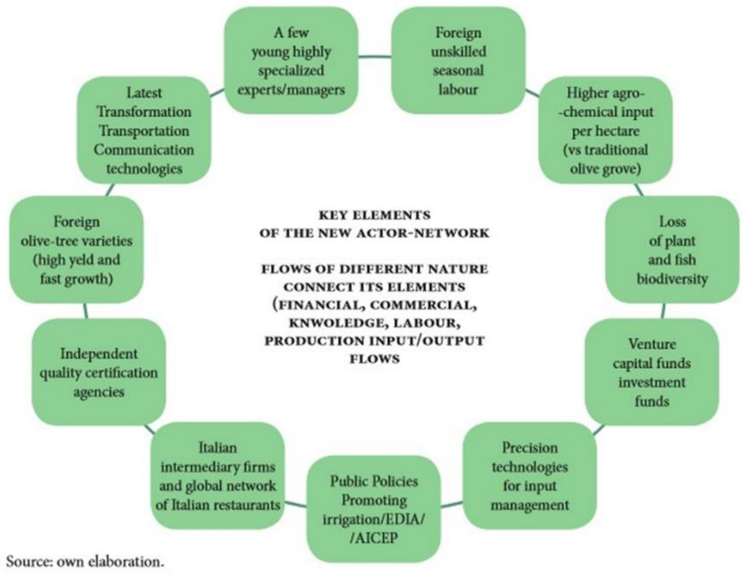

Figure 3. An abbreviated view of the actor-network associated with intensive olive grove governance in Alentejo (from Silveira et al, 2018). This figure shows the circular and vicious nature of the current bio-economy paradigm in the sector.

The Landscapes Approach

Diverse Landscape approaches have been advocated to help unravel the complexity underpinning coupled human-environmental systems and related decision-making mechanisms (Angelstam et al, 2019a). This is therefore far from a new approach, as already in 1950 Geographer Carl Troll hinted at the need for a novel landscape science that "requires continuous and close contact with the large number of disciplines in the natural and the economic and social sciences". Later, Grodzynskyi (2005) in his seminal book, reviewed the landscape concepts' natural, anthropocentric and intangible interpretations as defined in the wide range of landscape research schools that have emerged in North America, and especially in Europe. As also shown by Angelstam et al (2019a), a vast array of approaches and models aiming to embed the landscape concept into operational practices and structures related to land governance, planning and management have been suggested. These approaches are lately arising as a potential pathway to overcome the various failures encountered in the Ecosystem Services Framework, and as an attempt to tackle the sustainable governance of rural areas and related farming systems.

Actually, a certain attempt to unify and raise awareness of landscape approaches as operational tools is lately arising, with common principles being established and their applicability and advantages clearly argued. (e.g., Sayer et al. 2013; Sayer et al, 2015; Sayer et al, 2016; Reed et al, 2017). According to the Global Landscapes Forum (https://www.globallandscapesforum.org /) a Landscape Approach is about "*balancing competing land use demands in a way that is best for human well-being and the environment. It means creating solutions that consider food and livelihoods, finance, rights, restoration and progress towards climate and development goals*".

In parallel to such scientific efforts, several global level concepts and processes aiming at implementation of a landscape approach include UNESCO's Biosphere Reserves, the International Model Forest Network (www.imfn.net) and the Global Landscapes Forum (www.landscapes.org). These attempts hint to a potential for integration among different landscape approach concepts and initiatives. Advancing in such direction is urgently required to address the interconnected wicked challenges of economic development, ecological integrity, and social justice that are essential components of human well-being through a stronger territorial basis (e.g., Duckett et al. 2016).

Assessing states and trends of sustainability, which is currently advocated using ecosystem services, natural capital (Wackernagel et al. 1999), landscape services (Bastian et al. 2014) or nature's contribution to people (Pascual et al. 2017), involves challenges, which are both disciplinary and related to stakeholder engagement and participation. This is a goal that can be advanced through implementation of landscape approaches, although it requires that individuals reconnect to the landscape as their place of living which they constantly influence (Selman 2012), and building trust and trustworthiness among both academic and non-academic participants in problem-solving at a local landscape scale (Von Wehrden et al. 2019; Pinto-Correia et al. 2018). In general, ecological research dominates the ES and other common approaches (e.g., Angelstam et al. 2019b). To balance the ecological focus, social science also needs to contribute actively.

To address these issues, we proposed our own Landscape Approach that joins together the material, cultural and governance layers of complex land-use systems to ultimately seek the unravelling of landscape functions, benefits and services across a set of governance scales ranging from the region to the farm plot (figure 4).

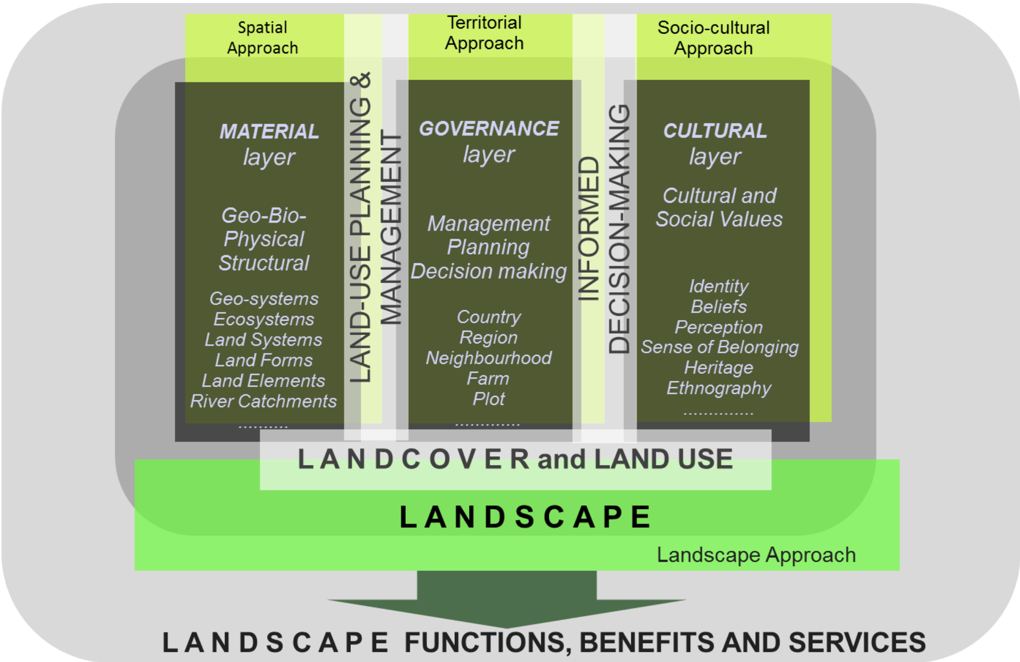

Figure 4: Theoretical framework for a landscapes approach that uses a joint spatial (material), territorial (governance) and socio-cultural analytical framework to unravel landscape functions, services and benefits using land cover and land-use as entry point where the ecological and social meet.

Transition pathways currently on-going in olive groves in Alentejo are especially well placed as object of study for the application of a complex analytical approaches such as the one described in figure 4 can be useful. The scale (moving towards increased homogeneity and simplification of the landscape, beyond the farm and farm-plot), social-ecological complexities (with implications over local economies), cultural (impacts on landscape character and significance), governance (outsourcing of decision centers away from the region and even the country and towards the global market nodes) and ecological (negative impacts of landscape mosaic changes) aspects of the intensification and expansion of olive groves makes this analytical framework ideal to better understand the consequences for sustainability and resilience of this rapidly shifting farming system.

Figure 5. Portrays of the new olive grove landscapes arising in Alentejo through the processes of intensification and expansion of olive groves leading to a simplification and loss of character with profound effects on society, economic and environmental aspects, thus demanding landscape-based solutions.

Future scenarios of change

Our research in this paper is based on a trans-disciplinary approach, and thus ultimately aimed to contribute to knowledge co-construction. This is indeed a central component of any landscape approach, both in theoretical (Sayer et al, 2013) and operational (Sayer et al, 2015 & 2016) terms.

Since a cross-scale and sustainability-oriented understanding of complex social-ecological systems is a key aspect of any landscape approach (Sayer et al, 2013, 2015 & 2016; Angelstam et al, 2019), it became crucial to generate scenarios, and to identify underpinning narratives (figure 6), of future likely change and impact on the wider olive grove farming system. To achieve this, the four narratives underpinning scenarios that had been developed and applied under to generically examine the financial sustainability of diverse farming systems across Europe, were used as a basis for devising how the coupled social and ecological, material and immaterial and territorial and governance aspects of the resulting landscapes would likely evolve in the mid-term future (6-20 years). This is a period of analysis under which the policy cycles (mainly 6-year CAP funding schemes), bio-physical and ecological risks related mainly to climate change and biodiversity loss and cultural shifts in perception become jointly relevant.

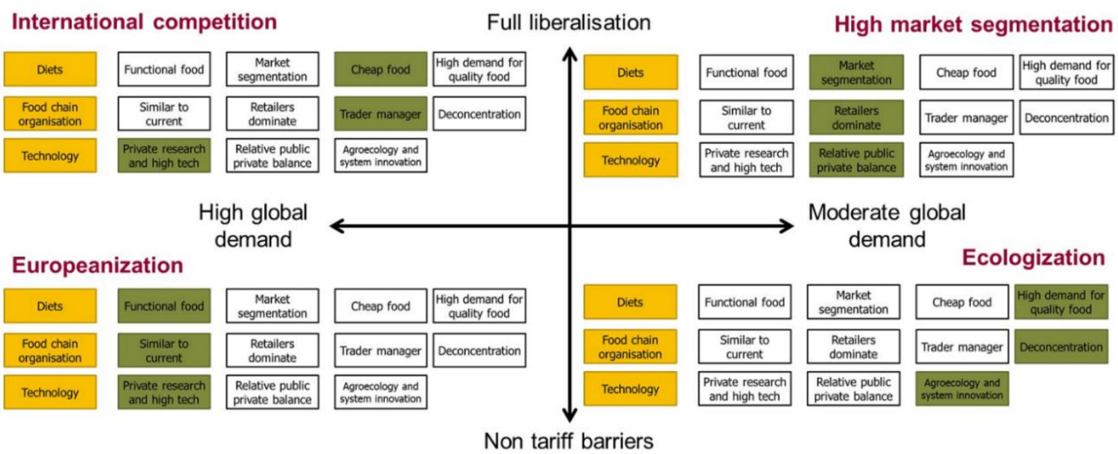

Figure 6: Mid to long-term narratives underpinning future scenarios devised for future changes in the farming systems across Europe, including in the olive groves of Alentejo. Scenarios encompass the material, perceptive, governance, scalar and ecological aspects that are all indispensable components of a Landscapes Approach.

Deliberation around these narratives took place with multiple stakeholders acting across diverse spheres and levels of governance (including farming and farming unions, public administration, the industry and research) ultimately aiming to devise more sustainable solutions for the sector (https://www.sufisa.eu/wp-content/uploads/2019/07/Deliverable-4.2.pdf). Knowledge co-construction approaches and trans-disciplinary research are in themselves key components of any Landscapes Approach (Sayer et al, 2013).

The outputs from the scenario stakeholder workshop demonstrate that strong divergences exist within a sector as complex as the olive grove and olive oil one. Divergences focus around whether olive groves should aim at maintaining current expansion and intensification trends, and especially as to what the role of public and private, local and exogenous and economic and social actors should be

Main divergences were found between stakeholders in the intensive and traditional production modes. In addition, strong divergences were detected between advocates of the governance of these complex farming systems being placed at the local level, and those others advocating externalization and outsourcing linked to global markets, operating under a clear productivist mindset. This duality could be considered as underpinning a market segmentation scenario.

Indeed, one aspect that came out of these workshops is that what sustainable development means in practice is extremely biased and seems to be very much informed by the personal economic interests of certain actors (e.g. intensive olive grove entrepreneurs and investors) holding enormous market and opinion power. This potentially complicates the much-needed transitioning between a bio-economic and an eco-economic paradigm in this sector (Silveira et al, 2018). Further complications arise from the fact that although a clear discourse of economic independence from the public sector is detected amongst many producers (thus advocating the international competition scenario), funding linked to the CAP (linked to the Europeanization scenario) is still seen as extremely relevant. This is a contradiction that does seem difficult to concile, and leads to discussions relevant to the ecologization scenario, which although being largely acknowledged as the most effective pathway towards sustainability, is seen as to idealistic and unachievable under current economic, political and social trends.

It may be argued that adopting a landscapes approach could hereby serve a double purpose beyond that already being achieved to secure dialogue and knowledge co-construction. This double purpose includes that of aligning converging worldviews and personal objectives under common goals and shared values and visions and translating this into better coordinated actions across scales.

Discussion and conclusions: applying a landscape approach to move towards increased sustainability and resilience

Landscape approaches have for a long period of time been proposed and discussed, although mainly restricted to academic circles and research (Angelstam et al, 2019a). Lately, an attempt to reach consensus around the basic principles (Sayer et al, 2013) and operational mechanisms (Sayer et at, 2015 & 2016) of what Landscape approaches should entail has been defined. Despite being originally intended for reconciling biodiversity conservation and human development targets in tropical environments (Reed et al, 2017), its potential for improving governance and stewardship towards increased sustainability and resilience is becoming apparent (Angelstam et al, 2019a & 2019b).

The recent process of rapid expansion and intensification of the olive grove sector in the Alentejo has rested on strong political and social support. This change is largely impacting the social, economic and ecological fabric of the regional rural territories in the region. In defense of these trends, over-simplified arguments linked to a bio-economic paradigm are being disseminated by those actors bearing stronger market power, detracting power from other actors advocating for alternative pathways, and thus ultimately degrading governance systems.

A Landscape Approach bringing together challenges of space and scale, knowledge co-construction, complexities in social-ecological systems and consideration of cultural preferences linked to local and regional contexts, seems to be a clear pathway to overcome current barriers towards sustainability. Nonetheless, this is indeed a very complex goal, and one for which a radical shift between the bio-economic and the eco-economic paradigm is required from both civil society, the private and the public sector. This does not yet seem to be the case for olive groves in the Alentejo. Whether a gradual implementation of the 10 principles prescribed by Sayer et al (2013) could lead to increased sustainability of the system remains to be seen.

References

Angelstam P, Grodzynskyi M, Andersson K, Axelsson R, Elbakidze M, Khoroshev A, Kruhlov I, Naumov V. 2013. Measurement, collaborative learning and research for sustainable use of ecosystem services: landscape concepts and Europe as laboratory. Ambio 42(2):129–145

Angelstam, P., Muñoz-Rojas, J., & T. Pinto-Correia, 2019a. Landscape concepts and approaches foster learning about ecosystem services. Landscape Ecology. 34:1445–1460

Angelstam P, Manton M, Elbakidze M, Sijtsma F, Adamescu M, Avni N, Beja P, Bezak P, Zyablikova I, Cruz F, Bretagnolle V, Díaz-Delgado R, Ens B, Fedoriak M, Flaim G, Gingrich S, Lavi-Neeman M, Medinets S, Melecis V, Muñoz-Rojas J, Schäckermann J, Stocker-Kiss A, Setälä H, Stryamets N, Taka M, Tallec G, Tappeiner U, Törnblom J, Yamelynets T. 2019b. LTSER platforms as a place-based transdisciplinary research infrastructure: learning landscape approach through evaluation. Landscape Ecology. 34: 1461-1484.

Bastian O, Grunewald K, Syrbe R-U, Walz U, Wende W. 2014. Landscape services the concept and its practical relevance. Landscape Ecology. 29(9):1463–1479

Duckett D, Feliciano D, Martin-Ortega J, Munoz-Rojas J. 2016. Tackling wicked environmental problems: the discourse and its influence on practice in Scotland. Landscape Urban Plann 154:44–56

EDIA. 2016. Anuário Agrícola de Alqueva 2016. Beja

EDIA. 2017. Anuário Agrícola de Alqueva 2017. Beja

European Union Environmental Agency (EEA), CORINE Landcover 2012,

Garnett, T., M. C. Appleby, A. Balmford, I. J. Bateman, T. G. Benton, P. Bloomer, B. Burlingame, M. Dawkins, L. Dolan, D. Fraser, M. Herrero, I. Hoffmann, P. Smith, P. K. Thornton, C. Toulmin, S. J. Vermeulen, H. C. J. Godfray. 2013. Sustainable Intensification in Agriculture. Premises and Policies. Science, Vol. 341, Issue 6141, pp. 33-34

Grodzynskyi MD. 2005. Piznannia Landshaftu: Misce i Prostir [Understanding Landscape: Place and Space], vol 2. Kiev University Publishing House, Kiev

Guzmán, G.I., González de Molina, M., Soto Fernández, D., Infante-Amate, J., Aguilera, E 2018. Spanish agriculture from 1900 to 2008: a long-term perspective on agroecosystem energy from an agroecological approach. Regional environmental change, 18-4, pp. 995-1008

Infante-Amate, J . 2014. Quién levantó los olivos? Historia de la especialización olivarera en el sur de España (ss. XVIII-XX). Madrid, Ministerio de Agricultura, Alimentación y Medio Ambiente, 2014, 360 pp

Marques C. e Carvalho, M. 2017. A Agricultura e os sistemas de produção do Alentejo. Breve Caracterização da sua evolução, situação atual e perspectivas». Posse e Uso da Terra – Caracterização da Agricultura no Alentejo. Cadernos Poder Local. Página a Página. Lisboa

Ministério da Agricultura, do Desenvolvimento Rural e das Pescas, *Despacho Normativo 1/2002*, 4 de Janeiro, Diário da República n.º3/2002, Série I-B

Ministério das Finanças, Ministério do Ambiente e Ministério da Agricultura, do Desenvolvimento Rural e das Pescas, *Despacho 3025/2017*, 11 de abril, Diário da República, 2.ª série, n.º 72

Pascual U, Balvanera P, Díaz S, Pataki G, Roth E, Stenseke M, Watson RT, Dessane EB, Islar M, Kelemen E, Maris V. 2017. Valuing nature's contributions to people: the IPBES approach. Current Opinion in Environmental Sustainability 26:7–16

Pinto-Correia T. & C. Azeda, 2017. Public policies creating tensions in Montado management models: insights from farmers' representations. *Land Use Policy*, 64: 76-82.

Reed J, Vianena J, Barlow J, Sunderland T. 2017. Have integrated landscape approaches reconciled societal and environmental issues in the tropics? Land Use Policy 63:481–492

Rockström J, Williams J, Daily G, et al. 2017. Sustainable intensification of agriculture forhuman prosperity and global sustainability. Ambio 46: 4–17

Sayer J, Sunderland T, Ghazoul J, Pfund JL, Sheil D, Meijaard E, Venter M, Boedhihartono AK, Day M, Garcia C, van Oosten C. 2013. Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. Proc Natl Acad Sci 110(21):8349–8356

Sayer J, Margules C, Boedhihartono AK, Dale A, Sunderland T, Supriatna J, Saryanthi R. 2015. Landscape approaches; what are the pre-conditions for success? Sustain Sci 10(2):345–355

Sayer JA, Margules C, Boedhihartono AK, Sunderland T, Langston JD, Reed J, Riggs R, Buck E, Campbell BM, Kusters K, Elliott C, Minang PA, Dale A, Purnomo H, Stevenson JR, Gunarso P, Purnomo A. 2016. Measuring the effectiveness of landscape approaches to conservation and development. Sustain Sci 12:465–476

Selman P. 2012. Sustainable landscape planning: the reconnection agenda. Routledge, London

Silveira, A., Muñoz-Rojas, J., Pinto-Correira, T., Guimarães, M. H., Ferrão, J., Schmidt, L. 2018). The sustainability of agricultural intensification in the early 21st century: insights from the olive oil production in Alentejo (Southern Portugal). In Delicado, A., Domingos, N., Sousa, L. de (Eds.), Changing societies: legacies and challenges. Vol. 3. The diverse worlds of sustainability, pp. 247-275. Lisbon: Imprensa de Ciências Sociais

Vanwalleghem, T., Amate, J. I., de Molina, M. G., Fernández, D. S., & Gómez, J. A. 2011. Quantifying the effect of historical soil management on soil erosion rates in Mediterranean olive orchards. *Agriculture, Ecosystems & Environment*, 142(3–4): 341–351.

von Wehrden H, Guimarães MH, Bina O, Varanda M, Lang DJ, John B, Gralla F, Alexander D, Raines D, White A, Lawrence RA. 2019. Interdisciplinary and transdisciplinary research: finding the common ground of multi-faceted concepts. Sustainability Science 14(3):875–888

Wackernagel M, Onisto L, Bello P, Linares AC, Falfán ISL, Garcıa JM, Guerrero AIS, Guerrero MGS. 1999. National natural capital accounting with the ecological footprint concept. Ecological Economics 29(3):375–390

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MAPPING PREFERRED TRAJECTORIES OF LOCAL DEVELOPMENT IN SOUTHEAST PORTUGAL

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Abstract

Mediterranean land systems are amongst the most susceptible to global change, in part due to the region's vulnerability to climate change and misfit within a high production demanding political and societal setting. The impact of global drivers at a local scale, i.e. the possible trajectories of change of a territory, are context-dependent, and to some extent dependent on how local actors perceive them and act upon them. In this study, we focus the territory of Serpa, Mértola and Alcoutim – three municipalities from southeast Portugal – to understand how different actors from across the territory anticipate the development of the territory and its land systems. We have conducted 22 interviews to collect individual perspectives and gathered 23 to play the territory game to find collective perspectives. From our results, we get a picture of a depopulated territory, constrained by ill-adjusted policies to its harsh conditions, including little water availability and continuous depopulation. We found contrasting preferred trajectories of development for the territory. In one hand there is a preference for prioritizing traditional land systems, usually rainfed and multifunctional. Contrasting, it is recognized a need for hydro-agricultural infrastructures that would increase water availability and allow for profitable agricultural activities and thus fixate population. The different perspectives fit with a wider debate on the role of agriculture, intensification and ecosystem services under an increasingly arid Mediterranean. The next challenge is to understand how to integrate local needs and initiatives within a broader scale strategic plan.

Introduction

Trough land management and territorial practices, human decisions and activities are a main driver of land system change (Turner et al. 2007). At a global scale, land systems dynamics can usually be linked with population, affluence and technology variables (Peña et al. 2007). Yet, these relationships tend to fade when descending to the local scale (Turner et al. 2007). How local actors and institutions interact with global trends, through their perceptions and decisions, can influence local dynamics (Nayak and Berkes 2014, Funatsu et al. 2019). Hence when aiming to understand possible pathways of development at a local scale it is important to consider how dynamics are being perceived and how actors are willing to deal with them. Understanding the relationship between global drivers and local effects can improve the capacity to push for desired pathways of development (Pinto-Correia and Kristensen 2013, Magliocca et al. 2018), by highlighting at what level of governance actions need to be taken.

In the Mediterranean basin, humans have been managing their surroundings for centuries, creating the diversity of land systems and landscapes that still today characterize the basin (Blondel 2006, Malek and Verburg 2017) Technological advances and policy support that favour market-driven agriculture, are adding pressure to the systems that have evolved and been managed as multifunction and low input systems (Pinto-Correia and Mascarenhas 1999). When viable, the tendency is to intensify production and increase productivity (Peña et al. 2007). In peripherical areas, either in geographic, economic and/or productive terms, systems are being pushed towards states of lesser human management through extensification, abandonment or afforestation (Debolini et al. 2018). Although contrasting, and varying in its degree of repercussion, all of these trends influence how land systems are being managed, potentially threatening natural and cultural values associated with certain land systems (Bugalho et al. 2011).

How local actors and institutions interact with these global forces can influence the trajectory of development (Nainggolan et al. 2012), and in turn influence global dynamics (van Vliet et al. 2015, Magliocca et al. 2018). Thus, strategies for the sustainable development of the territory are in part dependent on actors of differing positions involved in decision-making and public sector action (Angeon and Lardon 2008). although sharing biophysical characteristics, represents a very diversified region in socio-economic terms (Blondel 2006).). Studies that attempt to characterize land systems dynamics at a finer scale are important to fully grasp this region particularities and design adequate policy instruments (Muñoz-Rojas et al. 2019) and different governance scales. This paper contributes to such effort by providing a characterization of Mediterranean land systems using a case study located at southeast Portugal, including 3 municipalities, Serpa, Mértola, and Alcoutim.

The goal of this paper is two-fold 1) gain a better understanding of the local dynamics in a marginal Mediterranean area; and 2) contribute to the unveiling of desired and sustainable pathways of development for the territory. To fulfil these, we used participatory methods and involved different actors engaged in the development of land systems in the territory under study.

Case study

The case study comprises 3 municipalities in south Portugal - Serpa and Mértola in the region of Alentejo, and Alcoutim in the region of Algarve (figure 1). Guadiana River crosses the 3 municipalities, and borders with Spain from Alcoutim all the way to its mouth, in the Gulf of Cádiz. The Alqueva dam (the largest artificial lake in the Iberian Peninsula) follows the Guadiana River along 83 km of its main course and it extends to 30 km above Serpa, irrigating 23 927 ha of the municipality (EDIA 2018). Alcoutim has 4 micro damns, ranging between 24 ha and 35 ha in potential irrigated area, all below its capacity, totalling 8.5 irrigated hectares amongst all (SNIRH 2019). The Nacional park of Vale do Guadiana, (PNVG) has 69 773 ha and is part of the Natura network under the birds' directive. The vegetation is dominated by holm oak woods, with extensive cistus areas and rained plantations (ICNF 2018). The Special Protection area of Castro Verde, relevant for the protection of steparian birds in Portugal, extends through 7 695 ha in the eastern part of Mértola (ICNB/ICNF n.d.).

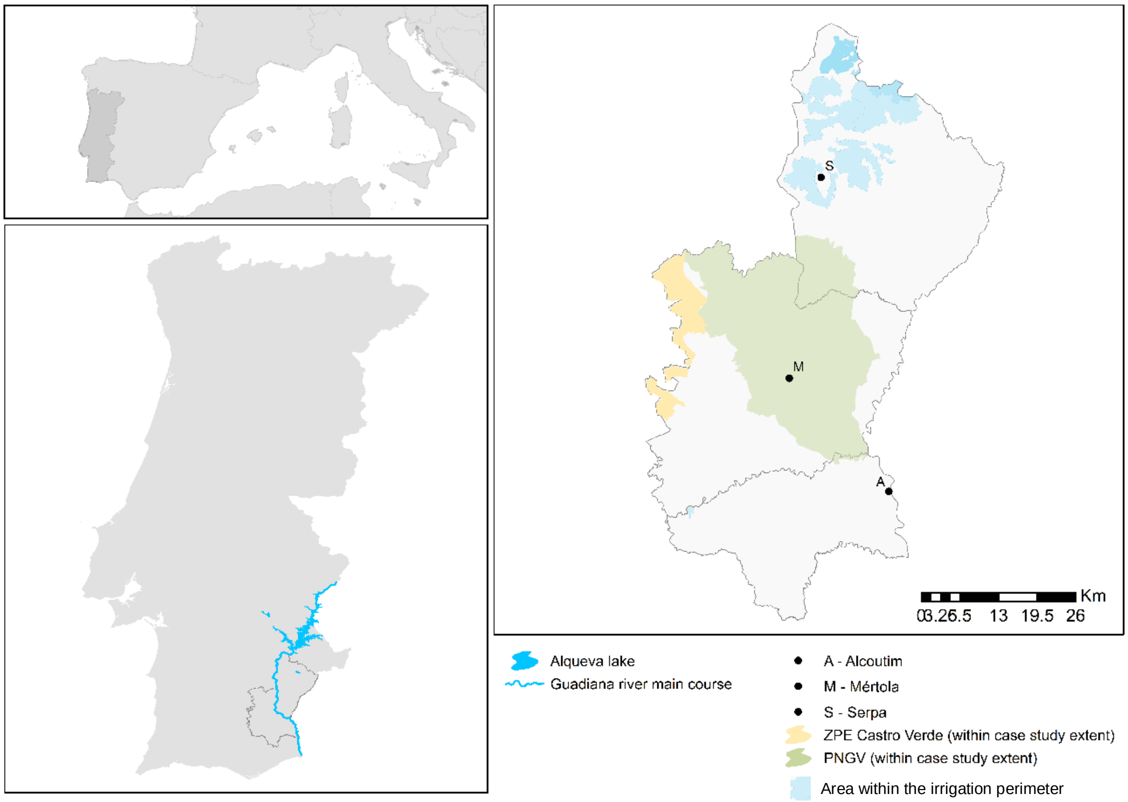

Figure 41 - Location of the case study

Southeast Portugal is highly susceptible to desertification (Rosário 2004). The climate is Mediterranean, and the region characterized by rainfall irregularity both monthly and annually (Roxo and Casimiro 1999). The territory has low ecological value and low aptitude for irrigation agriculture, except in the northern part of Serpa (Leitão et al. 2013, Magalhães et al. 2015). This together with its peripherical location, make this territory marginal in terms of agricultural production. Notwithstanding, agriculture is of relatively economic relevance, employing 15.3% of the working population in Mértola, 18,7% in Serpa and 9.8% in Alcoutim (being the 2nd, 1st and 5th economic sector employing the most people at the municipal level, respectively; INE 2011).

The landscape is a mix of agricultural, forest and agroforestry systems and scrublands. Most of the land is privately owned, with larger average property size in Mértola, and smaller in Serpa and Alcoutim. The landscape is a mix of agricultural, forest and agro-forestry systems and scrublands. Most of the land is privately owned, with larger average property size in Mértola, and smaller in Serpa and Alcoutim.

Table 25 - Summary information on the characteristics of the 3 municipalities in study

	Serpa	Mértola	Alcoutim
Area (ha)	110 563	129 287	57 536
Population density (nº/km2) [a]	14.1	5.6	5.1
UAA (ha) [b]	86 546	90 018	12 448
3-year average irrigated area (ha) [c]	8 244	649	52
Annual rainfall (mm)[a]	314.4	366.2	347.1

[a] (INE 2011)

[b] (INE 2009)

[c] For the year 2015. (SNIRH 2019)

Methods

The methodological approach developed in this case study includes a two-step process. In the first step, local perceptions on the land systems in the 3 municipalities were collected through interviews (22). In the second step we used the participatory approach called territory-game (Angeon and Lardon 2008, Lardon 2013), to promote the construction of a collaborative vision of the future of the land systems in the case study. Through a game-based approach, it is possible to provide actors with a simplified model of reality, to discuss desired outcomes and possible actions (Bishop 2011, Ornetsmüller et al. 2018), gaining a better understanding of desired and possible development pathways adapted to the territory in focus.

Territorial actors (i.e. actors with an explicit role in territorial development) were identified through a review and listing of active associations, cooperative and organizations operating within the territory, as well as relevant institutions at a local regional level. During the contact and data collection processes, other territorial actors were identified through snowballing sampling. In total more than 40 individuals were involved, from 26 different institutions including local farmer cooperatives, specific local cooperatives (beekeepers), farmer's associations, local action groups (LAG), technicians and elected representants from all 3 municipalities, technicians from regional agricultural/development institutions, individual farmers, farmers' associations, NGOs, researchers and a water management institution.

Data collection took place between October 2018 and April 2019. 22 interviews were done in person, in some cases with two respondents from the same institution in simultaneous (considered as 1 interview). The questions were divided into 4 sections: I - characterization of the land systems, II – Recent changes to the land systems; III – Visions for the Future and IV – Commercialization and local food chains. Interviewees were provided with a map of the territory to draw information if wanted and showed a map of land systems as classified for the whole Mediterranean basin, at two different time frames: 2005 and 2015 (see Fusco et al. 2018, 2019 for the land system classification methodology).

The participatory approach took place on the 17th of Abril, with 23 players divided into 5 groups with 4 to 5 players each. The approach follows a board game format to engage different territorial actors in discussing the actual state, future development and possible actions in the territory. It uses a map of the territory as a board and thematic cards to guide the discussion. The thematic cards were informed by data collected in the 1st step of this study, grey and scientific literature. The game is played in 3 steps: 1) diagnosing the present state and the main dynamics affecting the territory using the thematic cards the; 2) imagining a scenario of future development of the territory; and 3) agreeing on possible actions to meet the desired future. Each group presented its work in plenary (figure 2). A more in-depth description of the methodology can be found in (Angeon and Lardon 2008, Lardon 2013). Although the session lasted 3 hours, due to time constraints, the game was shortened with the combination of the first 2 steps. The thematic cards were used to inform a future scenario and not only a diagnosis of the present state.

The question that guided the game emerged from a preliminary analysis of the interviews and was defined as: "Which agricultural practices should be favoured to prevent desertification and strength local commercialization of agriculture products?". The players were provided thematic cards to guide the discussion that were developed with the data collected in the 1st step, defined earlier. The distributed cards were: 1)land systems, 2)soil ecological value, 3) protected areas and Natura network, 4) energy potential, 5) edaphomorphologic aptitude, 6) edaphomorphologic aptitude for tree cover, 7) local production, 8) social drivers, 9) commerce and transformation, 10) hydrographic region, 11) climate scenarios and 12) irrigation infrastructures (see figure 2 for an example of an info card). There was a skilled facilitator for the whole session and each table had an animator to guide the discussion within the groups.

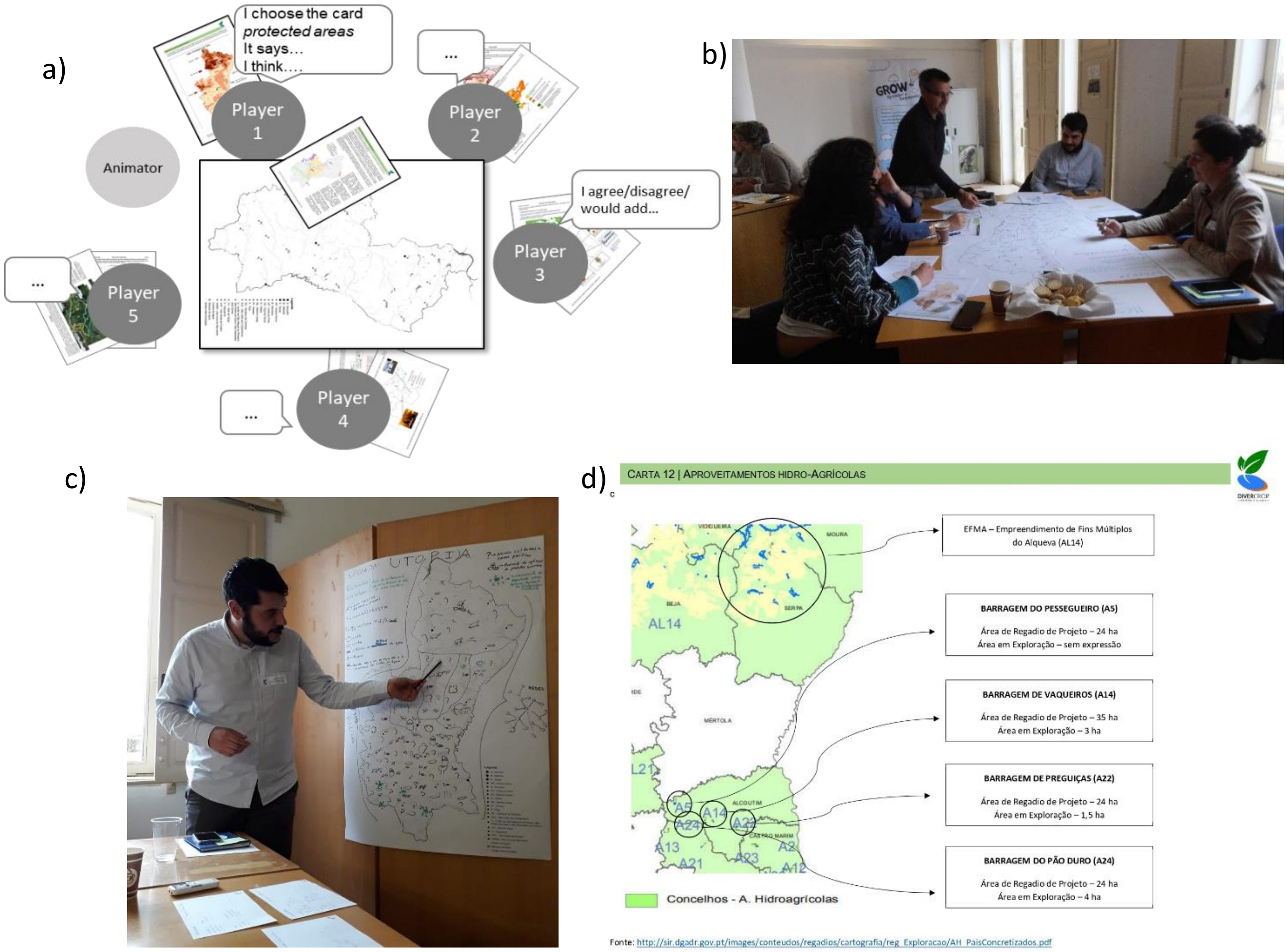

Figure 42 – a) Schematic representation of the game. The game is played over a paper map of the territory. In the each round, each player must choose amongst its cards a theme to discuss (b). At the end of the throw, the selected information must be drawn on the map. The results and maps are shared and discussed with all the groups (c). d) Example of info card (Soil Ecological Value)

The interviews and the plenary discussion of the participatory approach were recorded with the consent of the participants and transcribed. These, together with the resulting vision maps and actions from the territory game, were subject to a content analysis using an analysis grid. The results from both methodologies are presented together in the next section. Distinction between data collected by interview and participatory approach is presented if relevant. We include quotes of the actors involved to illustrate some of the discussed ideas.

Results

Establishing a reference point

Perceptions on the present state of the territory did not differ from data used to characterize the case study. For most participants, it was important to acknowledge the distinction of North of Serpa that has higher agricultural productivity and water availability. In general, the participants distinguished the territory between a) livestock production under different tree densities associated or not with fodder production; b) afforested area; and c) irrigated agriculture, offering a less differentiated characterization that the spatial analysis (Figure 3).

Past and present dynamics

The spatial analysis, developed by Fusco et al., 2018 and 2019, found little changes in the land systems between 2005 and 2015 (Figure 3). Most respondents agreed there was little change between that time frame.

Most respondents reminisced 30 to 50 years back to describe significant changes to the land system. During this period, there was a growth of the forested area, mainly Pinus, in Alcoutim and Mértola due to policy incentives. The measure “2080” (EEC regulation 2080/92, established by the decree 199/94) was mentioned often by the respondents when talking about the afforestation. In Alcoutim, respondents interpreted this phenomenon as an opportunity to generate revenue from land with low profitability. In Mértola, some argued, it was the absentee landowners who opted for afforestation. The financial support for pine plantations has come to an end, and their future is now uncertain since they are not producing fruit as it was supposed to. Interviewees attribute this lack of productivity to the installation of the pine plantations in the shallowest soils of the territory.This example was often used to illustrate how policies for agriculture and development are not suited to the reality of the territory.

“People did not want to abandon the land, because it was family property, even if unproductive. Entering the European Union and agrarian policy made possible the forestation of the properties instead of them just being abandoned.” - technician in forest association

“The dynamics in Alcoutim and Mértola revolve around what was proposed by the EU. During the wheat campaign, there was a big investment in fertilizers and a lot of soil loss. Then it came to the support for the reforestation of agricultural lands” - technician in forestry association

Irrigation is a relatively new reality in the territory, with the operationalization of the Alqueva dam in 2011 in Serpa. Some of the respondents expressed that the opportunity to use irrigation to diversify agriculture was not fully taken. Instead, market pressure, together with favourable policies, drove towards the dominance of olive yards. According to the crop cover data, Olive yards cover 75% of the irrigation perimeter in Serpa, namely intensive and super-intensive productions (EDIA 2018).

“I am in favour of Alqueva but believe there should be limits to intensification. I was in favour of the Alqueva project, and of the possibility of agricultural diversification that did not exist.” – president LAG operating the AMS

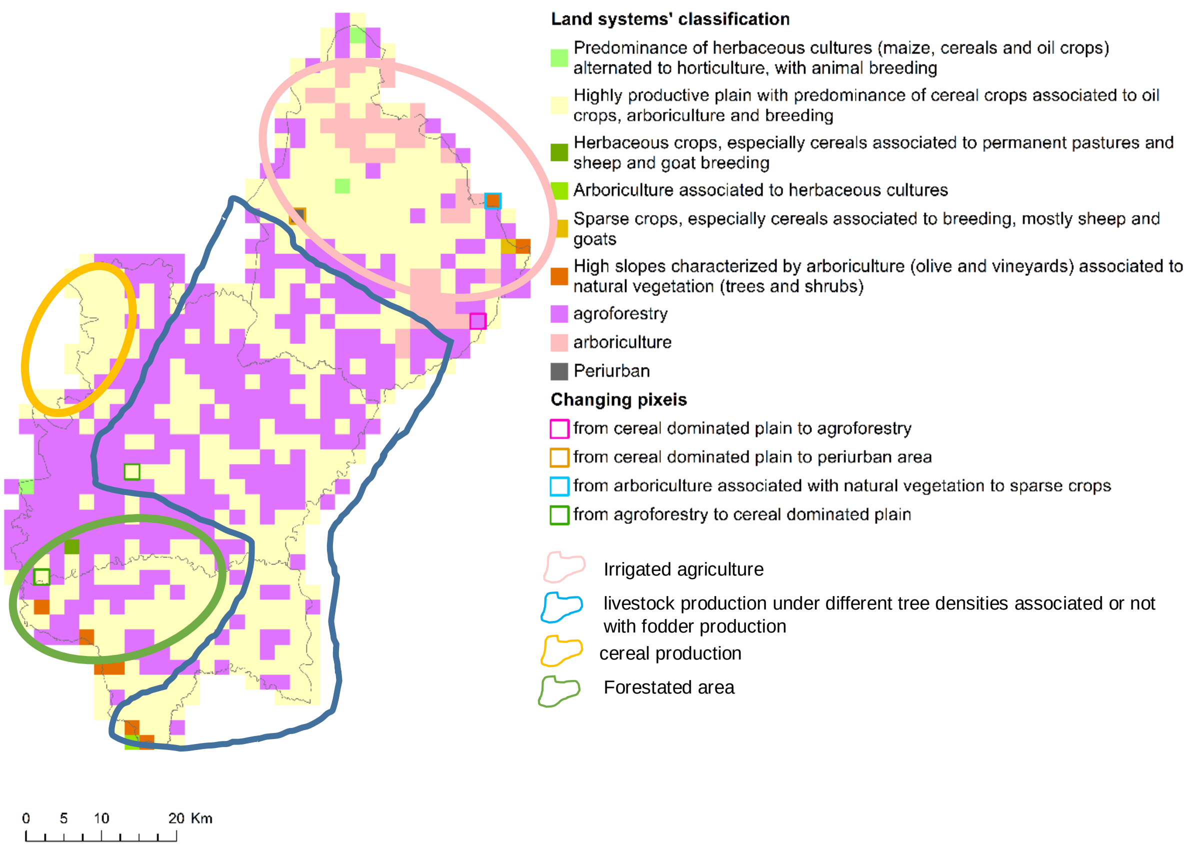

Figure 43 – Land systems as characterized in the spatial analysis (2x2 km pixels) and as described by the territorial actors (drawn shapes over the map).

Many participants presented this growth into intensive monocultural as an example of the development that they do not wish for the territory. In a contrasting position, respondents highlighted the economic development and dynamics it brought, stressing that there is room for other types of agriculture. Namely, Serpa is the host of a skill centre for biological production. Yet, it was more or less consensual that the "social model of Alqueva", as it was labelled by one of the respondents, is flawed, driven by large company interests, not promoting the right dynamics to fixate the population and revitalize the territory. Simultaneously, it was generally felt that drought has been aggravating in the last years with consequences for production.

"Rainfed will not work in the future because of water scarcity. And if it will be scarce, we need to invest in water." – farmer in Alcoutim

"Without water, there is no life. For the last years, we have been in drought (…) my neighbours that have cattle were getting seriously worried. Because food you can buy, but water no…" – beekeeper in Mértola

Although seen as stable, some respondents reported changes to livestock production in the last 10 years. Mainly, small ruminants are being replace by cattle. This due to the lower profitability and demand of small ruminants but also due to incentives from the Common Agrarian Policy (CAP). Reportedly, livestock owners in the territory have had to be granted "urgent access to water" to sustain the animals in 2018 during the drought, whereas other types of production did not enjoy the same benefits.

It also consensual amongst actors that there is not enough cooperation in the territory, and lamb producers used to illustrate the problem. The majority described them has unorganized and believing that this is hindering the sector. It is also perceived that most lamb producers do not have the means to sustain production till slaughter, thus selling their products (usually to intermediaries that sell them to fatteners) early in the production stage and still with little market value. This was considered aggravated by the isolation of the territory and its distance to slaughterhouses, increasing commercialization difficulties. Including the missed opportunity to sell the product a regional and traditional differentiation. Issues of isolation and commercialization were echoed concerning other products.

(Un)Desired Future

In a brighter prevision, montado (a valued and protected silvo-pastoral system, here considered under *Livestock production under different tree densities associated or not with fodder production)* was thought to persist*, crops* would be diversified, techniques water seeding practices would be widespread and drought-resistant species introduced. Contrasting, we also found a grimmer prediction, with continuous desertification, land abandonment, and the progressive intensification of agriculture, where it is viable, and further marginalization of areas where it is not, and degradation of traditional systems, including the *Montado.*

Despite different predictions, the desired future was transversal to participants and methodologies - a developed territory, where agriculture would play an important role, including traditional systems yet favouring crop diversity; an easiness of access to water and of distribution and commercialization of local products; and with conditions to attract and retain people (figure 4). Main consensual points concerning the future development of the territory are presented in table 2.

Differences are found on how to achieve such vision, namely the role of water in an agricultural production system:

"Agriculture must be irrigated. What is done in rainfed systems can only be valued by its services, like biodiversity." – technician at water management institution

"Rainfed production is not playing *with agriculture. […] Irrigated agriculture cannot eliminate rainfed production."* – extensive producer

Table 26 - Desired future as expressed by the actors and possible actions

ISSUE	DESIRABLE FUTURE	SUGGESTED ACTIONS	POSSIBLE ACTORS
Maintenance, protection and improvement of land systems	Improved soil Politics and measures fitted to extensive, multifunctional systems (of Montado in particular) Increased tree cover Predominance of multifunctional systems Exceptions in the management rules within the Natural park that would benefit important practices like beekeeping. A silvo-pastoral regime, with a minimized divide and possible clash between measures for forest and agricultural practices.	Change payment schemes and values not to favor ill-adjusted or unsustainable practices Integration of "forest" and "agricultural" policy measures considering the existence of agroforestry systems- Empowerment of farmers, landowners and policy makers on good practices, adaptive management, water and soil conservation techniques	Political decision makers Municipalities, associations, national park
Increase water availability	Water seeding – agricultural practices concerned with water conservation such as swales and ponds. Use of irrigation has a complement to rain fed systems Accessible irrigation infrastructures to a wider population	Empowerment of farmers, landowners and policy makers on good practices, adaptive management, water collection and conservation techniques	Farmers, general population, municipalities
Cooperation between actors	More dialogue amongst different entities Find and converge on common points of concern	Creation of lobby group to represent the interest of the territory near decision makers	All associations and institutions operating in the territory
Population	Maintain and increase rural population	Incentives for business opportunities and job creation in the territory	Local entities – governmental and non-governmental

ISSUE	DESIRABLE FUTURE	SUGGESTED ACTIONS	POSSIBLE ACTORS
Local market	Easiness of access to of local products in the local market and increase awareness of buyers for local consumption.	Facilitation of the placement of local products in the local market increase awareness of local buyers for local consumption	Markets, Commerce, Collective cantinas, restaurants. All with a communication strategy at a local and global scale
Transformation and commercialization strategies	Organized producers to gain commercialization strength Multi-functional processing centre in the territory. Differentiating marketing The Guadiana River as a “road” to reach a wider market	Creation of a platform of commercialization of the products from the territory	Associations and individual producers
Energetic production	Investment in small projects across the territory		

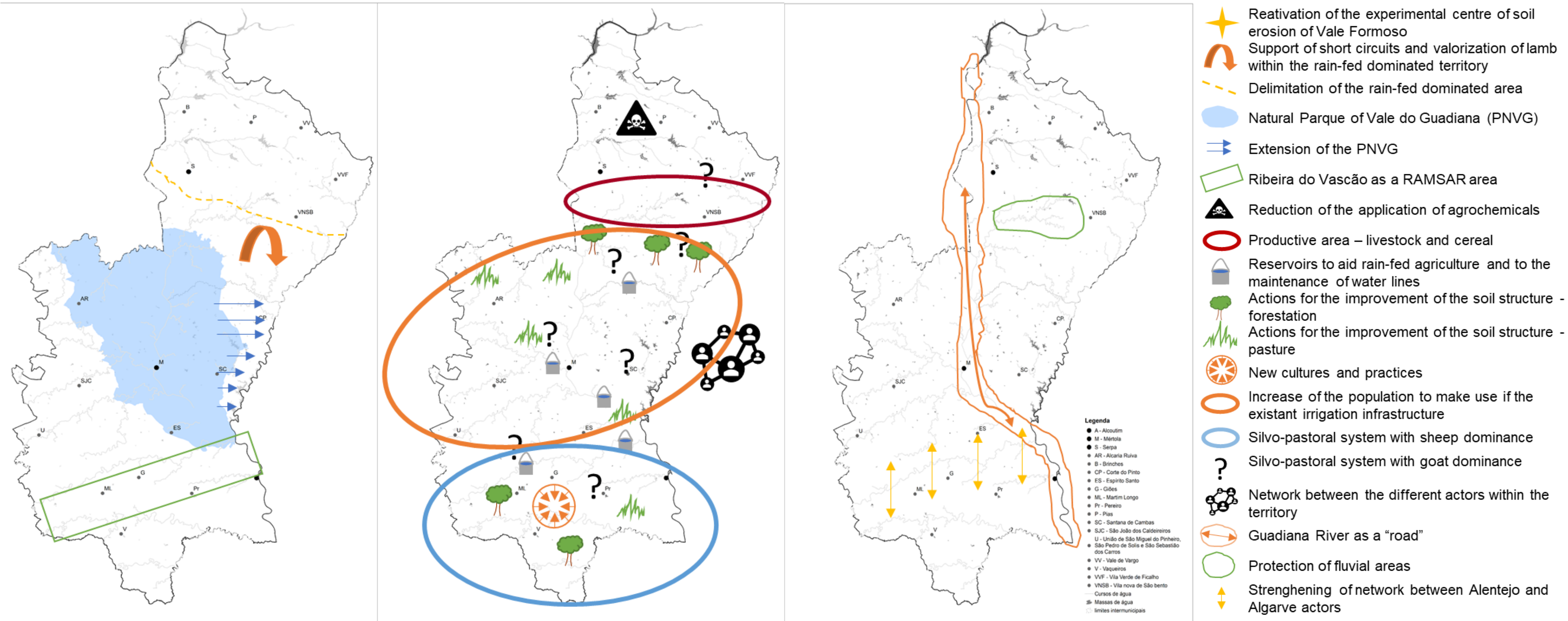

Figure 44 - Schematic representation of future scenario draw by 3 of the 5 group in play. In visions A and B there is a clear divide between the rainfed and irrigated areas (dotted line in A, and a “transition area” in B. The relevance of water resources is present in through the maintenance of the status of ribeira do Vascão, the creation of reservoirs throughout the territory and the use of Guadiana river as a “road

The idea of the introduction or increased access to irrigation infrastructure was described as both a necessity and an unwanted scenario. For some participants, irrigated agriculture was considered a mean to diversify agriculture, fight increasing aridity, and even a necessity for agriculture to continue to be viable under a changing climate. This feeling was particularly strong in Alcoutim, where most participants mentioned the construction of a dam in the municipality as a necessity. The participants that defended dams and irrigated agriculture did not frame rainfed systems as unevaluable. Instead, the persistence of the traditional systems, due to low productivity and revenue, was deemed as bound to their value beyond production, namely through agro-environmental policies. Contrasting, other participants considered the investment in irrigated agriculture would diminish the existence of extensive systems. Hence, participants refer to water seeding techniques such as swales and ponds, which can be implemented at a farm level, to increase water availability. The introduction and farming of drought-resistant species was also supported.

Many of the discussed desired developments for the future imply an action or a change, i.e. not maintaining the status quo. There is a high concordance between the actions defined by the participants and the desired future. The defined actions are summarized in table 2. Although concrete actions were agreed, in its majority actions are dependent from a higher level of decision, often relating to development or agrarian policies. However, there is also a will of organization and cooperation of actors at different levels, including producers, associations and public institutions

Discussion

Dealing with change

The main dynamics identified by the participants in this study are in alignment with trends described in the literature in marginal Mediterranean areas (Pinto Correia et al. 1998, Van Doorn and Bakker 2007, Nainggolan et al. 2012, Debolini et al. 2018). A trend towards irrigated farming, intensification of production and predominance of a single culture was one of the main issues found. In the context of biophysical constrains that characterizes the Mediterranean region, can this trend be sustained in the long term? The opinions found in this study are not consensual. Under the recent strengthening of national and international markets and increasing demand for Mediterranean products, expansion and intensification of agriculture have been encouraged in the Mediterranean (Casas et al. 2015), resulting in higher yields and crop diversification (Caraveli 2000). Yet, similarly to other areas, the fast-paced intensification within the case study region has been raising environmental concerns. Namely relating to the overexploitation and contamination of water (Palma et al. 2009, Ramos et al. 2019), homogenization of the landscapes as well as socio-economic concerns (Silveira et al. 2018). As so, when weighting on intensification in marginal Mediterranean areas it is relevant to investigate who are the beneficiaries, and how it affects the continuity of low-intensity systems, the natural and cultural values they hold, and the services they provide (Rodríguez-Ortega et al. 2017).

The afforestation phenomenon, found mainly in Alcoutim, was seen as a prime example of ill-adjusted CAP to the local context. Pine plantations add little economic value to the territory, and idle reverting depopulation. Further, afforested marginal areas tend to host lower biodiversity levels, and can increase risks of fire hazard (Marull et al. 2015, Otero et al. 2015), comparatively to well managed mosaic landscapes. Alternatively, the promotion of natural regeneration in marginal areas can potentially maintain biodiversity values (Andrés and Ojeda 2002, Navarro and Pereira 2015).

In Mértola, it is harder to distinguish a main trend of development. In one hand policy incentives led to an increase of grazing pressure (Almeida et al. 2016, Pinto-Correia and Azeda 2017). Simultaneously, erratic rain behaviour and low water providence were reported to have affected livestock effectives. Thus, although extensive life stock production dominates the landscape, there is a movement for diversification of cultures and of production methods. Projects such as the recovery of peri-urban food gardens and the implementation of water conservation practices within rainfed production systems are being supported by both the municipality and non-governmental organizations. This apparent "resistance" to global trends can be in part attributed to the civic engagement of Mértola (Morais 2010).

We found a general acknowledgement of the importance of the ecosystem services beyond production, and in particular of those provided by the traditional land systems. This reinforces the pertinence of mechanisms that allow the valorisation of these services and functions (Madureira et al. 2013, Guerra and Pinto-Correia 2016, Lima Santos et al. 2017).

A divergent shared vision

The division around the use of water for development captured in this study is evocative of the debate happening at a wider scale. A position stands by the increase of the irrigated area, not just as means of intensification, but also to safeguard production under climate change. Water requirements are expected to increase, whilst water resources to become scarcer (Costa et al. 2012). The adoption of efficient irrigation has a high-water saving potential (Fader et al. 2015), that could allow for maintaining or increasing production levels under increased aridity. Nonetheless, the deviation of water resources towards agriculture raises concerns for possible conflicts with non-agricultural uses (Iglesias et al. 2007, Döll et al. 2009, Gómez Gómez and Pérez Blanco 2012) and even more in areas arguably less fit for intensive agriculture. A contrasting position defends that rainfed systems ought to be kept and privileged. Yet, most likely adaptations will be needed concerning water management, including water conservation practices such as no-tillage (Laraus 2004, Kassam et al. 2012), that are contrary to common management strategies (Pinto-Correia et al. 2011).

Finally, the study shows that coordination and cooperation amongst actors are highly desired and considered to steer the development of the territory into the desired path. Thus, demonstrated interest by actors is not sufficient, and mechanisms should be put in place to promote higher engagement and support bottom-up initiatives.

Conclusion

Local dynamics in our case study appear to be dominated by global drivers, namely agrarian/rural development policies and market value, that privilege efficiency and production, over natural and cultural value. Local governance, in the form of associations and municipalities, alone and in partnerships, has been seeking to promote diversification of production, strengthening of local markets and to increase water availability. Despite a common vision for a developed and diversified territory with agriculture at a relevant position, disparities amongst stakeholders arise concerning the role of water and irrigation in such a semi-arid region. Although there is an expressed desire to preserve traditional and extensive production systems, it is unclear if the opportunity arises (by increased access to water), areas with lower aptitude will undergo intensification, nonetheless. These findings reinforce the idea that although local initiatives are needed and important, the development of marginal Mediterranean areas is dependent of action at a wider scale (Nacional and European), to define a common strategy towards the desired goal, attending and accommodating territorial specifications.

References

Angeon, V., and S. Lardon. 2008. Participation and governance in territorial development projects: the "territory game" as a local project leadership system. *International Journal of Sustainable Development* 11(2/3/4):262.

Bishop, I. D. 2011. Landscape planning is not a game: Should it be? *Landscape and Urban Planning* 100(4):390–392.

Blondel, J. 2006. The 'Design' of Mediterranean Landscapes: A Millennial Story of Humans and Ecological Systems during the Historic Period. *Human Ecology* 34(5):713–729.

Bugalho, M. N., M. C. Caldeira, J. S. Pereira, J. Aronson, and J. G. Pausas. 2011. Mediterranean cork oak savannas require human use to sustain biodiversity and ecosystem services. *Frontiers in Ecology and the Environment* 9(5):278–286.

Debolini, M., E. Marraccini, J. P. Dubeuf, I. R. Geijzendorffer, C. Guerra, M. Simon, S. Targetti, and C. Napoléone. 2018. Land and farming system dynamics and their drivers in the Mediterranean Basin. *Land Use Policy* 75:702–710.

EDIA. 2018. *Produção Serpa - área e culturas*.

Funatsu, B. M., V. Dubreuil, A. Racapé, N. S. Debortoli, S. Nasuti, and F.-M. Le Tourneau. 2019. Perceptions of climate and climate change by Amazonian communities. *Global Environmental Change* 57:101923.

Fusco, J., E. Marraccini, and M. Debolini. 2019. Intensification, periurbanization and specialization of agriculture as significant short-term land system dynamics in the Mediterranean basin. Colloque SAGEO 2019, Clermont-Ferrand, 13-15 november.

Fusco, J., R. Villani, M. Moulery, T. Sabbatini, L. Hinojosa-Valencia, C. Napoleone, and A. Bondeau. 2018. *DIVERCROP project - Deliverable 1.1: Report on the comprehensive database building*.

ICNB/ICNF. (n.d.). *Zonas de Protecção Especial: Castro Verde. Plano sectorial da Rede Natura 2000*.

ICNF. 2018. Parque Natural do Vale do Guadiana — ICNF. http://www2.icnf.pt/portal/ap/p-nat/pnvg.

INE. 2009. Agricultural Census 2009 - Utilized Agricultural Area (UAA) by Geographic location (NUTS-2013). Instituto Nacional de Estatística, IP – Portugal.

INE. 2011. Population Census 2011 - Resident population (No) by Place of residence. Instituto Nacional de Estatística, IP – Portugal.

Lardon, S. 2013. Developing a territorial project. The 'territory game', a coordination tool for local stakeholders. *FaçSADe (38)*:1–4.

Leitão, M., N. Cortez, and S. B. Pena. 2013. *Valor Ecológico do Solo de Portugal Continental*.

Magalhães, M. R., A. Müller, and S. B. Pena. 2015. *Aptidão Edafo-morfológica à Agricultura de Regadio para Portugal Continental*.

Magliocca, N. R., E. C. Ellis, G. R. H. Allington, A. de Bremond, J. Dell'Angelo, O. Mertz, P. Messerli, P. Meyfroidt, R. Seppelt, and P. H. Verburg. 2018. Closing global knowledge gaps: Producing generalized knowledge from case studies of social-ecological systems. *Global Environmental Change* 50:1–14.

Malek, Ž., and P. H. Verburg. 2017. Mediterranean land systems: Representing diversity and intensity of complex land systems in a dynamic region. *Landscape and Urban Planning* 165:102–116.

Muñoz-Rojas, J., T. Pinto-Correia, and C. Napoleone. 2019. Farm and land system dynamics in the Mediterranean: Integrating different spatial-temporal scales and management approaches. *Land Use Policy* 88:104082.

Nainggolan, D., J. de Vente, C. Boix-Fayos, M. Termansen, K. Hubacek, and M. S. Reed. 2012. Afforestation, agricultural abandonment and intensification: Competing trajectories in semi-arid Mediterranean agro-ecosystems. *Agriculture, Ecosystems & Environment* 159:90–104.

Nayak, P. K., and F. Berkes. 2014. Linking global drivers with local and regional change: a social-ecological system approach in Chilika Lagoon, Bay of Bengal. *Regional Environmental Change* 14(6):2067–2078.

Ornetsmüller, C., J.-C. Castella, and P. H. Verburg. 2018. A multiscale gaming approach to understand farmer's decision making in the boom of maize cultivation in Laos. *Ecology and Society* 23(2).

Peña, J., A. Bonet, J. Bellot, J. R. Sánchez, D. Eisenhuth, S. Hallett, and A. Aledo. 2007. Driving Forces of Land-Use Change in a Cultural Landscape of Spain. Pages 97–116 *Modelling Land-Use Change*. Springer Netherlands, Dordrecht.

Pinto-Correia, T., and L. Kristensen. 2013. Linking research to practice: The landscape as the basis for integrating social and ecological perspectives of the rural. *Landscape and Urban Planning* 120:248–256.

Pinto-Correia, T., and J. Mascarenhas. 1999. Contribution to the extensification/intensification debate: new trends in the Portuguese montado. *Landscape and Urban Planning* 46(1–3):125–131.

Rosário, L. do. 2004. *Indicadores de Desertificação para Portugal Continental*. Direcção G.

Roxo, M. J., and P. Casimiro. 1999. MEDALUS Mediterranean desertification and land use. Estudos sobre desertificação no Baixo Alentejo Interior - Concelho de Mértola. *GeoINova* 0:6–29.

SNIRH. 2019. Dados de Bases. Sistema Nacional de Informação de Recursos Hídricos - Agência Portuguesa do Ambiente.

Turner, B., E. F. Lambin, and A. Reenberg. 2007. The emergence of land change science for global environmental change and sustainability. *Proceedings of the National Academy of Sciences* 104(52):20666–20671.

van Vliet, J., H. L. F. F. de Groot, P. Rietveld, and P. H. Verburg. 2015. Manifestations and underlying drivers of agricultural land use change in Europe. *Landscape and Urban Planning* 133:24–36.

LOCAL AGRICULTURE REACTION TO GLOBAL DYNAMICS. THE CASE OF VEGA BAJA DEL JARAMA, MADRID (SPAIN)

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Introduction

Farming and land system dynamics are affected by global processes that are far beyond their power influence. Globalization, which transformed food systems and the relationships between cities is now at a crossroads (Marsden, 2013). The planet is facing an imminent socioecological crisis (de Castro et al. 2007) and food is one of the critical sectors where profound changes are needed. The group of high-level experts of the United Nations Committee on World Food Security defines sustainable food systems as ones which respect the environment, protect biodiversity and ecosystems, and satisfy nutritional needs by providing culturally acceptable, accessible and healthy food while protecting and improving rural means of life, quality and social wellbeing (HLE, 2017).

Sustainable food systems go beyond agriculture. The connection between locality and sustainability has long been claimed by food sovereignity's advocates (Holt-Gimenez, 2011). This relocation of food system is taking a different shape, though. The retail sector has incorporated "local" as part of their commercial strategies and there is an increasing presence of local food in supermarkets. The business model ain restaurants and catering are "reinvented" and adapted to consumers' growing interest in local products, sensorial experiences around food and the value assigned to the sense of belonging and identity (Cushman & Wakefield, 2018). This relocalization reduces transport, but the rest of conditions from the global system basically remain unchanged i.e large retail operators, intensive production -even eco-intensive- unbalanced relationships, etc.

The local governance context evolves as well at a high speed. Aimed to transform urban food systems at a city scale, an ally appeared recently: the Milan Urban Food Policy Pact (MUFPP) which was launched in October 2015. It has become a frame of reference, as a voluntary treaty signed by cities on committing to working in the development of sustainable, inclusive, resilient, secure and diversified food systems, to guarantee healthy food accessible for everyone. It proposes a rights based model, aiming at reducing food waste and preserving biodiversity, while mitigating and adapting to the effects of climate change. In many ways, this matches the Sustainable Development Goals outlined in the United Nations summit in September 2015. Food councils and food strategies, are relatively new tools for making local policies in the Global North, and have the potential to amplify and consolidate national and international efforts in this direction and facilitate a more synergic approach to implementing SDGs (Ilieva, 2017).

Since a decade ago efforts to re-localize the food system are gaining ground in a way that is supposed to induce changes in the primary sector, improving its conditions and sustainability. It is also well documented that the crisis and proximity to the city induces changes in periurban agricultural practices to adapt to the urban context and the growing urban demand for healthy and proximity food (Adell, 1999; Avila-Sanchez, 2011; Branduini et al, 2017). Despite this growing interest, urban food systems remain fundamentally dependent on global flows (Toth, Rendall and Reitsma, 2016) and ties with local production are barely maintained.

Land systems experience opposing trends, and while major forces keep boosting global food systems, local food is gaining prominence with different approaches. Exploring a local reality allows us to confront how the tension between these two tendencies is resolved or not. The global scale is widely analysed based on global statistics and reports. Nevertheless, understanding the context and specificities at the local level necessarily involves ad hoc field work as data are not disaggregated and qualitative information from stakeholders and local actors is not available. Therefore we select a case study in the region of Madrid (Spain capital city), to bring to the ground a critical question: Is there a local reaction to the global dynamics of the food system? Who are the social and political actors of these reactions? We explore the perception, demands and adoption of measures at the local level, distinguishing between the public and the private sector, as well as the civil society, echoing the well-known triangle of Wiskerke (2009). We can discover who gives priority to creating favorable context conditions for the revitalization of the primary sector and who links this revitalization of the sector with the relocation of the food system and which role they consider for public policies, and specifically for public procurement policies that prioritize local production.

In this paper we present the results of local participatory research developed in the Community of Madrid by Research Group GIAU+S (line of Urban Planning, Agroecology and Food Systems) Universidad Politécnica de Madrid, in collaboration with other entities.

Methodology

The research unfolds at two different scales. At a regional level, we focus on the Comunidad de Madrid, and three different projects provide insights in the evolution of the land and food systems: previous work on "Integrating Periurban Agrarian Ecosystems in Spatial planning (PAEC-Sp)" provides the background and analysis about the evolution of agrarian systems and the direct and indirect impact of urbanization. This analysis and data have been updated within the Operational Group PAUSA (Platform Organic Agriculture, Urbanism and Food Systems). From a recent project "Dynamization of agroecology in the Comunidad de Madrid" we obtain a characterization of the agroecological sector in the region of Madrid.

At a subregional scale we present the results of a case study encompassing three rural municipalities, with a strong agrarian tradition, in the vicinity of the metropolitan area of Madrid (Spain) in Cuenca Baja del Jarama and Titulcia. It has been analyzed within the DIVERCROP project. Based on interviews with relevant informants and participatory workshops, we identify the way in which local population perceive the main changes in land systems along the last ten years and the perspectives for the next thirty. The analysis goes through the evolution of the agrarian systems and practices and the orientation of food production towards local markets.

The research provides insights into the stakeholders' expectations towards the role that public procurement could play in the articulation and consolidation of an emerging sector of production that is more sustainable -in large part, agroecological. It takes into account current distributionof land dediated to organic production in the Comunidad of Madrid, and the orientation of these exploitations, with a special focus on the agroecological projects, for their innovative character. For the latter we update the data provided by the platform Madrid Agroecological which has mapped agroecological consumption and production groups and other spaces with potential to support the agroecological transition, such as public Nurseries.

Results obtained at a local scale can not be extrapolated or generalized, but working with scenarios enables us to explore possibilities. We draw on three basic scenarios concerning general data on public procurement and then move to a specific product, which was selected for the DIVERCROP project, oil, and explore the spatial implications that these scenarios would have on the region.

Regional scale. Agriculture in a region that pretends to be global: Madrid

The region of Madrid hosts 6,5 million inhabitants and aspires to consolidate as a large service hub. Since the 1980s, Madrid strives to be included in the ranks of "global cities" and plans were strategically oriented to building large transport infrastructure and promoting urban megaprojects to make the city attractive to investors, companies, tourists and citizens. Distinguished authors like Saskia Sassen (2016) position Madrid at the top rank of global cities, at least as a recipient of national and foreign investment in real state.

In terms of land dynamics, famingin the Community of Madrid is distributed almost equally between agricultural crops and livestock. Farming has become irrelevant in terms of its contribution to the GDP (0.10%) and to the workforce (0.75%). The figures on the origin of the food entering the region are eloquent: by 2003 food imports accounted for 2330.60 Mill €, by 2010 imports accounted for 98% of the total, a proportion that gives an idea of the regional dependency of the food system, both on external supply areas and on global chains.

The evolution of the land system follows a common pattern: according to Eurostat agricultural area continues to shrink, from 434,790 hectares in 2005, to 377,770 in 2013, which represents a loss of 13% of the surface. The agricultural area used and the number of farms decreased by 12%. In monetary terms, the sector remains more stable, as the reduction is limited to 5%. On the contrary, the decline is stronger in terms of employment, with a reduction of 24% of the labour force in the sector. Only the organic and agroecological farmers experience a positive trend, although the latter usually remains invisible to official statistics.

Paradoxically, the metropolitan area is a hotspot of food consumption. In the regional food industry there is a very low proportion of self-supply of local agricultural products. The regional food industry is oriented to satisfy the demands of the urban population, but not based on the transformation of local products (D. G. de Agricultura, Ganadería y Alimentación, 2017; Vilas Herranz, 2005).

The connection with the rural or peri-urban environment has almost disappeared. Farmers find it difficult to compete in terms of price with international production and, according to the research, they organize farming following subsidies' requirements. They have structural and organizational problems, without vision or entrepreneurial capacity. Monocultures are extended, and the number of farms is gradually reduced, increasing their size. It is an aging sector, in which it is not easy for new farmers to enter and who is in turn reluctant to change.

In this adverse context, and inspired by food sovereignty and agroecology, alternative practices to the global food system have emerged in the region of Madrid since 2000. Their core principles are strongly permeated by the knowledge and culture gleaned from peasant communities both in Latin America and in Spain. This is evidenced in experiences and platforms set up in Madrid, in their practical arrangements, and in their internal collaborative relationships (Simon-Rojo et al., 2018). They explicitly challenge the relationships of competition, their commitment to ecological farming practices and organic production are intended to build alternatives to the prevailing economic model. At the same time, the platforms organized around agroecology and food sovereignty act as channels of civic engagement that bring together farmers and consumers to revert the processes of food commodification that are at the core of capitalist exchange (González de Molina 1996). Their capacity to influence public policies and interact with institutions depends on the political context and the openness of local governments. It depends even more on their own ability to mobilize resources, seize their networks and the power of collective intelligence, and identify synergies between actors and proposals that enable them to be one step ahead of the institutions, pushing to overcome the latter's traditional inertia (Simon-Rojo et al. 2018).

Local scale. Struggling for an enabling environment for sustainable food systems

For the analysis at a local scale we move into the southeast area of the Comunidad de Madrid (Fig 2). It is an area with one of the most fertile plains of the region, i nwhich in previous times the cattle ranching also had an important presence. The rest of the area is occupied by rainfed crops and, to a lesser extent, by olive groves. Until the 1960s, it was an important source of food supply for the capital city. Still an intense agricultural activity is maintained, but the agrarian uses compete with mining activities and extraction sites, as well as urbanization and other artificial uses. Today, almost half the area is protected within the Sureste Regional Park.

In this context, the transformations are being boosted by a small bunch of projects, which have decided to orientate towards quality (organic production) and short supply circuits. Their performance is comparatively better than the rest of the sector, but, despite the potential proximity market that the metropolitan area implies, the model is far to be generalized.

There are general factors operating at a planetary scale such as globalization, the power of corporations and competition between territories (Maye, 2019) that all agents recognize. However, other global challenges such as planning for resilience or disaster risk reduction (and, specifically, food security) in a context of climate change and protracted crisis (Foster and Getz Escudero, 2014) are absent.

Both the private sector and the public one recognize that the proximity to a wide and diverse market such as the metropolitan region with more than 5 million people are a great opportunity. Specially if we take into account the changes in dietary habits and increasing interest in health. Social movements are the ones that do not approach the problem with the lens of “niches” (organic, quality) but do refer to the importance of reinforcing links between production and consumption, talk about identity and revisited culture around localness and food.

Between reseraches, the concept of hybridization it is becoming mainstream, applied mainly to commercialization and consumption. Most of the private sector recognises also that the food supply system combines local and global, agroecological, ecological and conventional production. Farmers are also in favor of a hybridization of the production and of diversification of channels, without finding contradictions between both options: from their logic, claiming support for local production, in connection with sustainability policies, is compatible with looking for export routes to their production, if they get better prices. Only the agroecological sector seeks to direct its production exclusively to local markets. In any case, the entire productive sector coincides with their peers in other parts of the globe, for whom the concern about economic viability precedes the rest of the issues and makes other objectives invisible (Ross, 2006). Consumer groups, social movements and social researchers give as much importance to the momentum of production as to awareness and education in consumption.

In this sense, the research provides insights into the stakeholders' expectations towards the role that public procurement could play in the articulation and consolidation of an emerging sector of production that is more sustainable -and in large part, agroecological-. Some urban policies and food strategies in nearby cities, such as Madrid, have introduced measures to promote sustainable food in public procurement[106]. A basic preliminar assessment of different public procurement scenarios, enables us to estimate the impact it would have on the sector. Given that the city of Madrid is the main pole of consumption in the region and it has already these public policies, Impact assesment is based on Madrid, that according to the official public procurement budget, in 2019 is expected to allocate 1,083,035 euros to buy food.

[106]Madrid's Food Strategy was passed in March 2017

If 20% of this public food procurement is aimed to provide a market channel to local organic farmers, it would represent 1,15% of their total business turnover. The figure rises to 4% if 70% of the public food procurement is supplied through organic agriculture.

In terms of land surface and production, agroecological farmers are a smaller group than the organic one. If 20% of the public food purchase were covered with agroecological production, that would represent 3% of their turnover a percentage that rises to 7.5% with 50% of public agroecological food purchase, and slightly above 10% when 70% of public food procurement is covered by agroecological projects. Since this second sector has smaller dimensions, the impact on it would be greater.

Resultados de escenarios:

A pesar de que estamos hablando de que la superficies necesarias para alimentar las Escuelas Infantiles con patatas ecológicas es muy reducida, en la Comunidad de Madrid no hay prácticamente superficie certificada en producción ecológica de patata, siendo esta inferior a 1 hectárea, computando tanto superficie en prácticas, como en conversión y certificada (MAPAMA, 2017). Sin embargo, sí que existe suficiente capacidad de producción en fincas agroecológicas hortícolas para cubrir la demanda de patata en comedores escolares. Los cálculos deberían extenderse para abarcar el conjunto de los productos hortícolas de temporada, como nos planteamos en la continuación de esta investigación.

la política municipal de incorporación de alimentación ecológica y de proximidad en Escuelas Infantiles. Es una política ya aprobada, aunque todavía en proceso de puesta en marcha, que responde a las demandas de la plataforma ecocomedores y otros colectivos, integrados en Madrid Agroecológico. El análisis geoespacial permite comparar el impacto potencial del cambio de modelo de suministro. Se toma como base de análisis un producto representativo y se evalúan distintos escenarios, según sea sistema de producción convencional o ecológico y según el sistema de distribución sea el normal de Mercamadrid o de proximidad (vinculado a Mercamadrid o directamente con los productores agroecológicos).

References

Adell, G. (1999). Theories and models of the peri-urban interface: a changing conceptual landscape.

Ávila-Sánchez, Héctor. (2011) "Socio-territorial changes in peri-urban food production spaces in Central Mexico." *Norois. Environnement, aménagement, société* 221: 39-51.

Branduini, P.N., Van der Schans, J.W., Lorleberg, W., Alfranca, O., Alves, E., Anderson, G., Branduini, E., LD, G., Heller, G., Herkströter, A. and Kemper, D., (2016). It is a business! Business models in urban agriculture. In Lohrberg et al. 2016. *Urban Agriculture Europe*

Cushman & Wakefield. (2018) Food & Beverage Retail España 2018.

D. G. de Agricultura, Ganadería y Alimentación. (2017). *Programa de Desarrollo Rural de la Comunidad de Madrid 2014-2020*. Madrid

De Castro, M., Ramis, C., Cotarelo, P., & Riechmann, J. (2007). *Cambio climático: un reto social inminente.*

Forster, T. & Getz Escudero, A. (2014). *City Regions as Landscapes for People Food and Nature (*p. 62). Washington, USA: EcoAgriculture Partners.

HLPE. 2017. Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome

Holt-Giménez, E. (2011). Food security, food justice, or food sovereignty. *Cultivating food justice: Race, class, and sustainability*, 309-330.

Ilieva, R. T. (2017). Urban Food Systems Strategies: A Promising Tool for Implementing the SDGs in Practice. *Sustainability*, 9 (10),17 07

Marsden, T. (2013). From post-productionism to reflexive governance: Contested transitions in securing more sustainable food futures. *Journal of Rural Studies*, 29, 12 3 -13 4.

Maye, D. (2019) 'Smart food city': Conceptual relations between smart city planning, urban food systems and innovation theory. *City, Culture and Society*, 16. pp, 18-24.

Ross, N. J. (2016) How civic is it? Success stories in locally focused agriculture in Maine. *Renewable Agriculture and Food Systems,* 21(2). pp 114-123.

Sassen, S. (2016). *Global networks, linked cities*. Routledge.

Simon-Rojo, M., Couceiro-Arroyo, A., & Fariña-Tojo, J. (2019). La relocalización alimentaria débil: desconexión entre agentes del territorio y planificación espacial/Weak food relocation: Disconnection between territorial agents and spatial planning. *Urbano*, 106-123 DOI: https://doi.org/10.22320/07183607.2019.22.39.06

Simon-Rojo, M., Morales Bernardos, I. & Sanz Landaluze, J. (2018). Food Movements Oscillating Between Autonomy and Co-Production of Public Policies in the City of Madrid. *Nature and Culture*, *13*(1), 47-68.

Toth, A., Rendall, S., & Reitsma, F. (2016). Resilient food systems: a qualitative tool for measuring food resilience. *Urban ecosystems*, 19(1), 19-43.

Vilas Herranz, F. (2005). *Estructura de la industria alimentaria y las tendencias del consumo en la Comunidad de Madrid: Base para la realización de estudios sectoriales.* Madrid: Consejería de Sanidad - D. G. de Salud Pública de la Comunidad de Madrid.

Wiskerke, Han. 2009. On Places Lost and Places Regained: Reflections on the Alternative Food Geography and Sustainable Regional Development. *International Planning Studies* 14 (4): 369–387. doi:10.1080/13563471003642803

ACTORS, SCALES, SPACES DYNAMICS LINKED TO GROUNDWATER RESOURCES USE FOR AGRICULTURE PRODUCTION: DRIVERS OF CHANGE AND FUTURE PERSPECTIVES OF THE TERRITORY IN HAOUARIA PLAIN, TUNISIA- A TERRITORY GAME APPROACH

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Abstract

Groundwater resources became a recognized enabler of important rural and socio-economic development in Mediterranean countries. However, the development of this groundwater economy is currently associated with an increased pressure on the available resource and negative implications on the socio-ecological system. While there is a wide recognition that resource degradation threatens the sustenance of the agricultural system and the region's economy, viable strategies for effective water resources governance have not been forthcoming. Managing complex socio-ecological systems, such as occur in water resource management, is a multi-actor, multi-scale and dynamic decision-making process. Such a complex process involves a diversity of stakeholders. Local case studies developed in the framework of the Arimnet2 project DIVERCROP (Land system dynamics in the Mediterranean basin across scales as relevant indicator for species diversity and local food systems) have the purpose to characterize the current spatial agricultural dynamics, linked to the groundwater use, trends and impacts on agricultural practices, species diversity and local food systems. We chose to apply a territory game in the Haouaria plain, in Northern Tunisia, where farmers are currently dependent upon groundwater use for their livelihood and food security. The territory game is used as a collective learning and collaborative construction tool for building common representations of the future of the territory, perceived by local actors and planned by more global decision-makers. The perception of the territorial dynamics revealed three main issues: (i) the land fragmentation and the increasing urbanization, (ii) the agricultural products' marketing and the trade monopolies, and (iii) the pollution caused by agricultural and industrial activities. The local stakeholders emphasized the need to strengthen water resources management policies, farmland protection laws and farmers' collective organization, reforming regulated markets and providing farmers with alternative market opportunities. The local stakeholders coordinate actors, activities and spaces on their territory. Spaces such as El Garâa basin, littoral forest or transformation units are at stake to develop an integrated response to territorial issues. Local initiatives and global dynamics involve preservation of agricultural land, water management and territorial governance for an integrated development. These drivers of change have to be taking into account by the policy decision-makers.

LEARNING THROUGH SCENARIOS TO SUPPORT THE SUSTAINABILITY OF EU FARMING SYSTEMS

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Abstract: The increasing globalisation of food is affecting the European farming systems with growing market complexities and risks that require greater adaptive capacities, skills and smarter tools in farm and food chain management. Those tools and capabilities appear to be strongly influenced by learning processes. Learning processes are positively co-related to an improved capacity to successfully manage the farming system's conditions and changes across future scenarios. While farming systems can employ different learning patterns, the latter are mainly scenario-driven and focus on "glocal" objectives formulated by individual or networks, which are - in turn - affected by the ongoing management options and visions, as well as by limited local resources (including government extension services). If something is missing in this patchwork of skills, resources and local visions throughout participatory scenario analysis, farm managers and actors are forced to move within a temporal dimension across future alternatives and start thinking in more creative ways. The opportunity to develop more sustainable farming systems presupposes that farmers agree to include new environmental concerns in their action choices, so it implies a dynamic that entails a progressive change in their abilities and motivations to question the validity of the technical and normative knowledge acquired through past-intensive farming models. The farming system literature primarily deals with well-defined and static categories of farms, but only few papers include a temporal dimension and analyse the dynamic behind the farmers' decision-making process of learning through scenarios. Scenarios are highly temporal constructs, concerning future state of farming, with the objective to influence current decision making and action choices. There is a plentiful literature on time and temporality within sociology/geography, but this has only been sporadically integrated in the farming systems literature. In this paper we analyse how scenario analysis can further contribute to develop smart and tailored learning processes at the regional and local levels in order to tackle a key challenge for European agriculture, namely support for sustainability of production and marketing in diverse farming systems. This paper presents key results of critical reflections jointly made by researchers and stakeholders focusing on wine in Italy and olive oil in Portugal, poultry in Denmark, throughout participatory workshops aimed at the co-creation of future scenarios. Our findings provide science and policy making with insights into how farmers learn to make strategic and tactical decisions against potential future scenarios for their farming systems. The scenario analysis implemented encouraged an active learning process that influenced participants to re-examine the validity of their technical, experiential, and normative knowledge, which legitimise their reason for acting. The discussion shows which type of scenarios are favoured, actualised and how farmers collectively legitimise or avoid specific decisions in each scenario settings. Scenarios as a "future generating device" have a key role in the strategic process that guides agricultural actors to integrate specific knowledge, moral obligations, and sustainability principles to re-examine their decisions.

GREEN INFRASTRUCTURE FOR ECOLOGICAL AND STRATEGIC TERRITORIAL PLANNING TO IMPROVE THE INTEGRATION OF AGRICULTURAL LANDSCAPES

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Abstract

Agrarian landscapes, biodiversity, and local food systems are facing multiple challenges in metropolitan areas. These challenges are caused by factors such as the intense urban sprawl in metropolitan regions, the neo-liberal policies on the deregulation of land use, and the ever-increasing disconnection between the areas of production and consumption caused by the globalization of agri-food production. The effects are multiple such as changes in land use, rupture of inherited socio-ecological networks, fragmented agrarian landscapes, loss of connectivity, deterioration of biodiversity, and regression of traditional agricultural activity. In this context, the European Union's 2020 Biodiversity Strategy highlighted the urgent need to extend conservation initiatives beyond protected areas and expand conservation measures to the entire territorial matrix through the creation of Green Infrastructure (GI).

Although this territorial instrument is not exempt from criticism, from our point of view, it can be innovative in the way of dealing with different problems because of its holistic approach. Essentially because it offers a variety of practical solutions based on nature for a wide range of ecological, socioeconomic, and territorial problems, which can represent a turning point in the initiatives to address sustainable planning of the open green spaces in metropolitan areas more intensely subjected to urban sprawl.

A recent critical literature review of recent literature on the subject (Yacamán, Mata, and Ferrer, 2020), of the last 10 years, highlights the gap that exists in most research papers related to the analysis of the functions and the provision of ecosystem services of the territorial matrix from a socio-ecological approach. Based on the lack of attention paid, in both academic research and policies, we propose from a more innovative socio-ecological approach, to give more weight and visibility to the territorial matrix (composed mainly of agrarian landscapes), to improve the territorial resilience from a biological, ecological, and social point of view (Berdoulay et Soubeyran, 2020). This is since the conservation of the agrarian matrix will affect the functionality of the network, reducing the urban pressure of the nodes-composed of areas that host high biodiversity- and decreasing the fragmentation of the corridors -that ensure ecological connectivity-. For this reason, it is also necessary to reverse the secondary role assigned to traditional agriculture in GI planning as in general in strategic planning (Feria and Santiago, 2015), since a is necessary for the sustainable management of landscapes that maintain agroecosystem services. In conclusion, GI must contribute to strengthening sustainable agriculture and its landscapes from a multifunctional and territorialized perspective, through specific instruments, promoting the inclusion of agricultural parks, capable of activating local agriculture, particularly peri-urban agriculture, the conservation of fertile spaces of the territorial matrix, and the agrobiodiversity of agroecosystems.

FARMERS' PERCEPTIONS OF LEVERS AND BARRIERS TO CROP-LIVESTOCK INTEGRATION BEYOND FARM LEVEL. A CASE-STUDY IN FRANCE.

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Abstract: Integrating crop and livestock is broadly seen as an ideal option to maintain agricultural production levels while limiting environmental impacts on soil and biodiversity. Still, European crop-livestock farms keep declining due to globalized markets, agricultural policies and limited availability of workforce and skills. Reconnecting neighbouring specialized crop farms and livestock farms through grain, fodder, crop by-products and manure exchanges could be an alternative to overcome these limiting factors. Up to now, such collective organization is still rarely observed despite its potential advantages. In this study, we tried to understand farmers' perceptions to highlight levers and barriers to crop-livestock integration beyond farm level. We analyzed interviews of 19 farmers interested in building such collaborations in Ariege, South-western France (8 crop farmers, 7 livestock farmers and 4 crop-livestock farmers). We observed different levels of involvement considered by the farmers ranging from wishing to buy local feed or establish new crops only if a local cooperative was creating contracts, to wishing to build a strong collaboration among local group over time. Different types of collective organization were mentioned, ranging from polycentric organization involving only farmers up to a governance through a local cooperative. The main barriers were related to logistics and storage, time management, low costs of inputs as regards to the time needed to implement such local cooperation, and establishment of trust. The main levers were the existence of local cooperatives or machinery groups that could drive the project and establish contracts, new policies oriented toward collective actions and a niche-market that recognized the interest of local feed for livestock. We highlighted a strong implicit divergence between the mindsets of crop farmers relative to livestock farmers that could hinder this type of local cooperation as they have few relationships and low trust. We suggest that farmers that already have both crops and livestock may be an ideal-type to improve ties between specialized farmers. In-depth analysis of farmer motivations and long-term efforts to build strong local networks and new policies would thus be key to favour the development of crop-livestock integration beyond farm level.

COMPARING VIEWPOINTS ON AGRICULTURAL DEVELOPMENT

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INTRODUCTION

In developing countries, agriculture remains an important sector, contributing to both a large part of GDP and to rural employment. Some countries have launched ambitious policies to develop and sustain their agricultural sector. For instance, Morocco, the case study of our research is based on, developed a program in 2008, namely the Green Morocco Plan (GMP), defining two pillars of action. The first targets large-sized farms for the development of high added-value chains, with a modern and productivity-oriented agriculture. The second tends to ensure solidarity-based mechanisms to support small and medium-sized farms, of which the large majority of Moroccan farmers are comprised, with the objective of alleviating poverty through the increase of farmers' agricultural income. The former pillar is endowed with two to three times more funding than the latter (Marzin *et al.*, 2017). Main actions for the two pillars concern farmers' organizations, economic management of water resources, technical assistance, as well as the creation and modernization of distribution channels. In accordance with the GMP, the Moroccan government also adopted a new long-term water saving program (National Irrigation Water Saving Program), aiming at developing micro-irrigation.

The Mediterranean area faces several specific challenges, in addition to population increase and land fragmentation, these latter being common to most developing countries. Indeed, the Mediterranean region is foreseen to be a hotspot for the impacts of climate change, thus presenting a high vulnerability to global changes (Giorgi and Lionello, 2008). Vulnerability to climate variability and changes may be even more prominent for irrigated systems, which are common in the southern part of the Mediterranean Sea. First, irrigation has expanded in most countries of the Southern Mediterranean zone. In Morocco, for example, 13% of Utilized Agricultural Area (UAA) is equipped with irrigation (High Commission for Planning, 2007). Increasing water scarcity, due both to overexploited aquifers and climate changes, endangers the livelihoods of rural farmers in the Southern Mediterranean countries. In addition, market and processing conditions such as price volatility or storage ability of agricultural products (Lejars and Courilleau, 2014), which depend in turn on multiple factors such as farm type or localization, can accentuate the vulnerability of agriculture and certain social categories of farmers.

Encouraging both a sustainable development of the agricultural sector and lower resource use and impacts, depends, among others, on the availability of functional and accessible services to the greatest number of farmers, and in particular of agricultural advisory services (Dugué *et al.*, 2014). A salient issue affecting the effectiveness of advisory services is the (mis-)match between farmers' expectations (e.g., information, technical advices, innovation, etc.) and the real advices that can be provided (Dugué *et al.*, 2014). In addition, both advisory expectations, requests and services can depend on the diversity of farming systems, including the agro-ecological situations, pedoclimatic conditions, farming systems, and/or access to resources (e.g., financial, water, labor, etc.) (Dugué *et al*., 2014). This requires, at first, that the diagnosis of the specific agricultural and farming situation, its advantages, limits, and possible evolutions, is shared between farmers and the representatives of advisory services.

The case study of Morocco, which is the focus of this study, is of particular interest with regards to advisory services. Indeed, the Moroccan state faced the necessity to reform its advisory service for agriculture, particularly to achieve the goals of the "Green Morocco Plan". In 2011, the state thus initiated a new strategy for its agricultural advisory system, based on three main principles: (1) a diversity of actors involved in the management, implementation and financing of agricultural advisory systems (e.g., including both private and public actors); (2) a scaling down of the advisory services, from national to local, in order to provide a service that could be individual, personalized, and (3) providing farmers with modern technologies for analyses (e.g., soil) and communication to favor the wide dissemination of information, and the possibility of "remote advice" (e.g., consultation of online professional information) (Dugué *et al.*, 2014).

This paper questions how agriculture is perceived by different local actors, namely administration members and farmers. Addressing this question can be performed using different methods and data, e.g., focusing more on direct information (e.g., interviews) or indirect ones (e.g., literature). As individual and collective visions, by definition, evolve through time, we chose to gather information and viewpoints directly with the core actors of the agricultural system. Analysing a collection of oral and qualitative arguments, i.e., *verbatims* requires a method to be able to classify, organize, and compare these arguments. A very common method is the SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats). SWOT generally consists of a list of factors, which can be used to describe the current (corresponding to the SW section of the framework) and possibly future (OT) trends of both internal and external environments describing and/or influencing the studied system (Yavuz and Baycan, 2013). The SWOT analysis thus allows to conduct a situational evaluation (Wickramasinghe and Takano, 2009) to categorize key factors (Nazari *et al.*, 2018). To identify the main themes that SWOT arguments are based upon, the PESTLE approach is a useful tool. This framework has been used in the business and management sectors to monitor the macro-environmental factors that have an impact on the studied system environment (Yudha *et al.*, 2018). PESTLE considers Political, Economic, Social, Technological, Legal, and Environmental classes to categorize sets of factors and facilitate their analysis and comparison. Combining SWOT and PESTLE frameworks hence allows to build a deep insight and understanding on the current realities of a complex problem (Nazari *et al.*, 2018), where visions could differ either in terms of arguments, class, or categorization (e.g., an argument viewed as a strength for one type of actor could be considered as a weakness for another one).

The objective of this study is to compare/confront the visions of practitioners (i.e., farmers) and people responsible for local agricultural administrations (e.g., Regional and Provincial Boards for Agriculture), in order to qualitatively characterize the agricultural sector of a Moroccan agricultural region, namely the Saïss plain.

STUDY AREA

The Saïss plain covers 2,200 km^2, of which about 1,910 km^2 is dedicated to agriculture (Fofack *et al.*, 2015). Climate is of the semi-arid type, and irrigated agriculture has developed since the

1980's and has boomed since the 2000's, leading to a strong decrease in areas dedicated to rainfed crops, and subsequently to a large overexploitation of the aquifer (Ameur *et al.*, 2017a; Quarouch *et al.*, 2014). Irrigated crops (mainly potato, onions, plum and peach orchards, and vineyards) are cropped with a high use of chemical fertilizers and pesticides (Baccar *et al.*, 2018). In 2012, the irrigated area represented approximately 23% of the Saïss plain (Kuper *et al.*, 2016).

SURVEYS AND DATA ANALYSIS

We conducted two series of interviews and meetings with farmers or local administrations to build SWOT diagrams, summarizing their vision of the regional agricultural features. We then mobilized the PESTLE framework to highlight the main themes that were spotted by the two types of actors. The combined SWOT/PESTLE framework was hence used to investigate the current status of agricultural development in the Saïss plain, Morocco, based on the subjective points of view of the two types of actors' interviewees, i.e. two groups of farmers (two cooperatives), and four different local administrations responsible for agriculture.
Note that farmers' viewpoints were more focused on irrigated agriculture, as they all had access to irrigation, while local administration's viewpoints included both rainfed and irrigated agriculture. First, we interviewed individually local stakeholders to gather their viewpoints (in 2018), organized within the SWOT structure. Note that these interviews were performed individually for each structure (Table 1), but that more than one person participated in each interview. Individual SWOT diagrams were then merged and presented in a collective meeting comprising more diverse local stakeholders, for validation and completion. Second, we organized two collective farmers' meetings (in 2019), in which SWOT diagrams were completed by farmers to share their diagnosis with the research team.

Four local administrations responsible for agriculture (extension services) were asked to build a SWOT diagram: the Provincial Boards for Agriculture (DPA) of two provinces (1) El Hajeb and (2) Meknes; (3) the regional Agricultural Council ("Chambre d'Agriculture", CA); and (4) the National Board of advisory services in the agricultural sector (ONCA). These three types of extension services for agricultural development have different functions. While the Provincial Boards focus on subsidies' attribution, local statistics and provide technical assistance for agricultural projects financed by the GMP (e.g., for drip irrigation), the Agricultural Council and the National Board focus more on technical advices and rural development. The ONCA (National Board) was created in 2013 to fulfill the state ambitions of restructuring the advisory system, based on the objectives of the Green Morocco Plan. Its specific mission is to implement the actions of agricultural advice in the whole country (Dugué *et al*., 2014). It is structured with regional, provincial and local levels.

The two groups of farmers, with whom we built the SWOT structure, were located in the rural municipality of Iqaddar, which is a part of El Hajeb Province (within agrarian reform cooperatives of Regraga and Eddakhla, undergoing a privatization process). They are two cooperatives of "medium-sized" farmers (i.e., average of 14 ha and 9 ha for the Regraga and Eddakhla, respectively). Regraga involves 36 farms, and Eddakhla 43 farms (data 2015). For the two cooperatives, the main source of irrigation is groundwater, mainly mobilized with shallow and low yielding wells (69% and 72% for Regraga and Eddakhla, respectively). Regarding the farming systems (data 2015), in the Regraga cooperative, UAA was dominated by rainfed cereals (mainly wheat), market gardening, and forage crops (32%, 24% and 18%, respectively). In the Eddakhla cooperative, the main agricultural uses were cereals (34%), forage crops (21%), market gardening and fallows (18% and 17%, respectively). Livestock production is important for the two cooperatives, justifying the large area dedicated to cereals and forage crops. Eddakhla was created more recently than Regraga (1991 vs. 1972), the last presenting thus a higher parceling out, and more conflicts linked to successions, leading to more land transfers.

The results of the SWOT diagrams built by these two types of actors (local administrations in charge of agriculture / members of advisory boards in the one hand; farmers in the other) were then analyzed both in a quantitative and a more qualitative way. For the former, the analysis was based on the PESTLE framework to highlight the main themes identified by the two types of stakeholders regarding the four SWOT categories. The experts of the research team classified the SWOT factors across the six PESTLE classes (Political, Economic, Social, Technological, Legal, and Environmental). For the qualitative analysis, we illustrated the SWOT/PESTLE analysis with the main issues the actors expressed.

These analyses were performed to (1) compare viewpoints of two types of actors, and (2) identify whether different viewpoints co-existed among each type of actors.

PESTLE arguments

Members of the research team classified the different arguments mentioned by both farmers and local administrations within the PESTLE framework (Table 1). This classification highlighted that Environmental arguments presented the largest diversity (17 different arguments), followed by Technological arguments (3), and the less diverse argument being cited belonged the Legal class (Table 1; Figure 1). The Environmental class arguments included climate, soil, water and the diversity of crops and type of systems of the region. Arguments of all classes were cited by all interviewed actors, except Legal arguments which were cited only by two administrations. While arguments of Economic, Social, Technological and Environmental classes were found in all parts of the SWOT diagram, no Political threat was identified, and no Legal strength or weakness appeared during the interviews.

Table 1. Classification of cited SWOT arguments in the PESTLE classes for all stakeholders. In the column SWOT are indicated the SWOT categories mentioned according to the PESTLE classes (e.g., missing T means that no threat was mentioned).

PESTLE class	Class mentioned by	SWOT class	Arguments
Political	all interviewed	SOW	administrative procedures, agricultural development funds, agricultural policies, "big farmer", infrastructures, subsidies, agropolis*, strengthening ONCA and ONSSA, rural isolation
Economic	all interviewed	SWOT	ecotourism, financial resources, input prices, insurances, investment friendly zone, market access, marketing, "overproduction", production costs, product valuation
Social	all interviewed	SWOT	age of farmers, collective action, coordination between institutions, coordination between farmers, extension, fragmentation of land, labor, land tenure, professional organizations, succession, support/advice

Techno-logical	all interviewed	SWOT	direct sowing, efficacy of products, information, irrigation technics, know-how, mechanization, number of tractors, packaging, productivity related to technique, product quality, storage, valorization unit, yield/level of production
Legal	DPA El Hajeb, CA	OT	standards for export, labeled products (organic, terroir)
Environ-mental	all interviewed	SWOT	arboriculture, climate, climate change, dam (increase irrigated areas), diseases, diversified agriculture, frost, geographical location (close to big cities), livestock and forage resources, low area for livestock, one crop per year, onion country, rain, soil quality, suitable area for crop diversity, water, weeds development

* the Agropolis, located in Meknes (center of the Saïss area), is an industrial zone built to favor agricultural development, with the aim to strengthen the processing and marketing of agricultural products. Its construction was funded by the second pillar of the "Green Morocco Plan; ONCA: National Agricultural Advisory Board; ONSSA: National Office of Food safety.

The overall SWOT/PESTLE diagram showed the dominancy of the classes Environmental, Economic and Social (the two last being almost equivalent) (Figure 1A). However, downscaling to each SWOT compartment gives a rather different picture (Figure 1B). Environmental arguments largely dominated (>50% of the number of arguments) in both Strength (abundant water and very good soil quality being the two most cited) and Threat (climate change/variability and diseases being the most cited) arguments. Environmental arguments were still very important in the Opportunity frame (31% of all arguments, with the climate enabling diversification, and the future dams) and not really considered as a Weakness (although decreasing water quantity and soil quality were mentioned) (Figure 1B). No Legal nor Economic argument were considered as strengths, and Social arguments dominated the Weakness frame (e.g., lack of collective action, of cooperation, difficulty to find extra-workers). Technological arguments were seen more as a Strength (e.g., "know-how", increasing number of tractors) and Opportunity (direct sowing technics, possibility to improve irrigation technics) (Figure 1B).

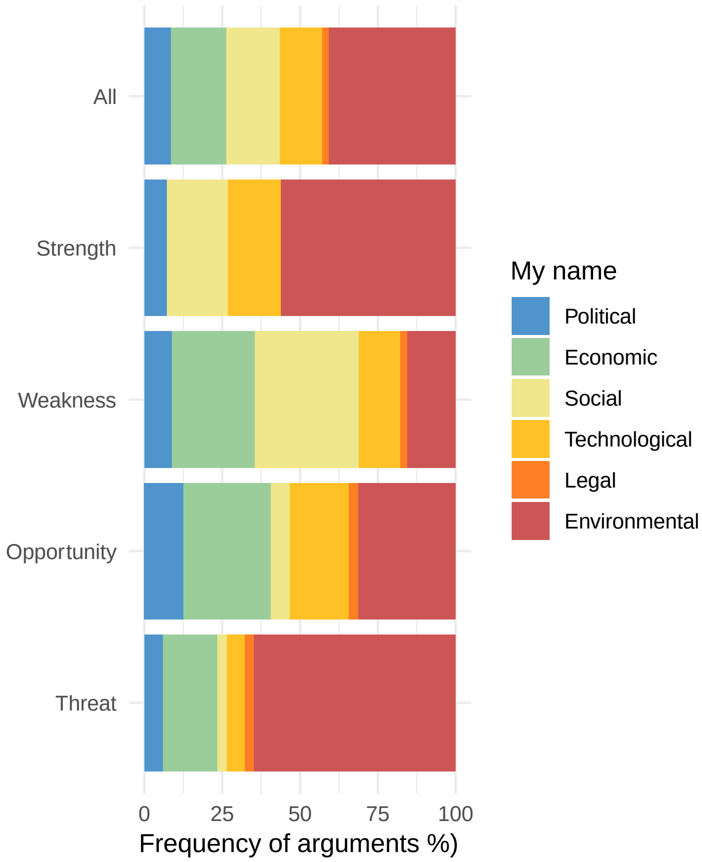

Figure 1. Distribution of PESTLE classes of for all SWOT arguments of the two types of actors (at the top) interviewed and according to each SWOT class.

COMPARISON BETWEEN THE TWO ACTORS' TYPES

Overall, the farmers' cooperatives had a more negative vision of agriculture than the local administrations, with more than 60% of arguments related to weaknesses and threats, and very few opportunities were identified (Table 2). While local administrations listed slightly more weaknesses than strengths, they identified more opportunities than threats.

Similarly, the PESTLE distribution profiles differed between the two types of actors. Legal arguments (Table 1) were cited only by local administrations' representatives, Environmental arguments were more cited by farmers' cooperatives than by local administrations (65.5% vs. 26.8%), and Technological and Social arguments were cited mainly by local administrations (Table 2). Finally, Economic arguments were (surprisingly) cited more by local administrations than by farmers' cooperatives (Table 2).

Table 2. Distribution of SWOT and PESTLE class for the two types of actors.

	SWOT class				PESTLE class					
Actors	S (%)	W (%)	O (%)	T (%)	P (%)	Eco (%)	S (%)	T (%)	L (%)	Env (%)
Farmers	23.6	29.1	14.5	32.7	9.1	14.5	5.5	5.5	0	65.5

Administra-tions	28.9	29.9	24.7	16.5	8.2	19.6	23.7	18.6	3.1	26.8

S: Strengths; W: Weaknesses; O: Opportunities; Th: Threats; P: Political; Eco: Economic; So: Social; T: Technological; L: Legal; Env: Environmental.

Combining SWOT/PESTLE allowed more insight into the preceding results. Only administrations' representatives identified Economic opportunities, such as ecotourism, new markets (e.g., Africa for onions) or attractiveness for investors. On the opposite, farmers' cooperatives cited many more Environmental weaknesses than the local administrations' representatives: impossibility of growing more than one crop each year, decreasing soil quality, lack of financial resources, and the "water issue" (quantity of water), also identified by one administration (DPA Meknes). Political arguments differed between the two types of actors, with threats (e.g., the "big farmer", rural enclosing) only cited by farmers' cooperatives vs. strengths (subsidies for agricultural development, presence of infrastructures) cited only by local administrations' representatives (Figure 2). This last argument thus appeared as oppositely perceived by the two types of stakeholders.

For the Social arguments, threats were identified only by farmers' cooperatives (lack of good advisory service), and strengths only by administrations (good qualification of workers, food advisory system). Again, this argument opposed the two types of actors. The Social arguments were overall much more developed by local administrations' representatives (Figure 2). Finally, only the representatives of local administrations identified Technological weaknesses (Figure 2), such as a low production level due to a low technicity of farmers and a lack of mechanization.

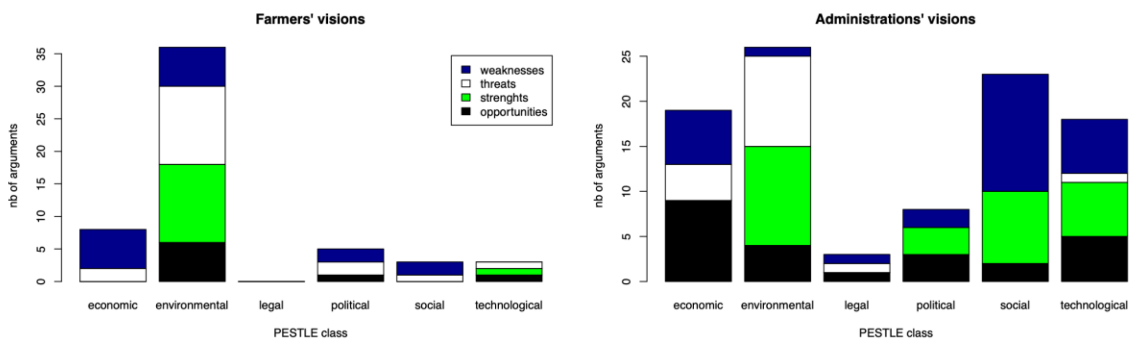

Figure 2. SWOT/PESTLE analysis according to the two types of actors

VARIABILITY OF VIEWPOINTS WITHIN TWO ACTORS' TYPES

The distribution of Strengths, Weaknesses, Opportunities and Threats concerning local agricultural development (specific to irrigated areas and crops) differed between the two cooperatives of farmers (Table 3). The cooperative of Eddakhla highlighted a more pessimistic view of agriculture, with weaknesses and threats representing about 2/3 of the arguments (30.4% and 34.4%, respectively). Both farmers' cooperatives identified several threats, but those of Regraga also foresaw several opportunities (18.8% of all arguments, Table 3). The threats identified by the two farmers' cooperatives related mainly to the Environment class, and concerned the climate issue (i.e., droughts, lower rainfall frequency, climate change, frost), development of pests and diseases, and the overexploitation of deep-water aquifers. While the Regraga members also identified Economic threats (overproduction of onion, commercialization issue), members of the Eddakhla cooperative identified Political (the “big” farmer, and rural enclosing), Social (lack of advisory system) and Technological threats (lack of efficiency of chemical products). Similarly, opportunities identified by the farmers’ cooperatives related to Environmental arguments, mainly regarding the climate (rainfall abundance) which allows a diversity of crops, especially grape and fruit trees. Members of the Regraga cooperative also identified one Political and one Technological opportunity, related to subsidies and technical improvement for irrigation (drip system).

This hence led to different representations in the distributions of Political, Economic, Social, Technological, Legal and Environmental classes between the two farmers’ cooperatives. However, the arguments of type “Environmental” dominated for both cooperatives, followed by Political arguments for the Eddakhla cooperative, and Economic arguments for the Regraga cooperative (Table 3). Surprisingly not dominating, Economic arguments were perceived by Eddakhla members as weaknesses (commercialization issue, lack of funding, high cost production) only, and both as weaknesses and threats by Regraga members (lack of funding, soil quality for the weaknesses, and commercialization issues and overproduction for the threats).

The visions of local administrations’ representative were more equally distributed between Strengths, Weaknesses, Opportunities and Threats (Table 3). The ONCA administration displayed the most different distribution, by identifying more weaknesses than strengths (Table 3). Consistently with farmers’ cooperatives, all local administrations perceived more threats than opportunities in the near future. Threats were also mainly Environmental (climate, resource overexploitation, diseases), Economic (increasing price of inputs, no insurance system, overproduction and difficulty of opening new markets), with one Legal (standards) and one Technological (difficulty to stock perishable products) argument. The opportunities foreseen by local administrations were more numerous and diverse, especially for the Chamber of Agriculture (all PESTLE classes), and less for ONCA (only Economic and Technological arguments). One noticeable opportunity concerned the possibility of attracting new investors, identified by all local administration but the DPA of Meknes.

Regarding the Pestle classes, Legal arguments were identified only by two out of four local administrations (Table 3). These concerned labelling and standards. The other classes gathered arguments consistent between the different stakeholders. Social arguments were listed by the four local administrations. The DPA of El Hajeb was the only one to identify Social opportunities, e.g., land to mobilize, advisory structures. The four administrations identified Social strengths, related to qualified workers, advisory structures, and the presence of research institutes and young farmers. Social weaknesses were also identified by three out of four local administrations (all except the DPA of Meknes). They were the most numerous (57% of arguments of the Social class), and related to the lack of farmers’ organization/coordination, the bad organization of interprofessional structures, the lack of specialized workers, the issue of succession (parceling out of land), and the too low supervision rate.

Table 3. Distribution of SWOT and PESTLE class for the arguments mentioned by the two groups of farmers and the four local administrations

	SWOT class				PESTLE class					
Actors	S (%)	W (%)	O (%)	Th (%)	P (%)	Eco (%)	So (%)	T (%)	L (%)	Env (%)

Coop. Eddakhla	26.1	30.4	8.7	34.8	17.4	13	8.7	8.7	0	52.2
Coop. Regraga	21.9	28.1	18.8	31.2	3.1	15.6	3.1	3.1	0	75
CA	28.6	22.9	28.6	20	8.6	17.1	22.9	14.3	2.9	34.3
DPA El Hajeb	28.6	28.6	28.6	14.3	9.5	14.3	28.6	14.3	9.5	23.8
DPA Meknes	28.6	21.4	28.6	21.4	7.1	28.6	14.3	21.4	0	28.6
ONCA	29.6	44.4	14.8	11.1	7.4	22.2	25.9	25.9	0	18.5

Coop.: cooperative; S: Strengths; W: Weaknesses; O: Opportunities; Th: Threats; P: Political; Eco: Economic; So: Social; T: Technological; L: Legal; Env: Environmental

DISCUSSION AND CONCLUSIONS

DIVERGING PERCEPTIONS OF AGRICULTURAL DEVELOPMENT

The analyses of the SWOT comparison highlighted a higher homogeneity between the visions of local administrations, despite their different roles, than between the two groups of farmers, from two neighboring cooperatives but with divergent perceptions. The main differences between the two farmers' cooperatives could be linked to their history and perception of the future. For instance, the group for which the strengths were less numerous (Regraga) is the oldest one (creation in 1972 vs. 1991 for Eddakhla), in which land conflicts exist, due to succession issues and land fragmentation leading to more land transfer operations. This oldest cooperative was also foreseeing more opportunities, which could be linked to the presence of younger farmers, with more aspirations than the older members of the Eddakhla cooperative. Since the individual land distribution in 1991, these latter members have not had the time to capitalize and individualize their production process, thus remaining trapped in sharecropping processes in order to finance their agricultural activities. These inter-generational specificities have already been identified in this region through a role-playing game developed by Ameur *et al.* (2015). In this study, undertaken in the same area, the authors highlighted that older farmers adopted a "defensive strategy" and were more risk-averse than younger farmers (generally the cooperative's next generation), who look forward to developing a more entrepreneurial agriculture, and explore different futures (Ameur *et al.*, 2015). Regarding the potential opportunities, while the highest presence of investors in the Regraga cooperative could be seen as an opportunity foreseen by these farmers, it was not cited. By grabbing their resources, the "big farmers" have been perceived as a threat by the other cooperatives, in opposition to the view of all local administrations' representatives. For these, they are seen as an opportunity, as they are supposed to achieve the agricultural prowess of the Green Morocco Plan. This may be linked to the dualistic representation of Moroccan agriculture. Even though the Green Morocco Plan is also supposed to support small-scale and subsidence-oriented farming, this dual representation was blamed by farmers, tagging large-sized farms as a threat. The Green Morocco Plan, following the land reform cooperatives, attracted new actors looking for easy profits, among which private urban investors (Petit *et al.*, 2018). Although Petit *et al.* (2018) qualified these as "dilettante farmers [and] not entrepreneurs", their projects have been strongly subsidized. This could explain the farmers vs. administrations viewpoints.

DISCREPANCY AROUND THE ADVISORY SYSTEM

Another main difference between farmers and administrative institutions concerned the advisory system, seen both as a Strength and a Weakness by the institutions (existing training system, but a low number of advisers), while one group of farmers mentioned a complete absence of the advisory sector. This discrepancy is of major importance, as a strong advisory system is an important element for agricultural systems to develop, innovate, and increase their sustainability and resilience (Dugué *et al.*, 2014; Dugué *et al.*, 2015), and to help strengthen farmers' individual and collective capabilities (Baccar *et al.*, 2018). This discrepancy could be linked to the quantitative aspect identified by the local administrations: farmers may not recognize the existence and legitimacy of the (public) advisory system if they do not have access to it. Another reason could be linked to the potential confusion between a public and private advisory system. In the 1980's and 1990's, the disengagement of the Moroccan State led private operators (e.g., suppliers of inputs and agricultural equipment, agro-business structures, etc.) to integrate the agricultural advisory system, especially regarding technical advice (Dugué *et al.*, 2014). This led, in some areas (e.g., non-irrigated), to more regular contacts between farmers and these private advisors as compared to public advisors. More recently, the Green Morocco Plan planned to further integrate this private advisory sector within its policy, by e.g., financing their interventions (as this would be, for the State, more economically efficient) (Dugué *et al.*, 2014). However, part of these interventions could still have to be paid by farmers, thus limiting the scope and impacts of the private advisory sector to the wealthier farmers. Moreover, according to Dugué *et al.* (2015) most family farmers consider that advices have to be free, and would thus be reluctant to fund it themselves. This access to the advisory system could increase the socioeconomic differentiation between farms, already currently very large, and linked to the access to groundwater, land, and more recently to financial capital (Ameur *et al.*, 2017a). This however remains a hypothesis, as the distinction between private and public was made by the local administrations: "public supervision is limited"; while this specification did not appear in the farmers' discourses.

INDIVIDUAL OR COLLECTIVE?

Overall, the social arguments were overall much more developed by the local administrations' representatives as compared to farmers' cooperatives. One main argument developed by both types of actors concerned the collective level, identified as a major weakness (40% of all weaknesses identified globally). These arguments were related to the lack of collective action and organizations of farmers (cooperative functioning, community work, collective crop planning), of professional and inter-professional organizations, but also between the local institutions. Lack of collective actions could hamper the development of agriculture, and even endanger it. For instance, regarding the groundwater depletion and the necessity to install drills to attain confined aquifers (to replace now useless shallower structures), collective funding could be an option to face the impossibility for each individual family farmer to fund this operation. However, the distrust of collective action observed locally prevents such investments, which could moreover be subsided under some conditions (Dugué *et al.*, 2015). Similarly, collective work could allow resource-constrained farmers to increase their production. Although this was observed for some farms in the Saïss region (for the resources: agricultural material, collective work, and knowledge sharing) (Baccar *et al.*, 2018), it is declining (Dugué *et al.*, 2014). Similarly, a collective crop plan could help to face water depletion though a better control of water consumption (Ameur *et al.*, 2018). This lack, and decreasing, will for collective action is due to the history of agricultural land in Morocco, the de-collectivization process being still recent in some areas (e.g., 1991) and imposed cropping patterns remained even after, although land was attributed to individuals (Ameur *et al.*, 2017b). This led to a strong wish of farmers for their autonomy, which involved an individualization process, while, at the opposite, collective work was linked to "a painful state-imposed past" (Ameur *et al.*, 2017b). This independence is both from the state and from fellow assignees, who were enrolled in the collective actions of cooperatives (Petit *et al.*, 2018). However, one can also note a generational gap for this individual vs. collective issue; with young farmers involving themselves more in collective thinking (Ameur *et al.*, 2015).

ENVIRONMENTAL CONCERNS

Finally, one main result of our study concerned the "environmental" vision of the different actors interviewed. First, environmental issues were more significant for farmers' cooperatives than for the local administrations' representatives. Second, these issues were not identified at the same time scale: weaknesses for farmers vs. threats for farmers and administration (e.g., climate change; water scarcity). It is interesting, for instance, that climate change was cited only by two out of four local administrations; while climate variability was cited by only one. These were two main focuses of farmers, cited numerous times during the workshops. This is also true for another environmental issue, i.e., pests, diseases and weeds. These differences could be explained by the time- and space- scales of the two different types of actors involved in this study. While farmers, part of this changing environment, who suffer from depleting groundwater and from the "casino game" type of markets, are continuously expected to pay to update their adaptive strategies (e.g., more capital for deeper drilling), local administrations have a broader vision in space, which is also irregular in time. These differences in time and space observations could be linked to reduced contacts between these administrations and farmers, apart from the subsidizing system (by definition discontinuous in time). Overall, these environmental concerns focus on the productive resources, and their uncertain future, especially with regards to water availability. This could be linked to the phenomenon of exclusion of farmers observed for the irrigated system (Ameur *et al.*, 2017a): as water tables decline, farmers need to invest money that smaller farmers do not have, leading to their marginalization.

CONCLUSIONS

Our study aimed at building SWOT frameworks with two different types of actors, farmers/practitioners and responsibles for local agricultural administrations, represented by two and four groups, respectively. Analyzing those results according to the PESTLE concept, our results highlight discrepancies between visions on different points: the environmental concerns, the role and importance of the advisory system, and the opportunity or danger represented by investors. One common point concerned the lack of current collective action and vision, partly explained by the agrarian history. Surprisingly, the economic issues were more cited by the administrations' representatives than by the farmers' cooperatives. These results highlight different ranking of concerns (both in the SWOT and PESTLE frameworks). This could hamper the efficiency of the agricultural sector to develop and favor the alleviation of poverty, while facing the challenge of limiting rural exodus. To complete this diagnosis study, it would now be interesting to share our results in an enlarged arena of actors, in order to (1) acknowledge/update these results, and (2) elicit and analyze the reasons of the identified differences. This shared diagnosis would then be a first step towards designing more sustainable and resilient agricultural systems for the Saïss region.

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REFERENCES

Ameur, F., Kuper, M., & Dugué, P. (2018). L'exploitation des eaux souterraines dans le Saiss : la course que certains abandonnent. Alternatives Rurales, (6).

Ameur, F., Kuper, M., Lejars, C., Dugué, P., 2017a. Prosper, survive or exit: Contrasted fortunes of farmers in the groundwater economy in the Saiss plain (Morocco). Agricultural Water Management, 191, 207-217.

Ameur, F., Amichi, H., Kuper, M., Hammani, A., 2017b. Specifying the differentiated contribution of farmers to groundwater depletion in two irrigated areas in North Africa. Hydrogeology Journal, 25(6), 1579-1591.

Ameur, F., Quarouch, H., Dionnet, M., Lejars, C., Kuper, M., 2015. Outiller un débat sur le rôle des jeunes agriculteurs dans une agriculture en transition dans le Saïss (Maroc). Cahiers Agricultures, 24(6), 363-371.

Baccar, M., Bouaziz, A., Dugué, P., Gafsi, M., Le Gal, P-Y., 2018. The determining factors of farm sustainability in a context of growing agricultural intensification. Agroecology and Sustainable Food Systems, 43(4), 386-408.

Dugué, P., Bekkar, Y., Errahj, M., 2014. Quels dispositifs de conseil pour l’agriculture familiale marocaine ? Réflexions pour une démarche de conception des dispositifs de conseil. Alternatives Rurales, 1, 10p.

Dugué, P., Ameur, F., Benouniche, M., El Amrani, M., Kuper, M., 2015. Lorsque les agriculteurs familiaux innovent : cas des systèmes de production irrigués de la plaine du Saïs (Maroc). Agronomie, environnement et sociétés, 5(2), 87-95.

Fofack, R., Kuper, M., Petit, O., 2015. Hybridation des règles d'accès à l'eau souterraine dans le Saiss (Maroc) : entre anarchie et Léviathan. Etudes rurales, n °196, p. 127-150.

Giorgi, F., Lionello, P., 2008. Climate change projections for the Mediterranean region. Global and Planetary change, 63 (2-3), 90-104.

High Planning Commission (HCP) (2007) Prospective Maroc 2030: Quelle agriculture pour le Maroc? Rabat, Morocco

Kuper, M., Faysse, N., Hammani, A., Hartani, T., Marlet, S., Hamamouche, M.F., Ameur, F., 2016. Liberation or anarchy? The Janus nature of groundwater use on North Africa’s new irrigation frontiers. In: Integrated groundwater management. Springer, Cham, 2016. p. 583-615.

Lejars, C., Courilleau, S., 2015. Impact du développement de l'accès à l'eau souterraine sur la dynamique d'une filière irriguée. Le cas de l'oignon d'été dans le Saïs au Maroc. Cahiers Agriculture, 24, 1-10.

Marzin, J., Bonnet, P., Bessaoud, O., Ton-Nu, C., 2017. Etude sur l'agriculture familiale à petite échelle au Proche-Orient et Afrique du Nord. Synthèse. http://www.fao.org/family-farming/detail/fr/c/471479/

Nazari, M., Liaghat, A., Akbari, M.R., Keshavarz, M., 2018. Irrigation water management in Iran: Implications for water use efficiency improvement. Agricultural Water Management, 208, 7-18.

Petit, O., Kuper, M., Ameur, F., 2018. From worker to peasant and then to entrepreneur? Land reform and agrarian change in the Saïss (Morocco). World Development, 105, 119-131.

Quarouch, H., Kuper, M., El Hassane, A., Bouarfa, S., 2014. Eaux souterraines, sources de dignité et ressources sociales : cas d'agriculteurs dans la plaine du Saïss au Maroc. Cahiers Agricultures, 23(3), 158-165.

Wickramasinghe, V., Takano, S., 2009. Application of combined SWOT and analytic hierarchy process (AHP) for tourism revival strategic marketing planning: a case of Sri Lanka tourism. J. East. Asia Soc. Transp. Stud. 8, 954–969.

Yavuz, F., Baycan, T., 2013. Use of SWOT and analytic hierarchy process integration as a participatory decision-making tool in watershed management. Procedia Technol. 8, 134–143.

Yudha, S.W., Tjahjono, B., Kolios, A., 2018. A PESTLE policy mapping and stakeholder analysis of Indonesia’s fossil fuel energy industry. Energies, 11, 1272.

USING TRANSITION ZONES TO RE-THINK BIODIVERSITY-YIELD RELATIONSHIPS IN AGRICULTURAL LANDSCAPES

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Abstract: Agricultural landscapes have constantly been re-shaped due to changing land use, political structures, and societal demands. The resulting fragmentation has made transition zones between different farming and other land use systems dominant features in agricultural landscapes. Transition zones are areas where two land uses interact. These interactions are shaped by the shared abiotic and biotic gradients, with consequences for biodiversity-yield patterns. Land use intensity can shape transition zones by creating sharp or gradual edges. When investigating the relationship between biodiversity and yield in transition zones, it is impossible to do so without addressing land users, since they make management decisions based on their observations of the environment surrounding land use and property boundaries. Their management decisions affect neighboring land users, and both have to interact with each other, by sharing rights and responsibilities across field and property boundaries that could either correlate or mismatch with ecological spill-over effects. Moreover, different land users may have different priorities for their fields and field edges, with repercussions for biodiversity-yield patterns. Understanding ecological patterns that cross boundaries between land uses and habitats is central to identifying how agricultural land use affects biodiversity-yield relationships across landscapes. Moreover, combining information on ecological patterns with social changes (e.g. shifts in legal boundaries between land uses), could allow for a stronger representation of how land use systems interact within landscapes. Both social and ecological research on transition zones in agricultural landscapes could help shift the paradigm away from a compartmentalized understanding of biodiversity – yield patterns towards considering biodiversity and yield as jointly addressed in management practices for site-specific conditions, especially given the prevalence of transition zones throughout agricultural landscapes. This kind of approach could inform collaborative landscape management practices for achieving desired synergies between biodiversity conservation and food production. Here, we review and discuss transition zones and provide a preliminary road-map of how to research and use these areas for effective landscape integration of different land uses.

CAN POLLINATOR ABUNDANCE BE PREDICTED BY CURRENT AND PREVIOUS LAND USES?

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Abstract

The alarming global decrease in pollinator abundance and diversity requires an in-depth investigation about the stability of pollinator communities in agricultural landscapes in time. In the Mediterranean basin, the composition of pollinator communities is influenced by human practices, and especially agriculture, but there are few studies which model how pollinator communities respond to land use dynamics. This knowledge can provide important clues for biodiversity-friendly land use planning in agroecosystems based on careful evaluation of land use typology, diversity and dynamics.

Within the framework of the Arimnet2 project DIVERCROP (grant agreement n 618127), we concentrated on the pollinator abundance in order to understand its landscape drivers. In particular, we tested if (i) the abundance and diversity of pollinators in the sampled Semi Natural Habitats (SNHs) is predicted by the land use typology in the sampling year (2013), and if (ii) the abundance and diversity of pollinators depended also on land use dynamics determined by the shift in land use typologies over time (2013-2010).

In 2013, insects have been collected with pan-traps in the Pisa plain using 55 sampling points belonging to 5 SNH typologies (herbaceous areal, herbaceous linear, woody areal, woody linear, fallows) in three sampling times (June, July, September). Insect communities have been analysed using Co-Correspondance Analysis, and analysis of variance of the community distance matrix in response to land use factors was performed.

These analyses highlighted that the land use typology and stability shaped the community of pollinators in the Pisa plain. Many land uses censused in the insect sampling year (2013) contributed to shape the community in that year, and pollinators moved through the landscape following the resources offered by the different crops. When land uses of the previous years have been used as constrained axes in the analyses, it was shown that the overall correlation with the pollinator community was still significant. The land use typology in the sampling year explained the variation in insect abundance best, but the high correlation with land use typology of the previous years suggests that the proportion of perennial land use typologies in the 1km radius landscapes might contribute to explain insect abundance, evidencing that further investigation are necessary.

Introduction

In the last few years an alarm on global pollinator declines was raised by the scientific community (Potts et al., 2010). One of the most discussed anthropogenic causes of the decline is the decreasing quality and quantity of suitable habitat and habitat connectivity following land use changes and intensification of agricultural practices (Senapathi et al., 2017). Bees are the most studied group of pollinators, especially because of their pollination ecosystem service to crops, but also other insect groups (e.g. butterflies, wasp, syrphids etc.) contribute to plant pollination and rely on floral resources (Rader et al., 2016, 2020). Abundance and richness of pollinator communities strongly depend on the suitability of land use patterns (Kennedy et al., 2013, Aguirre-Gutierrez et al., 2015, Rollin et al, 2019), because pollinators like bees and wasps, which are central-place foragers, need flower resources but they are limited in their search range by their body size which affects flight ability (Benjamin, Reilly, & Winfree, 2014). In addition, the majority of bee species and flower-visiting wasps are ground nesters, thus the vegetation composition and management affect the quality of nesting sites present in the landscape (Potts et al., 2005). In this context, it has been reported that areas with wildflowers host more wild bee nests than fallow plots (Cope, Campbell, Grodsky, & Ellis, 2019). Unfortunately, there are few studies investigating how pollinator communities are affected by landscape management and land use change in time (Senapathi et al., 2017).

To improve landscape management aimed at fostering wild pollinator communities, it is necessary to develop models that are able to predict pollinator abundance and diversity from current and previous land use patterns and test if and how land use dynamics determine current pollinator communities. By using landscape-based population-dynamical modelling together with knowledge on the life cycle requirements of pollinators, we can provide information on land use typology, diversity and dynamics to support functional biodiversity (van Rijn, 2017).

In the Mediterranean basin, agricultural practices, species diversity and local food

systems are the complex result of historical and recent drivers which act at the landscape scale. Within the framework of the Arimnet2 project DIVERCROP (grant agreement n 618127), one of the objectives is to illustrate how land use dynamics affect patterns of biodiversity. In this context we analysed the response of key pollinator groups to land use typology and land use change. We hypothesize that perennial land use types are important for wild pollinators since they provide stability in terms of flower resources and nesting sites. In particular, we tested (i) at which moment during the growing season the abundance and diversity of pollinators in the sampled Semi Natural Habitats (SNHs) is best predicted by the surrounding land use typology, and (ii) if the abundance and diversity of pollinators depended also on the shift in land use over time (2013-2010). The answers to these questions support the discussion about best practices in coordination and cooperation at the landscape scale, and more specifically land use patterns in space and time, that can foster farming systems with improved levels of sustainability and resilience in relation to wild pollinator communities.

2. Material and Methods

2.1 Choice of sampling stations

In April 2013, we selected 55 semi-natural habitats (SNHs) in the Pisa plain. The SNHs were chosen according to five typologies, defined based on shape of the element and its woody vegetation cover: woody areal, woody linear, herbaceous areal, herbaceous linear and fallow. Any element longer that 100m, with a width of less than 25m was categorized as linear, otherwise it was categorized as areal. Any element with a woody canopy cover over 30% was categorized as a woody element, otherwise it was considered an herbaceous element. In addition, cropped fields with a temporary vegetation cover (fallows or recently abandoned fields) were classified as substitute of herbaceous areal.

The 55 SNHs were selected inside 15 circular landscape sectors (hereafter named "*block landscapes*") of 1 km radius from a reference sunflower field, having a gradient of SNH cover across the 15 landscapes. The objective was to have 1 SNH for each type in each block landscape, spaced by at least 150m among each other. However, woody areal elements and herbaceous areal elements of adequate size were not always present, forcing to reduce the number of semi-natural habitats in certain landscapes. In this set of SNHs, the minimum distance from the nearest element was 178m, the average 485m, and the maximum distance was 1056m, with an elevation ranging from -4 to 75 m a.s.l..

2.2 Pan traps sampling

Pan traps were made according to Westphal et al. (Westphal et al., 2008). We sprayed 900 plastic soup bowl (400 ml Pro-Pac, Vechta, Germany bowl) with UV-bright yellow, white, and blue paint

(Sparvar Leuchtfarbe, Spray-Color GmbH, Merzenich, Germany). Triplets of bowls of the three different colours were mounted on a single wooden stick forming a pan trap. In each semi-natural element one pan trap was set at the border of the element with a cultivated field, and another one at 12 meters from the border. The two traps were at least 25 meters (diagonally) apart to avoid interference (Droege et al., 2010). Three sampling rounds were carried out following the mean timing of sunflower bloom in the area of study: T1 - two weeks before the beginning of sunflower bloom (from 18 June to 5 July); T2 during sunflower bloom (from 18 July to 25 July); T3 four weeks after the end of sunflower bloom (from 19 September to 26 September).

The pan traps were placed at vegetation height and they were filled by approximately 350ml of water with a drop of detergent. Each pan trap was left active for four days.

The collected insects were extracted and classified in the subsequent groups (either Classes or Families or single species): Lepidoptera (butterflies and moths) , Syrphidae (hoverflies), Dolichopodidae (long-legged flies), Empididae (dagger flies), Vespidae (wasps), honey bees (*Apis mellifera* L.) and wild bees (Apoidea: Apiformes, excluding honey bees).

2.3 GIS data

The core of GIS data was extracted from the Tuscany Agency for Agricultural Payments (ARTEA), which trace the agricultural land uses year after year, including the crop, in each parcel of land. Data about urban areas, woodlands and infrastructures, as well as river courses and lakes, were extracted from the Web Map Service (WMS) Geoscopio of the Tuscany Region. The few areas for which land use could not be classified with the two above mentioned systems were identified and classified through visual observations of aerial photographs. Five sites were excluded because they still had more than 33% missing land use data. In total, data from 50 sites were included in the analyses.

The resulting 50 shapefiles, one per sampling point, were cleaned from topological errors using GRASS GIS (GRASS Development Team, 2016) algorithms and rasters of 1 square map unit (i.e. 1 square meter) were computed using SAGA (Conrad et al., 2015) classifying the land uses as described in Table 1.

The total area of each land use per raster was computed using the function *lsm_c_ca* from the R package *landscapemetrics* (Hesselbarth, Sciaini, With, Wiegand, & Nowosad, 2019) in R 3.4.4.

Table 1*: Land use classes used in this study, and a brief explanation of each class. Land use data were estimated in 1 km radius around all the 55 Semi-Natural Habitat sites selected in the countryside of Pisa, Italy, using data from from Tuscany Agency for Agricultural Payments (ARTEA) and Web Map Service (WMS) Geoscopio of the Tuscany Region.*

Class	Description
Non habitat	Water courses, lakes, roads
Urban area	Urban areas including farming buildings and sport areas.
Urban green	Green areas including public gardens and private gardens
Grain cereals	Oats, spelt, wheat, durum wheat, millet, barley, rye, switchgrass, triticale
Sunflower	Sunflower
Grain legumes	Common bean, faba beans, chickpea, soya bean

Feed pastures legumes	Alfalfa, Italian sainfoin, trefoil, vetch
Feed pastures others	Non-legumes grasses, as well as agricultural meadows and pastures
Vineyard	Vineyards
Maize	Maize
Commercial horticulture	Commercial horticultures
Vegetable garden	Vegetable gardens managed by families
Commercial woodland	Planted woodlands for commercial purposes
Long term rotational	Long term rotational fields
Herbaceous SNHs	Channel banks, grasslands
Olive grove	Olive groves
Fruit trees	Fruit trees such as apricots, peach, pear…
Other grain crops	Flax, sugar beat, sorghum
Bare ground	Plough arable land
Rapeseed	Rapeseed
Nursery	Nurseries

2.4 Data analysis

Data analysis was performed using R 3.4.4. In order to deal with the non-linearity of the unconstrained variables we built CCA (canonical constrained correlation) models using the function *cca* from package *vegan* (Oksanen et al., 2016). The constrained (environmental) variables were selected using the criteria of variance inflation factor (VIF) in two steps. Firstly, for each year's land use set (i.e. 2010, 2011, 2012, 2013), a recursive computation of VIFs was performed excluding at each cycle the variable having the highest VIF, until all the environmental variables had VIF < 4. Secondly, only the land uses in common among the 4 VIF analyses were kept: this subset of land uses was used as environmental variables.

In order to test hypothesis one, we built three sampling time models (CCA June, CCA July and CCA September) using pollinators' community composition of each sampling round in 2013 as unconstrained variable. In the models, the abundance of each pollinator group was the mean of insect abundance for the two pan-trap triplets set per sampling site. The constrained (environmental) variables were the land use types retained in the subset for 2013. Distance matrices were computed using Bray-Curtis index which is appropriate for detection of underlying ecological gradients (Faith, Minchin, & Belbin, 1987). In order to test the significance of constrained axes, we performed an ANOVA-like permutation test for the three CCA models, using the function *adonis2* from package *vegan* (Oksanen et al., 2016) which fitted linear models to distance matrices using a permutation test with pseudo-F ratios.

In order to test hypothesis two, we built four models (CCA 2013, CCA 2012, CCA 2011 and CCA 2010) using the community composition of sampling round one (June) as unconstrained variable and the constrained (environmental) variables were the land use typology subsets for each year (2013, 2012, 2011 and 2010). Distance matrices were computed using Bray-Curtis index.

3. Results

The three sampling time models significantly explained the variation in community composition: CCA June [F(12, 33) = 2.23, p = >0.001], CCA July [F(12, 33) = 1.98, p = 0.004], and CCA September [F(12, 30) = 2.98, p = >0.001],. The Inertia explained by constrained axes was the highest using the community composition of September (CCA September, 54.4%), while the lowest Inertia explained by constrained axes was obtained using community data of July (CCA July, 41.8%; Table 2).

Table 2*: Canonical correspondence analysis (CCA) model summaries for pollinator community composition collected using pan-traps, and land use types estimated in 1 km radius around the 50 selected sites in the countryside of Pisa, Italy. In the three models, the estimated land use data are used as canonical axes.*

	CCA June		CCA July		CCA September	
	CCA1	CCA2	CCA1	CCA2	CCA1	CCA2
Eigenvalues	0.237	0.137	0.214	0.183	0.300	0.130
Cumulative variance explained	0.227	0.359	0.173	0.321	0.313	0.448
Specie-environment correlation	0.874	0.708	0.810	0.709	0.910	0.741
Total Inertia	1.043		1.238		0.961	
% Inertia explained by constrained axes	44.7%		41.8%		54.4%	

The land use types that significantly influenced community composition in the three sampling times in 2013 are listed in Table 3.

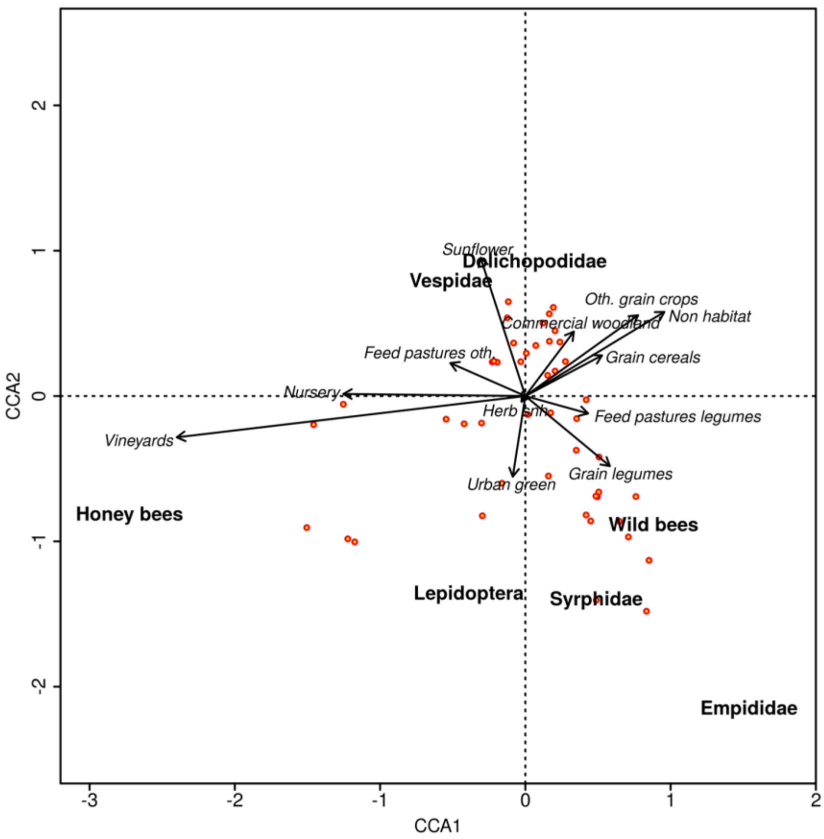
Table 3*: Significant land use typologies in a 1 km radius (in the three sampling times in 2013 – June, July and September) explaining the similarity matrices of pollinator community composition collected using pan-traps in 50 selected sites in the Pisa plain, Italy.*

	CCA June					CCA July					CCA September				
	Df	SS	R2	F	p	Df	SS	R2	F	p	Df	SS	R2	F	p
Non habitat	1	0.21	0.02	1.28	0.278	1	0.16	0.02	0.89	0.507	1	0.39	0.05	2.80	**0.015 ***
Sunflower	1	0.43	0.05	2.65	**0.021 ***	1	0.35	0.04	1.88	*0.071* .	1	0.15	0.02	1.10	0.352
Grain legumes	1	0.46	0.05	2.83	**0.018 ***	1	0.66	0.07	3.58	**0.001 ****	1	0.07	0.01	0.54	0.790
Feed pastures other	1	0.40	0.04	2.45	**0.033 ***	1	0.18	0.02	0.96	0.466	1	0.16	0.02	1.16	0.320
Vineyards	1	0.52	0.06	3.22	**0.009 ****	1	0.27	0.03	1.46	0.182	1	0.40	0.05	2.91	**0.014 ***
Herbaceous SNH	1	0.18	0.02	1.13	0.355	1	0.35	0.04	1.88	*0.072* .	1	0.48	0.06	3.42	**0.005 ****
Other grain crops	1	0.21	0.02	1.29	0.264	1	0.07	0.01	0.39	0.911	1	0.34	0.04	2.48	**0.030 ***
Nursery	1	0.50	0.06	3.06	**0.010 ***	1	0.13	0.01	0.68	0.699	1	0.24	0.03	1.69	0.125
Residual	33	5.38	0.60			33	6.11	0.66			30	4.17	0.54		
Total	45	8.90	1.00			45	9.21	1.00			42	7.69	1.00		

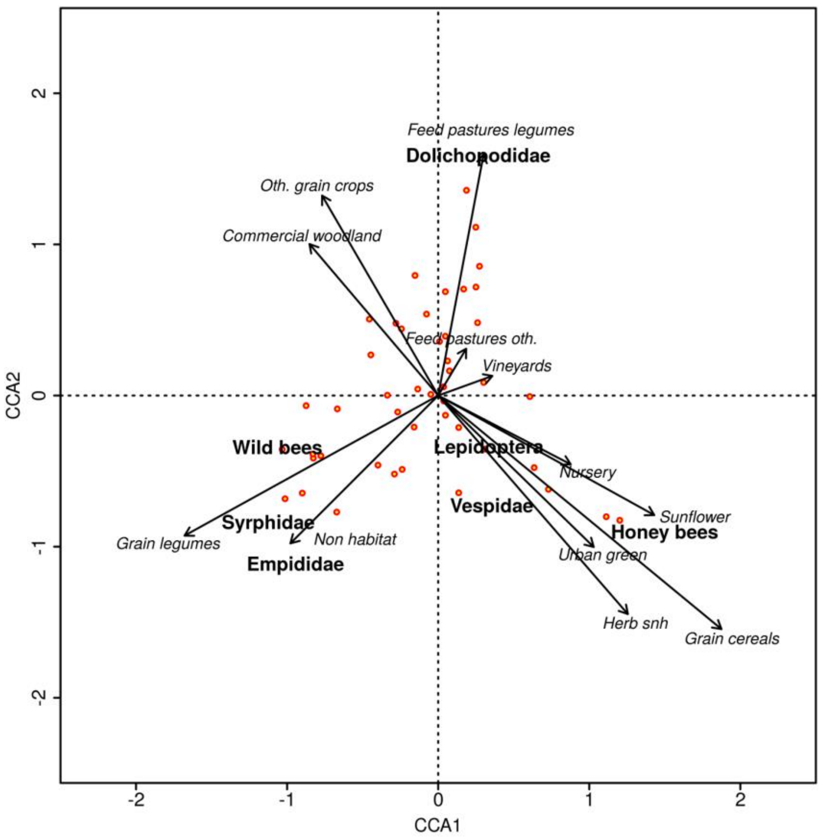
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Sunflower and grain legumes explained the variation in community composition in June and July (Table 3). Sunflower correlated positively with long-legged flies and wasps in June (Figure 1.a), while in July sunflower correlated positively with honey bees (Figure 1.b). Instead, grain legumes correlated positively with wild bees, hoverflies and dagger flies in both sampling times (Figures 1.a, 1.b). Later, in July and September, herbaceous SNHs explained the variation in community composition (Table 3) and correlated positively with butterflies, wasps and honey bees in July (Figure 1.b), and with butterflies and long-legged flies in September (Figure 1.c). Differently, vineyards were significant in June (Table 3), correlating positively with honey bees (Figure 1.a), and in September, when they correlated positively with butterflies. In addition, in June, other feed pastures and nurseries were significant (Table 3) and negatively correlated to wild bees, hoverflies, dagger flies and butterflies (Figure 1.a). In September, long-legged flies were more abundant in landscapes with commercial woodland, and wild bees, honey bees and wasps were dominant in landscapes with grain cereals and grain legumes, which are covered with spontaneous vegetation at this point in time (Table 3 and Figure 1.c).

a)


Sunflower
Dolichopodidae
Vespidae
Oth. grain crops
Non habitat
Commercial woodland
Grain cereals
Feed pastures oth.
Nursery
Herb snh
Feed pastures legumes
Vineyards
Grain legumes
Urban green
Honey bees
Wild bees
Lepidoptera
Syrphidae
Empididae
CCA1
CCA2

b)


Feed pastures legumes
Dolichopodidae
Oth. grain crops
Commercial woodland
Feed pastures oth.
Vineyards
Wild bees
Lepidoptera
Nursery
Sunflower
Vespidae
Syrphidae
Honey bees
Grain legumes
Non habitat
Urban green
Empididae
Herb snh
Grain cereals
CCA1
CCA2

c)

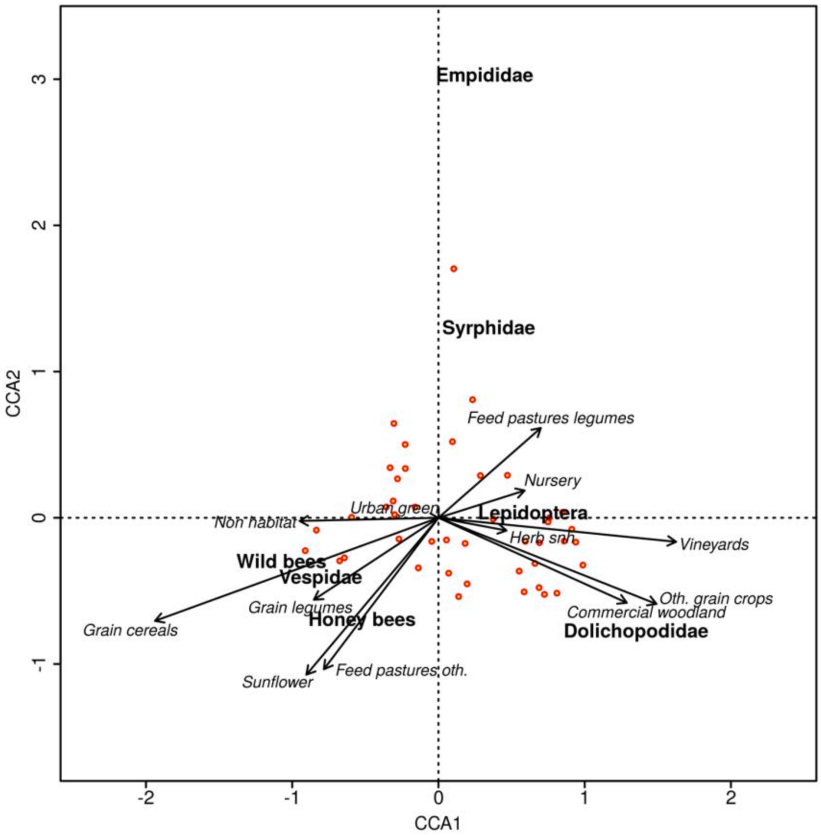


Figure 1: Canonical correspondence analysis (CCA) ordination bi-plot of land use types (arrows) estimated in 2013 in 1 km radius around the 50 selected sites in the countryside of Pisa and community composition collected using pan-traps in June (a), July (b), and September (c). Scaling on species.

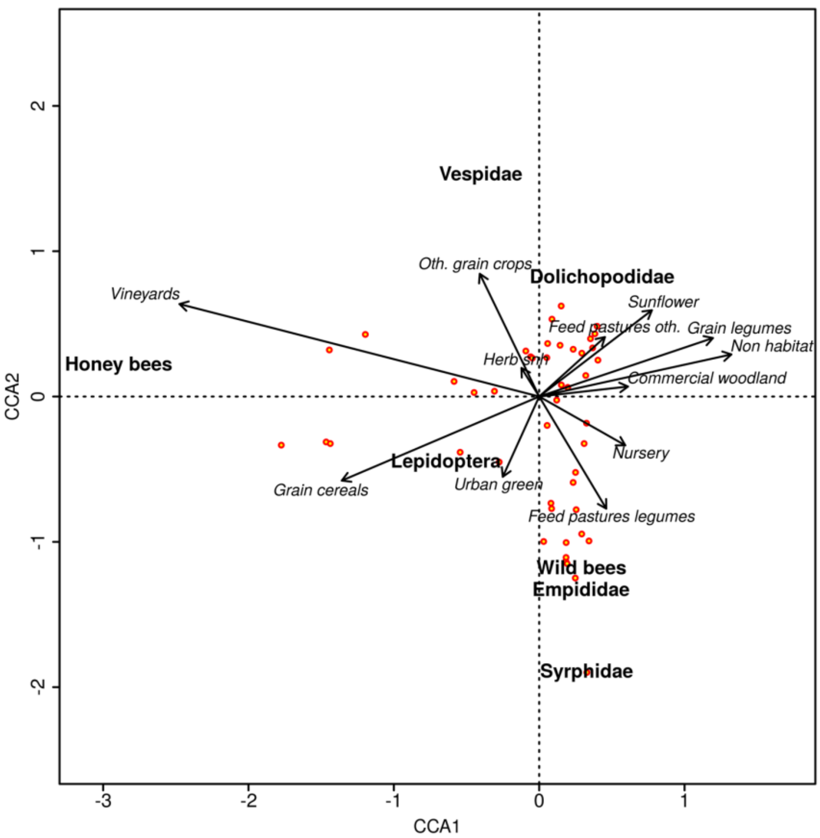
The land use data from the sampling year (2013 [F(12, 33) = 2.23, p = >0.001]) and the previous years (2012 - [F(12, 33) = 2.03, p = 0.003]; 2011 - [F(12, 33) = 2.01, p = >0.001]; 2010 - [F(12, 33) = 1.78, p = 0.009]) are all highly significant to explain the variation in insects abundance. The explanatory power of the land use typologies for the four models is listed in Table 4, while Fig. 2 shows the bi-plot of CCA 2011 model including pollinators and constrained environmental axes.

Table 4: Canonical correspondence analysis (CCA) model summaries for community composition of insect pollinators collected in June 2013 using pan-traps, and the extracted land use types for each year (2010-2013) in 1 km radius around the 50 selected sites in the Pisa plain, Italy. In the four models, one per year, the land use data for each year are used as canonical axes.

	CCA 2013		CCA 2012		CCA 2011		CCA 2010	
	CCA1	CCA2	CCA1	CCA2	CCA1	CCA2	CCA1	CCA2
Eigenvalues	0.237	0.137	0.223	0.122	0.209	0.136	0.234	0.090
Cumulative variance explained	0.227	0.359	0.214	0.331	0.200	0.331	0.225	0.311

Specie-environment correlation	0.874	0.708	0.858	0.679	0.842	0.704	0.869	0.614
Total Inertia	1.043		1.043		1.043		1.043	
% Inertia explained by constrained axes	44.7%		42.4%		42.2%		39.3%	

Figure 2: Canonical



correspondence analysis (CCA) ordination bi-plot of land use types (arrows) estimated in 2011 in 1 km radius around the 50 selected sites in the countryside of Pisa and community composition collected using pan-traps in June 2013. Scaling on species.

4. Discussion

Land uses contributed differently to explain the pollinator community composition throughout the season in 2013, confirming the first hypothesis. In all the three sampling rounds land use significantly explained the abundances among the pollinator groups. In September, the correlation between land use and pollinators was higher than in July (Table 2). Despite the fact that we only analysed the total number of individuals belonging to each pollinator group without taking into account in species composition, the variation explained by constrained axes was high. This shows that species belonging to these groups had similar needs in summer.

In July sunflower correlated positively with honey bees (Figure 1.b), which can be explained by the fact that in the sampling area, just before sunflower bloom, in July, beehives are actively placed in the surroundings of sunflower fields in order to produce honey and pollinate sunflower.

This may explain why we found more bees where the surface of sunflower in the area was higher. However, it is not clear why sunflower correlated positively with long-legged flies and wasps in June (Figure 1.a). Many larvae of long-legged flies nest in the soil or in decaying plant material, especially in semi-aquatic habitats (Pollet, 1992) and their abundance and diversity in these habitat is similar to that found in reed marshes, their preferred environment (Pollet, 2001). In our sampling area, the highest surface of sunflower fields is present in reclamation lands. This might imply that, earlier in the season, long-legged flies might reproduce nearby sunflower fields, in ditches or swamps, and then swarm in sunflower fields to feed on nectar and soft-bodied insects found on sunflower plants and its weeds (Kautz & Gardiner, 2019). An alternative hypothesis might be that Dolichopodidae, during the winter and early spring, directly use the undisturbed soil in future sunflower fields to reproduce, and then they stay there as adults until other flower resources are available. Later in the season, herbaceous SNHs and other grain crops seem to be important for long-legged flies. These habitat may provide flower resources to feed on.

Wild bees, hoverflies and dagger flies were more abundant in SNHs surrounded by grain legumes in June and July (Figures 1.a, 1.b). In the study area, grain legumes are composed mainly by soya beans and faba beans. We suppose that, while wild bees might have been favoured earlier by grain legumes, when those crops bloomed (around April) and then established their nests nearby, hoverflies and dagger flies might predate the aphids in the these crops after blooming. On the other hand, other feed pastures and nurseries negatively correlated to wild bees, hoverflies, dagger flies and butterflies in June (Figure 1.a). Before June, feed pastures are mown in order to produce hay. In landscapes with a high percent cover of feed pastures and nurseries the lack of resources might have distracted these pollinators from the landscape, forcing these highly mobile insects to find food elsewhere. Later, in September, non habitat positively correlated with wild bees, as well as honey bees and wasps (Figure 1.c). Non habitat comprises water courses, lakes and roads, thus on banks and road sides, pollinators might have found flower resources and nesting sites in a moment when crops are not blooming (Hevia et al., 2016).

In the study area, vineyards are a intensively managed crop, sprayed especially with fungicides. However, often weeds are not completely removed, and management consists in regular mowing. The usual vineyard management might explain the positive correlation with honey bees in June (Figure 1.a), and the positive correlation with butterflies in September (Figure 1.c). These pollinators may have been attracted by the flower resources provided by the spontaneous vegetation in the vineyards.

The variation in abundance of insects belonging to the key pollinator groups, sampled in 2013, was significantly correlated to land use data from all 4 years (2010-2013), . This may be explained by the fact that land use in the study area is partly composed of perennial crops and non-agricultural areas, offering a stable habitat to insects.

As expected, the land use data from 2013 provides the highest correlation with the pollinator community, as shown by the highest percentage inertia (44,7%) explained by constrained axes and species-environment correlation of the first CAA axes (Table 4). The percentage inertia explained by constrained axes using data from the years 2012 and 2011 is only slightly lower than that of 2013(42.4% and 42.2% respectively). The higher inertia explained by constrained axes up to 2011 model, may be explained by the common simple rotation used in the study area, where often wheat and sunflower alternate. In fact, in 2013, sunflower explained very well the insect assemblage in sampling rounds 1 and 2 (Table 3), and it is very likely that many of the sunflower fields in 2013 were also sown to sunflower in 2011 explaining the position of long-legged flies in Figure 2. On the other hand, the crop stability through the years may provide a benefit to the insect community and this is confirmed by the stable correlation of the insect community composition in 2013 in relation to land use composition in the previous years. Another clue supporting this hypothesis is in Figure 2, where the land uses closer to pollinators groups are often the more stable ones, such as urban green areas, vineyards and feed pasture legumes (mainly composed by alfalfa which has a mean crop cycle of three years in the study region) which are near to butterflies, honey bees, wild bees, dagger flies and hoverflies, respectively. However, the analyses presented do not fully prove our second hypothesis, but the high correlation between pollinator community composition with land use data from the three previous years evidences the need of further investigation in order to better understand the importance of perennial land use types in intensively managed agroecosystems.

The next step will be to analyse the land use dynamics in each focal landscape to determine if the correlation between pollinator communities and past land use typologies is better explained by the proportion of land use typologies in a focal landscape or by the stability or turnover of land use. On the one hand, this information can help us to predict pollinator community abundances and diversity based on past land use data, and on the other hand it helps to increase knowledge about the responses of pollinator communities to land use changes, especially differences between landscapes dominated by perennial and annual vegetation.

5. Conclusion

These analyses highlighted that the land use typology and dynamics at a relevant landscape scale for mobile wild pollinators shaped the community of pollinators collected with pan traps in the Pisa plain. Many land uses censused in the insect sampling year (2013) contributed to shape the community in that year, and pollinators moved through the landscape following the resources offered by the different crops. This provides strong support for the importance of spatial crop diversification to foster pollinator communities throughout the year. When land uses of the previous years were correlated to the pollinator composition, the results demonstrated that although part of the crops changed position in the landscape, the overall correlation with the pollinator community was still significant. We can conclude that a high proportion of perennial vegetation is important and can provide stable habitat to pollinators. It is no surprise that the land use typology in the sampling year explained the variation in insect abundance best, but the high correlation with land use typology of the previous years suggests that the proportion of land use typologies in the 1km radius landscapes were not changing much over time. In order to confirm this hypothesis a deeper data analysis is needed. The results of this study, and further investigation, can help to determine the importance of perennial habitats and land use mosaics to support pollinator communities.

6. Bibliography

Aguirre-Gutiérrez, J., Biesmeijer, J. C., van Loon, E. E., Reemer, M., WallisDeVries, M. F., & Carvalheiro, L. G. (2015). Susceptibility of pollinators to ongoing landscape changes depends on landscape history. *Diversity and Distributions*, *21*(10), 1129-1140.

Benjamin, F. E., Reilly, J. R., & Winfree, R. (2014). Pollinator body size mediates the scale at which land use drives crop pollination services. *Journal of Applied Ecology*, *51*(2), 440–449. https://doi.org/10.1111/1365-2664.12198

Conrad, O., Bechtel, B., Bock, M., Dietrich, H., Fischer, E., Gerlitz, L., … Böhner, J. (2015). System for Automated Geoscientific Analyses (SAGA) v. 2.1.4. *Geoscientific Model Development*, *8*(7), 1991–2007. https://doi.org/10.5194/gmd-8-1991-2015

Cope, G. C., Campbell, J. W., Grodsky, S. M., & Ellis, J. D. (2019). Evaluation of nest-site selection of ground-nesting bees and wasps (Hymenoptera) using emergence traps. *Canadian Entomologist*, *151*(2), 260–271. https://doi.org/10.4039/tce.2019.3

Droege, S., Tepedino, V. J., Lebuhn, G., Link, W., Minckley, R. L., Chen, Q., & Conrad, C. (2010). Spatial patterns of bee captures in North American bowl trapping surveys. *Insect*

Conservation and Diversity, *3*(1), 15–23. https://doi.org/10.1111/j.1752-4598.2009.00074.x

Faith, D. P., Minchin, P. R., & Belbin, L. (1987). Compositional dissimilarity as a robust measure of ecological distance. *Vegetatio*, *69*(1–3), 57–68. https://doi.org/10.1021/ja00731a055

GRASS Development Team (2016). Geographic Resources Analysis Support System (GRASS) Software, Version 7.0. Open Source Geospatial Foundation. Electronic document:. http://grass.osgeo.org

Hesselbarth, M. H. K., Sciaini, M., With, K. A., Wiegand, K., & Nowosad, J. (2019). landscapemetrics: an open-source R tool to calculate landscape metrics. *Ecography*, *42*, 1–10.

Hevia, V., Bosch, J., Azcárate, F. M., Fernández, E., Rodrigo, A., Barril-Graells, H., & González, J. A. (2016). Bee diversity and abundance in a livestock drove road and its impact on pollination and seed set in adjacent sunflower fields. *Agriculture, Ecosystems and Environment*, *232*, 336–344. https://doi.org/10.1016/j.agee.2016.08.021

Kautz, A. R., & Gardiner, M. M. (2019). Agricultural intensification may create an attractive sink for Dolichopodidae, a ubiquitous but understudied predatory fly family. *Journal of Insect Conservation*, *23*(3), 453–465. https://doi.org/10.1007/s10841-018-0116-2

Kennedy, C. M., Lonsdorf, E., Neel, M. C., Williams, N. M., Ricketts, T. H., Winfree, R., ... & Carvalheiro, L. G. (2013). A global quantitative synthesis of local and landscape effects on wild bee pollinators in agroecosystems. *Ecology letters*, *16*(5), 584-599.

Oksanen, J., Blanchet, F. G., Friendly, M., Kindt, R., Legendre, P., McGlinn, D., … Wagner, H. (2016). vegan: Community Ecology Package. Retrieved from https://cran.r-project.org/package=vegan

Pollet, M. (1992). Impact of environmental variables on the occurrence of dolichopodid flies in marshland habitats in Belgium (Diptera: Dolichopodidae). *Journal of Natural History*, *26*(3), 621–636.

Pollet, M. (2001). Dolichopodid biodiveristy and site quality assessment of reed marshes and grasslands in Belgium (Diptera: Dolichopodidae). *Journal of Insect Conservation*, *5*(2), 99–116. https://doi.org/10.1023/A:1011371418903

Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O., & Kunin, W. E. (2010). Global pollinator declines: trends, impacts and drivers. *Trends in Ecology & Evolution*, *25*(6), 345–353. https://doi.org/10.1016/j.tree.2010.01.007

Potts, S. G., Vulliamy, B., Roberts, S., O'Toole, C., Dafni, A., Ne'eman, G., & Willmer, P. G. (2005). Role of nesting resources in organising diverse bee communities in a Mediterranean landscape. *Ecological Entomology*, *30*, 78–85.QDC Team. (2013). QGIS Geographic Information System. *Open Source Geospatial Foundation Project*. Retrieved from http://qgis.osgeo.org

Rader, R., Bartomeus, I., Garibaldi, L. A., Garratt, M. P. D., Howlett, B. G., Winfree, R., … Andersson, G. K. S. (2016). Non-bee insects are important contributors to global crop pollination. *Proceedings of the National Academy of Sciences*, *113*(1), 146–151. https://doi.org/10.1073/pnas.1517092112

Rollin, O., Pérez-Méndez, N., Bretagnolle, V., & Henry, M. (2019). Preserving habitat quality at local and landscape scales increases wild bee diversity in intensive farming systems. *Agriculture, ecosystems & environment*, *275*, 73-80.

Senapathi, D., Goddard, M. A., Kunin, W. E., & Baldock, K. C. (2017). Landscape impacts on pollinator communities in temperate systems: evidence and knowledge gaps. *Functional Ecology*, *31*(1), 26-37.

van Rijn, P. C. J. (2017). Natural pest control requires a complete landscape. *IOBC/WPRS Bulletin*, *122*, 107–111.

Westphal, C., Bommarco, R., Carré, G., Lamborn, E., Petanidou, T., Potts, S. ., … Kunin, E. (2008). Measuring Bee Diversity in Different European Habitats and Biogeographical Regions. *Ecological Monographs*, *78*(4), 653–671. https://doi.org/10.1890/07-1292.1

FARMERS' ROLES AND PERCEPTIONS AS CONTRIBUTION TO THE CO-DESIGN OF INSECT-FRIENDLY FARMING SYSTEMS AT LANDSCAPE LEVEL

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Abstract

Insects play a crucial role for the functioning of our ecosystem but they are decreasing in numbers and variety. Agricultural landscapes, which cover more than half of Germany's total area, can provide vast insect habitats if they are managed accordingly. So far, there is a lack of implemented insect-friendly farming systems, which calls for accepted solutions. However, little is known about stakeholders' perspectives concerning their problem awareness, attitudes, current behaviour, or possible solutions. The project aim is to jointly develop insect-friendly farming systems at landscape level that are beneficial for insects and economically viable, e.g., through the establishment of flowering bioenergy crops. By involving agri-ecologists, entomologists, social scientists, and stakeholders (farmers, landowners, farmers associations, advisory services, nature conservation organisations, decision-makers, etc.) the project initiates an integrative and collaborative process with iterative feedback-loops. In this paper, we present the empirical results of an actors' analysis (constellation and roles) and evaluate actors' perceptions and visons. We use semi-structured interviews to collect data and qualitative content analysis for data interpretation. Preliminary results include: (1) competing perceptions and values exist among stakeholders (pro-active and open-minded actors vs. sceptical actors); (2) ecosystem services provided by insects play a minor role for farmers; and (3) some farmers feel that the image of agriculture has been tarnished by insect biodiversity discourses. The discussion of our results is complemented with media publications on the issue. Finally, the results are valuable for the next steps of the co-design process, especially for the development of suitable insect-friendly measures at landscape level. Generally, the project outcome is embedded in the broader challenge to contribute to the initiation of a system change that encourages a rethinking of the current agricultural system and supports establishing an innovation niche.

Introduction

Insects play a crucial role for the functioning of our ecosystem in general and in agricultural landscapes in particular, for example providing pollination or natural pest control (Isaacs et al. 2009). However, insects are decreasing in numbers and variety. Intensification and simplification processes in agricultural landscapes and associated practices such as the use of agro-chemicals and pesticides, the deterioration of water bodies through fertilization or frequent cutting of grassland removing floral food sources of insects, result in a loss of habitats for insects and numerous other species (Grass et al. 2016; Potts et al. 2009). Consequently, the provision of the insects' ecosystem services decreases (Ekroos et al. 2014). Agricultural landscapes, which cover more than half of our planet's surface, can provide vast insect habitats if they are managed accordingly. To restore and foster biodiversity, it is therefore important that measures do not just concentrate on protected areas. Instead, insect-friendly measures have to be extended to a landscape level and should be carried out in production areas and the surrounding green infrastructure (Batáry et al. 2011). So far, there is a lack of implemented insect-friendly farming systems, which calls for the development of suitable solutions. However, little is known about actors' perspectives concerning their problem awareness and attitudes towards the insect biodiversity decrease, current farming practises or alternative acceptable solutions. However, the consideration of multiple actors, their diverging interests and concerns about landscapes is needed to legitimize decisions but also to generate suitable outcomes (Reed et al. 2009). Knowing the actors' roles and applying adequate participatory strategies (e.g. involving important actors actively in the development of solutions) supports that solutions are place-based, applicable, and accepted by the actors (Campellone et al. 2018; Zscheischler, Rogga, and Busse 2017; Lange, Siebert, and Barkmann 2016). Such a co-design process is in line with adaptive and collaborative landscape design and management approaches (Folke et al. 2005; Olsson, Folke, and Berkes 2004; Campellone et al. 2018). Co-design describes the collaboration between scientists and lay people (practitioners, decision-makers, etc.) in flexible and iterative processes with feedback loops (Meynard, Dedieu, and Bos 2012). Farmers and other actors should not be seen as mere recipients of inventions but as proactive co-developer of innovations (Meynard, Dedieu, and Bos 2012; Reed 2008).

To cope with the challenge of a decreasing insects biodiversity in agricultural landscapes and to address the requirements of actors involvement in the research process, the project 'FInAL' (FInAL - Facilitating insects in agricultural landscapes through renewable resources) has been initiated. The project aim is to jointly develop insect-friendly farming systems at landscape level that are beneficial for insects and economically viable, e.g., through the establishment of flowering bioenergy crops. For that purpose, landscapes labs will be established (see figure 1). By involving agri-ecologists, entomologists, GIS and monitoring experts, agri-economists, sociologists, and practitioners (e.g., farmers, landowners, farmers associations, advisory services, nature conservation organisations, decision-makers) FInAL is a real transdisciplinary (TD) project. The pilot phase of the project is being funded from 2018 until 2021. Nevertheless, there are attempts for a long-term funding to perform a sustained monitoring and assessment regarding the appropriateness of the farming system and to implement tested measures in other agricultural landscapes beyond the established landscape labs.

Whereas the overall FInAL project is dedicated to a broad bundle of ecological and socio-economic research questions, in this paper we focus on research questions related to the initiation phase of the co-design process from a sociological perspective:

RQ1: Who are the relevant actors in the landscape lab and what are their roles?

RQ2: What are the perceptions and visions of farmers' for establishing insect-friendly farming systems?

Material and Methods

Approach: Landscape labs

To elaborate farming systems at landscape level, the FInAL project uses the so-called 'landscape lab' approach. In the landscape labs innovative insect-friendly farming systems will be tested (including an interdisciplinary monitoring and evaluation) and implemented to promote fundamental and long-term changes in the agricultural production system. The landscape labs are located in specifically selected agricultural regions and cover an area of three per three kilometres each. The size reflects the mobility radius of bumblebees. The approach of landscape labs is based on a holistic landscape perspective that includes farm plots and the surrounding landscape infrastructure (e.g., semi-natural habitats) instead of focussing merely on single farm plots or individual farms. At the current state, the FInAL project focuses its activities on two landscape labs which will be implemented in two intensively used agricultural landscapes with conventional farming practices. Both landscape labs are located in Northern Germany (see fig.1). The first landscape lab is located in the Federal state of Brandenburg. Here, mainly intensive grassland production takes place. The region is characterized by big farms and plots. The second landscape lab is located in the Federal State Lower Saxony. Due to the fertile soil, the production focus is on crops and only to a marginal extent on grassland. The farms and plots are medium-sized.

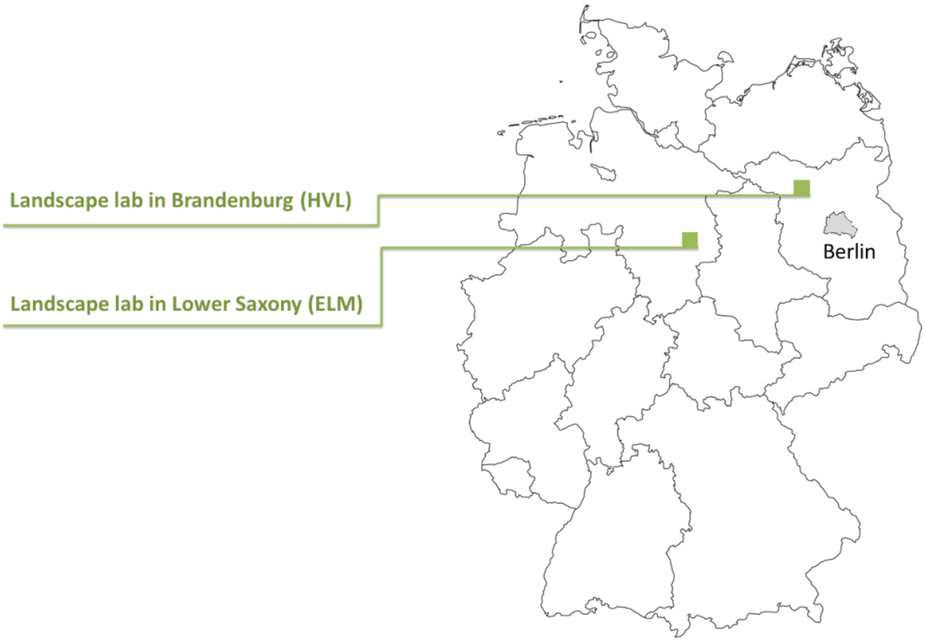


Figure 45: Location of the future landscape labs in Germany

Methods: collecting and analysing data

The design of insect-friendly farming systems in agricultural landscapes can be understood as contemporary complex phenomenon in a real-life context. Most aspects of the issue are new and still unknown. Thus, we applied an explorative and qualitative research approach, which is mentioned in the literature as being suitable for such phenomena (Patton 2019).To identify the actors' constellation and roles (RQ1), we conducted informal interviews with our partners in practice in 2018, held an informative workshop in one of the landscape lab regions in May 2019, and asked in the qualitative semi-structured interviews (Patton 2019) about additional actors applying the snowball principle. The outcome of the analytical process is a matrix with the actors' constellation, their roles, and the strategy for their involvement in the co-design process. Actor or stakeholder analysis is an important and often used method in multi-actor contexts to systemize empirical data on actors, to get an overview on the situation in the case study area, and to derive adequate participatory strategies (Reed et al. 2009; Hermans and Thissen 2009).

We used these semi-structured interviews to analyse the perception and visions of the actors which were mainly farmers (RQ2). In the landscape lab HVL, we conducted 3 interviews with farmers and 2 interviews with other land managers. In the second landscape lab, we performed 19 interviews with farmers and 1 interview with a private nature conservation organisation. The interview guideline was based on own previous knowledge from similar projects, established literature, and the informative workshop. The guideline contained questions about 1) the perception of insect decrease; 2) the importance of insect biodiversity for the farm and region; 3) existing insect-friendly measures on the farm or the managed land; and 4) the requirements for the development of insect-friendly farming systems. The interviews lasted between 30 minutes and one-and-a-half hours. To meet the requirements of transparency and reliability in qualitative research (Patton 2019), we produced interview notes, which included the personal impression and circumstances of the interview situation, as well as additional information beyond the recorded interview itself. The audio-recorded interviews were transcribed. Afterwards, the transcripts were sent to interviewees, thus providing them with copies with which to confirm the interview content. This procedure follows the ethical standards of qualitative social science (Mero-Jaffe 2011).

To analyse and interpret the semi-structured interviews, we used the method of qualitative content analysis described in Kuckartz (2014) and Schreier (2014). Recognizing that there are diverse types of qualitative content analysis, we applied the structured type to perform an interpretive thematic analysis. For this type, the use of thematic categories is common. Whereas the main topics are developed deductively (from the interview guideline), the specific thematic categories were built inductively. Inductively means that the categories stem from the empirical material. This approach is often applied when the phenomenon is novel and categories are unknown.

Results

Results of RQ1:

Both landscape labs vary in their number of farms and individual farm sizes. Due to the agricultural structure in the HVL region, in this landscape lab only a few farmers are active. In contrast, the area of landscape lab ELM is cultivated by 24 farmers (Table 1). Both lab regions have water and ground organisations that represent the interests of owners and users, regional nature conservation authorities, biogas plants, other administrative organisations, and local residents. In contrast to the lab region ELM, in HVL there is no official agricultural advisory service.

Table 27: Relevant actors in the landscape labs and their roles

Actor category	Actors in landscape lab HVL	Actors' roles in HVL	Actors in landscape lab ELM	Actors' roles in ELM	Participatory strategy per actor category
Agricultural users	8 farms and farm manager	Mostly conventional agricultural activities, 2 farms cover the main part of the area	24 farms and farm manager	Conventional agricultural activities, 5 farms cover the main part of the area	Active involvement in the co-design, implementation, and dissemination of measures
Other land users and managers	Regional water and ground association	Organisation of public interest, maintenance of water bodies and riparian stripes	Regional ground association 'Feldmarksinteressentschaft'	Community of interest of land owners, maintenance of waysides and field margins	Active involvement in the co-design, implementation, and dissemination of measures
	District administration	Organisation of public interest, maintenance of waysides			Active involvement in the co-design, implementation, and dissemination of measures
			Private forest owners	Management of forests	Informed about project progress
	Private hunters	Hunting	Private hunters	Hunting	Informed about project progress

Agricultural advisory	---	---	Regional chamber of agriculture	Advisory services, experimentation	Involvement in the dissemination of measures and setting-up policy recommendations
Nature conservation	Regional nature conservation authority	Decisions regarding impact mitigation regulation and species and habitat protection measures, etc.	Regional nature conservation authority	Decisions regarding impact mitigation regulation and species and habitat protection measures, etc.	Involvement in setting-up policy recommendations
	Regional governmental ornithological centre	Research and monitoring of protected species	Private nature conservation organisation	Land owner of several land plot	Informed about project progress
Renewable energy	1 Biogas plant operator	Production of biogas, external company using mainly regional substrate	2 Biogas plants operator	Production of biogas, managed by local farmers using regional and supra-regional substrates	Involvement in the co-design and implementation of measures
Business	Regional agricultural trading firm	Purchase of products, sale of operating	Regional agricultural trading firm	Purchase of products, sale of operating	Involvement in the dissemination of measures

		material & machines		material & machines	
Other actors of minor interest for insect-friendly farming systems	Other administrative organisations	Reginal decision-making, authorization, management, etc.	Other administrative organisations	Reginal decision-making, authorization, management, etc.	Informed about project progress
	Local residents	Recreational activities, owner of home gardens, etc.	Local residents	Recreational activities, owner of home gardens, etc.	Informed about project progress

The actors' roles in the landscapes do not differ much in both lab regions. On basis of these roles we derived an adequate participatory strategy for the co-design process. Farmers, other land managers, and the biogas plant operator should be involved actively from the beginning in all phases of the process. In contrast, advisory service and business actors can be better involved in the later phases such as dissemination of measures and setting-up policy recommendations. Less important actors only need to be informed about the project progress.

Results of RQ2:

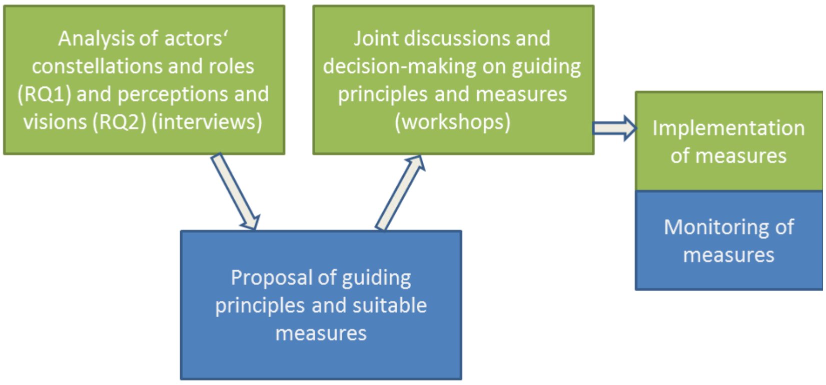
Interviewees differ, sometimes substantially, in their perceptions about a decrease in insects. For some farmers, the topic is more relevant, for others it has not played an important role yet. Many farmers did not perceive a decrease in insect biodiversity on their farms and in their regions. They often stated that they lack knowledge about insect biodiversity to be able to assess the issue. However, all of them were aware of the problem because of the high media presence of the topic in the last two years. A few farmers mentioned indirect indicators that they related to decreasing numbers of insects, for example less swallows nesting on their farmhouses. Some of the interviewees doubted that the problem even exists. Generally, farmers do not want to be blamed for the decrease of insects and be accused for being the sole culprits in the debate about reasons for the decline of insect biodiversity.

"To attribute the death of insects to the impact of agriculture, I believe, one should not do that and it is also incorrect. Rather, one should also look at the other aspects: Traffic, light, etc. What does it mean, more insects? If only someone would determine how many flies and how many mosquitos are killed on the streets, and how many used to be on the windshield—those are quite daring speculations. One should also look at the weather and … and … so much plays a role in this." (Q1)

Most interviewees advocate that the issue should be treated in a holistic manner, where multiple causes, such as light pollution, are considered as well. Some farmers feel that the image of agriculture has been tarnished by insect biodiversity discourses.

"The image of agriculture ultimately is not all that pretty. If we only look at the story of glyphosate that has been going through the media. I personally would be the first advocate to say, we don't need glyphosate … If the general public wants that, then it must obviously … be supported by everyone." (Q2)

Ecosystem services provided by insects in agricultural landscape, such as pollination and pest control play minor role for the interviewed farmers. Very few farmers mentioned the role that insects play for their regions. As it is difficult for the farmers to observe the direct correlation between the occurrence of beneficial insects and aspects such as their yield, monitoring results from the project are a reason for some of them to join the project.



In regards to actors' motivations, most farmers are open-minded, and are willing to participate in the landscape labs. They are aware of the need to contribute in general to insect biodiversity. They feel that performing insect-friendly farming will be required by the agri-environmental funding schemes in near the future. Participating in the project is also frequently considered as an opportunity to improve society's image of agriculture. However, some other farmers are more sceptical. Scepticism was stated in various forms. Many farmers mentioned that if alternative crops are grown as a measure to increase insect biodiversity (e.g., flowering energy crops), there has to be a demand and a value chain utilizing the produced crops. A lack of experience with alternative crops was stated as another obstacle for the implementation. A few farmers also reported on larger contexts, for example being held responsible for the insect decrease by the general public while consumers are not willing to pay more for food that is produced in an environmentally friendly way.

Some farmers already apply farming measures that support insects by providing nutrition and reproduction and hibernating/wintering habitats. They use flowering field margins or stripes, fallow periods, intercrop cultivation and others. Most of these measures are acknowledged as CAP greening schemes. At the same time, farmers often are not aware that these measures can be considered as insect-friendly. Some farmers also adapt their routines, for example by spraying pesticides at night when there are no bees present, on windless days, or in a point application.

The analysis of farmers' perceptions and visions is an important preparing step for the further co-design process of insect-friendly farming systems, which includes also the implementation and monitoring. The main steps of this process are illustrated in figure 2.

Figure 2: The integration of the both actors' analysis into the co-design process of the FInAL project. Boxes in green are steps with a close involvement of actors (mainly farmers) and boxes in blue are steps which are mainly performed by the scientists.

The farmers stated a broad range of individual requirements for the co-design of insect-friendly farming systems. Although farmers ask for proposals of suitable measures by agroecologists and agronomists, they want be actively involved in discussion and decision processes regarding the development and implementation of measures. Further requirements mentioned were stated regarding agricultural measures on the field and the surrounding landscape infrastructure (e.g. hedges or margins on water bodies). Concerning the agricultural measures on the field, interviewees had different views. Some preferred large-scale on-field measures (e.g. intercropping), because they require fewer working steps, whereas others preferred measures that focus on small and marginal areas (e.g. field margins). Most farmers prefer to conduct such measures on less productive plots. Generally, it is important to farmers that they can use the machinery they already possess. One farmer proposed to design a joint long-term rotation plan which involves different farm plots. The majority of the other farmers stated that they would support the idea. The opportunities that emerge from this collaborative approach are discussed in the next section. Preferences regarding the type of insects being fostered, for example a focus on rare varieties, biomass or beneficial insects, were expressed only occasionally. When the farmers referred to this aspect, their main concern was that the measures did not foster pests and harmful insects Promoting beneficial insects groups, such as pollinators and insect predators or parasites of pest insects was considered as a welcome effect but not an absolute necessity. Many farmers stated that they have only limited knowledge about insect biodiversity. Their knowledge is focussed on crop harmful insect species. Therefore, farmers wish to get in knowledge exchange with the scientists.

Discussion and Conclusion

Our interview results in form of actors' perceptions and visions can be contextualized with the broader public debate on insect biodiversity loss. The considerable interest of the general public and politics is reflected in the wide media coverage, an increasing number of scientific articles, petitions and political decisions. In the Federal State Bavaria, the public referendum 'Save the bees' for protecting biodiversity and natures' beauty was initiated by the BUND, a German nature conservationist organisation[107]. Due to the success of the referendum, the nature conservation law in Bavaria was amended in July 2019.[108] A reaction to the amendment proposal was that Bavarian farmers preventively cut their fruit trees to avoid that meadow orchards with fruit trees would be protected by the new law.[109] In the Federal State Brandenburg, the petition 'Save species diversity – save the future' has been started by the BUND and NABU in April 2019. The launch of the alternative petition for protecting insects ('Protect insects – preserve cultural landscapes') in the same Federal State and at the same time indicates that farmers and their organisations have a different point of view than nature conservation organisations. [110] They advocate that the insect topic should be treated in a holistic manner, where multiple causes are considered and a diversity of possible interventions is discussed. In general, many farmers feel pressured and some of them even negate any responsibility. In a statement, the managing director of a farmer association of the state Brandenburg and an initiator of the petition 'protect insects – preserve cultural landscapes' said: "*It is a fact that the living conditions for insects have*

[107] https://www.bund-naturschutz.de/aktionen/volksbegehren-artenvielfalt.html
[108] https://www.verkuendung-bayern.de/gvbl/2019-405/
[109] https://www.sueddeutsche.de/bayern/volksbegehren-artenvielfalt-biotop-baumfaellen-1.4445780
[110] http://initiativebienensummen.de/#

not worsened by agriculture in the past 25 years."[111] More drastically, he added: „*The insect lie is the biggest lie since the mad cow disease.*"[1] Our research project is not about finding culprits, it is about using the potential of agriculture and to find solutions together. Including the co-design approach actively involves farmers and aims at finding solutions that are viable and implementable by the practitioners. In our opinion, this is the way to go if the developed measures are to be accepted, disseminated to other agricultural landscapes, and to finally address the decrease of insects systemically.

Regarding the relevance for farmers and their motivation to participate we assume that the topic insect-friendly farming is mainly induced by science, decision-makers, media, and the public. Without the initiative through the FInAL project, this issue would not have been brought up by the interviewed farmers themselves. At the same time, farmers recognize the chance of getting involved in the project. The perceived benefit lays in the active contribution of developing future and practice-friendly agri-environmental funding schemes. Farmers perceive the public demand for a sustainable transformation of the agriculture system. Therefore, they want to be an active part of this transformation instead of only being an adopter of top-down decisions.

The farmers' proposal of designing collaboratively on the landscape level (including farm plots and the surrounding green infrastructure) provides opportunities for agroecology, social science, and agricultural practice at the same time. Some studies show that biodiversity conservation has to be considered on a landscape level and that landscapes consisting of diverse structural elements are beneficial for insects (Tscharntke et al. 2002; Steingröver, Geertsema, and van Wingerden 2010). In agricultural landscapes, cultivated plants such as oilseed rape (*Brassica napus*) or leguminous plants (*Leguminosae*) can also be a food source to insects but field margins usually exhibit a higher abundance of insect species than the centres (Stanley, Stout, and Clough 2013). Thus, it is necessary that close to the production area, within reach of the insects, there are non-crop areas which are suitable as insect habitats (Zhang et al. 2007). Fostering insects on a landscape level requires cooperation among the farmers that farm the respective land. The fact that the impetus for cooperation in one of the landscapes labs comes from a farmer and other farmers were open to this idea is a good basis for landscape level management. However, time will tell whether different interests and ideas of farmers can actually be harmonized and merged into a joint implementation of insect friendly measures. For social science, experimenting joint actions based on volunteers generates insights into how collaborative actions can be initiated, established and sustained. Additionally, it provides the opportunity to identify factors of success or failure and to build boundary concepts (Steingröver, Geertsema, and van Wingerden 2010). The benefits for the agriculture practice is in experimenting with joint actions, social learning, building up a farmers networks, and promoting social capital (Campellone et al. 2018; Steingröver, Geertsema, and van Wingerden 2010; Reed 2008).

As an outlook, the actors' roles, perceptions, and visions are an important basis for the further steps of our co-design process, especially in the development of measures at the landscape level. The outcome of the whole project is embedded in the broader challenge to contribute to the initiation of a system change that encourages a rethinking of current agricultural system and supports establishing an innovation niche. The approach of the FInAL project is future-oriented and integrative by including the landscape scale and their diversity of actors. Applying this approach, we contribute to the IFSA theme 6 'Landscape integration of farming'.

Literature

Batáry, Péter, András Báldi, David Kleijn, and Teja Tscharntke. 2011. "Landscape-Moderated Biodiversity Effects of Agri-Environmental Management: A Meta-Analysis." *Proceedings*

[111] https://www.maz-online.de/Brandenburg/Brandenburger-Bauernbund-bezeichnet-Insektensterben-als-Agrarluege

of the Royal Society B: Biological Sciences 278 (1713): 1894–1902. https://doi.org/10.1098/rspb.2010.1923.

Campellone, Robert M., Kristina M. Chouinard, Nicholas A. Fisichelli, John A. Gallo, Joseph R. Lujan, Ronald J. McCormick, Thomas A. Miewald, Brent A. Murry, D. John Pierce, and Daniel R. Shively. 2018. "The ICASS Platform: Nine Principles for Landscape Conservation Design." *Landscape and Urban Planning* 176 (August): 64–74. https://doi.org/10.1016/j.landurbplan.2018.04.008.

Ekroos, Johan, Ola Olsson, Maj Rundlöf, Frank Wätzold, and Henrik G. Smith. 2014. "Optimizing Agri-Environment Schemes for Biodiversity, Ecosystem Services or Both?" *Biological Conservation* 172 (April): 65–71. https://doi.org/10.1016/j.biocon.2014.02.013.

Folke, Carl, Thomas Hahn, Per Olsson, and Jon Norberg. 2005. "Adaptive Governance of Social-Ecological Systems." *Annual Review of Environment and Resources* 30 (1): 441–73. https://doi.org/10.1146/annurev.energy.30.050504.144511.

Grass, Ingo, Jörg Albrecht, Frank Jauker, Tim Diekötter, Daniela Warzecha, Volkmar Wolters, and Nina Farwig. 2016. "Much More than Bees—Wildflower Plantings Support Highly Diverse Flower-Visitor Communities from Complex to Structurally Simple Agricultural Landscapes." *Agriculture, Ecosystems & Environment* 225 (June): 45–53. https://doi.org/10.1016/j.agee.2016.04.001.

Hermans, Leon M., and Wil A.H. Thissen. 2009. "Actor Analysis Methods and Their Use for Public Policy Analysts." *European Journal of Operational Research* 196 (2): 808–18. https://doi.org/10.1016/j.ejor.2008.03.040.

Isaacs, Rufus, Julianna Tuell, Anna Fiedler, Mary Gardiner, and Doug Landis. 2009. "Maximizing Arthropod-Mediated Ecosystem Services in Agricultural Landscapes: The Role of Native Plants." *Frontiers in Ecology and the Environment* 7 (4): 196–203. https://doi.org/10.1890/080035.

Kuckartz, Udo. 2014. *Qualitative Text Analysis: A Guide to Methods, Practice & Using Software - SAGE Research Methods*. London: SAGE Publications Ltd. https://dx.doi.org/10.4135/9781446288719.

Lange, Andrej, Rosemarie Siebert, and Tim Barkmann. 2016. "Incrementality and Regional Bridging: Instruments for Promoting Stakeholder Participation in Land Use Management in Northern Germany." *Society & Natural Resources* 29 (7): 868–79. https://doi.org/10.1080/08941920.2015.1122135.

Mero-Jaffe, Irit. 2011. "'Is That What I Said?' Interview Transcript Approval by Participants: An Aspect of Ethics in Qualitative Research." *International Journal of Qualitative Methods* 10 (3): 231–47. https://doi.org/10.1177/160940691101000304.

Meynard, Jean-Marc, Benoit Dedieu, and A. P. (Bram) Bos. 2012. "Re-Design and Co-Design of Farming Systems. An Overview of Methods and Practices." In *Farming Systems Research 405 into the 21st Century: The New Dynamic*, edited by Ika Darnhofer, D. Gibbon, and Benoit Dedieu. Dordrecht: Springer Science and Business.

Olsson, Per, Carl Folke, and Fikret Berkes. 2004. "Adaptive Comanagement for Building Resilience in Social-Ecological Systems." *Environmental Management* 34 (1). https://doi.org/10.1007/s00267-003-0101-7.

Patton, Michael Quinn. 2019. *Qualitative Research and Evaluation Methods. Integrating Theory and Practice*. Fourth edition. Thousand Oaks: SAGE Publications Ltd. https://uk.sagepub.com/en-gb/eur/qualitative-research-evaluation-methods/book232962.

Potts, S. G., B. A. Woodcock, S. P. M. Roberts, T. Tscheulin, E. S. Pilgrim, V. K. Brown, and J. R. Tallowin. 2009. "Enhancing Pollinator Biodiversity in Intensive Grasslands." *Journal of Applied Ecology* 46 (2): 369–79. https://doi.org/10.1111/j.1365-2664.2009.01609.x.

Reed, Mark S. 2008. "Stakeholder Participation for Environmental Management: A Literature Review." *Biological Conservation* 141 (10): 2417–31. https://doi.org/10.1016/j.biocon.2008.07.014.

Reed, Mark S., Anil Graves, Norman Dandy, Helena Posthumus, Klaus Hubacek, Joe Morris, Christina Prell, Claire H. Quinn, and Lindsay C. Stringer. 2009. "Who's in and Why? A Typology of Stakeholder Analysis Methods for Natural Resource Management." *Journal of Environmental Management* 90 (5): 1933–49. https://doi.org/10.1016/j.jenvman.2009.01.001.

Schreier, Margrit. 2014. "Qualitative Content Analysis." In *The SAGE Handbook of Qualitative Data Analysis*, by Uwe Flick, 170–83. 1 Oliver's Yard, 55 City Road, London EC1Y 1SP United Kingdom: SAGE Publications Ltd. https://doi.org/10.4135/9781446282243.n12.

Stanley, Dara A., Jane C. Stout, and Yann Clough. 2013. "Quantifying the Impacts of Bioenergy Crops on Pollinating Insect Abundance and Diversity: A Field-Scale Evaluation Reveals Taxon-Specific Responses." *Journal of Applied Ecology* 50 (2): 335–44. https://doi.org/10.1111/1365-2664.12060.

Steingröver, Eveliene G., Willemien Geertsema, and Walter K. R. E. van Wingerden. 2010. "Designing Agricultural Landscapes for Natural Pest Control: A Transdisciplinary Approach in the Hoeksche Waard (The Netherlands)." *Landscape Ecology* 25 (6): 825–38. https://doi.org/10.1007/s10980-010-9489-7.

Tscharntke, Teja, Ingolf Steffan-Dewenter, Andreas Kruess, and Carsten Thies. 2002. "CONTRIBUTION OF SMALL HABITAT FRAGMENTS TO CONSERVATION OF INSECT COMMUNITIES OF GRASSLAND–CROPLAND LANDSCAPES [*]." *Ecological Applications* 12 (2): 354–63. https://doi.org/10.1890/1051-0761(2002)012[0354:COSHFT]2.0.CO;2.

Zhang, Wei, Taylor H. Ricketts, Claire Kremen, Karen Carney, and Scott M. Swinton. 2007. "Ecosystem Services and Dis-Services to Agriculture." *Ecological Economics* 64 (2): 253–60. https://doi.org/10.1016/j.ecolecon.2007.02.024.

Zscheischler, Jana, Sebastian Rogga, and Maria Busse. 2017. "The Adoption and Implementation of Transdisciplinary Research in the Field of Land-Use Science—A Comparative Case Study." *Sustainability* 9 (11): 1926. https://doi.org/10.3390/su9111926.

WHAT LEARNING ARRANGEMENTS TO ACCOMPANY INNOVATING AGROECOLOGICAL MANAGEMENT OF LANDSCAPE RESOURCES ACROSS SCALES? LESSONS FROM THREE CASE STUDIES IN WESTERN FRANCE.

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Abstract

In the last decades, landscape changes in north-western France have been marked by a significant development of large livestock-cropping farms and of urbanized poles, but also of alternative agricultural systems (e.g., organic farming) and initiatives for regenerating cultural landscapes (e.g., bocage landscapes). In this context, developing research studies in landscape ecology /agronomy /management, in partnership with local actors (from farmers to local authorities), to foster sustainable practices of management of landscape resources, led us to point three main difficulties. They are related to: 1) the need for local actors to deal with uncertainties in the relationships between landscapes, management practices and ecological functions, 2) the mutual relative ignorance of farmers and land-use planners about their respective contribution to the landscape dynamic, 3) the gaps between agricultural and land-use planning schemes, and between these policy schemes and the local initiatives, in terms of involved actors, scales, objectives and processes. We present lessons learnt from three case studies, from field to regional scales, in which we are dealing with these difficulties by designing and testing learning arrangements with local actors. In the first case, with a group of farmers innovating in bocage agroforestry, we extend an agronomic diagnosis approach by integrating indicators of ecological functions, factors at play (landscape and practices) and farmers' management resources. In the second case, we propose realistic simulations of the contribution of farming production activities to landscape dynamics, as a support tool for land-use planning. In the third case, to support groups of actors in the design, the implementation and the ownership of green infrastructures, we propose a process in successive stages and tool kits for organizing local experiences.

Introduction

As recalled by Liquete *et al* (2015), maintaining and developing Green Infrastructures (GI) has been put forward by the European Union as a priority issue, GI being defined as a "strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services". In this perspective, GI have become shared features in several European policies dealing with *e.g.*, agriculture, biodiversity conservation, or land and resource planning (Liquete *et al.*, 2015). Still, difficulties in aligning these sectorial policies have been pointed (Hodge *et al.*, 2015; Xu *et al.*, 2019). Besides, Green Infrastructures are shared features for numerous and diverse stakeholders that have however different perspectives on GI, different managerial responsibilities or production objectives, at different scales, on different territories (*i.e.*, on different management, project and/or living areas). In fact the variety of stakeholders involved in such GI-schemes implementation processes remains quite low, while the beneficial role of public participation in such experiences has been shown (Xu *et al.*, 2019). Both the complex relative influences between actors on land-use decisions and the lack of knowledge of each other, are key issues that should be addressed to foster more participative and efficient GI design processes (Hauck *et al.*, 2016). In this perspective, stakeholders' involvement into social learning about GI underlying processes (*e.g.*, ecological processes or land-use decision making), and stakeholders' involvement into GI design and management projects may reinforce each other (Opdam *et al.*, 2016). Farmers may be envisaged as key stakeholders in such approaches considering their important roles in landscape management both as producers, land owners and citizens (Primdahl *et al.*, 2013).

In this paper we report from three case studies about the way we contributed to learning tools and approaches with stakeholders for GI sustainable design and management, with a specific attention to farmers' roles. These three case studies have been taking place in landscape-project territories situated on the Armorican Massif of North-Western France (Bretagne and Pays-de-Loire Regions). The area of the Armorican Massif is characterized by a bedrock of much eroded granite and diverse metamorphic rocks, a gently rolling terrain and an oceanic climate. Crop - livestock systems are the most common farming systems. Bocage landscape (*i.e.*, with hedgerows networks) is the main cultural landscape of the area. These studies range from farm to municipality then county scales, and from participatory approaches with mainly farmers and advisers to approaches with multiple stakeholders (*i.e.*, with land-planners, farmers and advisers, then also with *e.g.*, education actors and citizens).

After a presentation of the context, the starting points and content for each case study, we will discuss the lessons learned as regards the difficulties and opportunities outlined above and during the experiences. Hereafter, the phrases in italics correspond to the notes we have taken during workshops; they illustrate actors' feedbacks. The phrases that are both in italics and between quotation marks correspond to our translation of the actors' writing.

1. Accompanying farmers' innovations in bocage agroforestry from a principle of diagnosis-observatory in their farm and landscape context (case study nr1)

Agrarian systems combining trees with crops and grassland used to be common across European countries and more specifically, as in the French Bretagne Region, took the form of hedgerows alongside fields. In this region, the greatest development of what we would designate today as an agroforestry system fully integrated in both farming production and the local-regional economy (*e.g.*, tenure boundaries, main source of fuel and timber wood), was reached in the nineteenth Century. In the twentieth Century, a widespread removal of hedgerows occurred with land consolidation programs accompanying the productivity-based development of agriculture. The previous integrated agroforestry system turned into a variety of farmers' individual paths, according to their values but also to their evolving resources (human resources, *e.g.*, knowledge and workforce; material resources, *e.g.*, equipment and products; natural resources, *e.g.*, land). In the same period, scientists and environmental associations raised people awareness about the environmental issues associated to hedgerows and hedgerows-network landscapes (*i.e.*, bocage landscapes). More broadly, such awareness led to further incorporating environmental issues in both agricultural and landscape planning policies, with for instance hedgerows considered as green infrastructures eligible for cross compliance in the first CAP Pillar, or regional hedgerows-planting schemes. Maybe because bocage landscapes were then rather envisaged as remnants of totally vanished farming systems, and hedgerows primarily considered as environmental infrastructures, such schemes marginally involved farmers as managers and potential designers of hedgerows. In this context, a group of farmers and technicians founded an association[112] with the willingness of *"exchanging, educating and organizing so that the bocage culture remains part of the agricultural profession, in connection with the territories, which landscapes they [the farmers] contribute to shape"*. The association states working for *"the maintenance and renewing of a quality bocage linked to farming activity"*.

In the frame of a European project on agroforestry then a national research-development project, we[113] have developed research works in partnership with the farmers' association. The main issue addressed by the farmers and their advisers was *how to assess and monitor (including by*

[112] Terres & Bocage Association founded in 2008: http://terresetbocages.org/
[113] UMR BAGAP and UMR SAS in Rennes

themselves) their novel practices of design and management of hedgerows from a multifunctional perspective and as a baseline for further developments. In a first experience, we set up a study to assess the current differences in terms of environmental and agricultural functions between herbaceous field margins, young 15-20 years-old hedgerows (designed by the association) and old 100-200 years-old hedgerows in their farm and landscape context. We could assess that young hedgerows were of intermediate status between herbaceous field margins and old hedgerows in terms of biodiversity and carbon storage. Young hedgerows started to produce biomass for firewood and mulch, and to fulfill functions expected by farmers such as protecting and enclosing cattle in pastures, regulating soil erosion, or for landscape scenery[114]. If this first study allowed us to draw up a first state of play, it could not fully answer to farmers' main questions about assessing their practices, as the study focused on the functional implications of the presence, structure and age of the hedgerows at one point in time.

The works of this first stage were organized through introductive then feedback workshops with farmers and advisers, and the definition and implementation of on-farm observations, measurements and interviews. The feedback workshop of this first stage of work allowed us to have a collective discussion about the results and then, to further identify *farmers' questions about how to direct their practices to develop these multiple functions of hedgerows*. *For instance, farmers asked about how to favor biodiversity by their hedgerows design and their management practices (biodiversity for natural regulation but also birds or huntable species), how to assess and monitor their use of the "co-products" from hedgerows as organic fertilizer in fields, or how to assess if and how much fallen leaves contribute to soil organic matter in field.* It appears that such questions fit well into an agronomic diagnosis approach, which is well known by farmers. A diagnosis approach generally aims at identifying a problem of importance (*e.g.*, of decrease in yield) and the levers of action that could be mobilized to "solve the problem". The interest of such an approach is that it focuses on causal relationships between farmers' resources, practices and the phenomenon of interest, and aims at providing farmers with tools to make their own assessment (*e.g.*, indicators from observations). In our particular situation, such an approach required to be adapted, because i) the interest of farmers is not solely on fields but both on fields and hedgerows alongside, ii) the phenomena of interest are environmental and agricultural functions of diverse nature, iii) the landscape context is part of the drivers of environmental and agricultural functions, and iv) environmental and agricultural functions as well as farmers' practices, farmers' resources and the surrounding landscape are fundamentally evolving under different dynamics.

In this perspective, the ongoing work aims at designing and testing with farmers a diagnosis - observatory of the environmental and agricultural functions of contrasted fields and hedgerows alongside, as a learning arrangement to support farmers in further developments. The aim is first to describe the phenomenon of interest, *i.e.*, a process underlying environmental functions (*e.g.*, carbon input for carbon storage and organic matter availability, or type of flora biodiversity for complementary resources for pollen-gathering insects). Second, we constitute a step-by-step root causes analysis with farmers up to their practices (*e.g.*, carbon inputs to the soil under a hedgerow may come from plant residues because of grass crushing and/or herbicide spraying, but also from sediments due to soil erosion from upslope fields). Third, we go further in the root causes analysis up to their farm and landscape/territorial resources: such resources are at play in farmers' decisions and practices and may finally influence the environmental processes (*e.g.*, landscape diversity or mutual-aid networks may be such resources).

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[114]https://www.agforward.eu/index.php/en/bocage-agroforestry-in-brittany-france.html

2. Simulating the farmers' contributions to landscape mosaics and corridors at municipality scales from within-farms decision-making (case study nr2)

The "Green and Blue Corridors" French Policy (GBC scheme) has been stated in the frame of the National Strategy for Biodiversity, and organized at the regional level through the "Regional Ecological Consistency Schemes". The core objective, relying on landscape ecological principles, is to define and maintain ecological networks favorable to the movements and development of spontaneous flora and fauna, including both remarkable and ordinary areas. Within this framework, biodiversity issues shall be stronger integrated into account in local land-planning schemes. In Pays-de-Loire Region, hedgerow networks with associated grassland and ponds are identified as the "bocage network". In the frame of a research project dealing with farming contribution to ecological networks in periurban areas, we followed up the processes and debates of several developing land-planning schemes. At these local scales, bocage ecological continuities largely depend on the specificities and spatial arrangement of farming activities. Yet, in local debates and reports about the implementation of GBC schemes into land-planning schemes, farming activities were often mentioned in quite general or caricatural manner: the diverse farms and diverse ways of farming were not envisaged as drivers of landscape patterning diversity, hence not as potential levers of action. Moreover, in such regions of the Armorican Massif the fragmentation of farm territories (*i.e.*, parceling and scattering of farmland) and the rather smooth topography make it quite difficult to "read" directly the contribution of farms to local landscapes.

This starting point led us in this project to explore means to represent the contribution of farmers to landscapes due to farms diversity and within-farms decision-making[115]. One key aspect was to find a balance between realism and stylization of the landscape simulation so that scenarios of farming and landscape changes would be feasible and remain relevant in the territorial context. To perform the simulation, we chose one municipality (of about 60 Km^2) which was part of a larger territory under a process of setting up a territorial coherence program. Our objective was to assess from simulation the contribution of the diversity of farms to grassland ecological continuities at this municipality level. We identified and characterized different types of farming systems from farmers' interviews at the scale of the larger territory encompassing the municipality. Four types (to remain simple) of crop-livestock farming systems were identified, which mainly differed by their cattle production orientation and their rate of grassland and fodder crops *versus* annual crops for sell, in their overall crop acreage. The agricultural field pattern of the whole municipality was reconstituted from the Land Parcel Identification System (LPIS) and from aerial photography: 64 farms were identified, which fragmented territories stretched largely over the municipality area. We performed several scenarios, with allocating different combinations of farm types to the 64 farm territories. Then in each farm, crops and grassland (both temporary and permanent grassland) were allocated according to the crop acreage of the farm type, and according to the archetypes of farmers' decision rules collected during the interviews (*e.g.*, according to constraints of distance to the farmstead, of field surface, or to requirements in terms of grassland staying duration). In these landscape simulations, built-up areas, roads, rivers and very constraining fields of semi-natural grassland (*e.g.*, on very small, sloppy or wet fields, eventually with bush encroachment) were out of the simulation process and remain as in the initial observation. For each simulated landscape, the ecological continuities formed by the temporary and permanent grassland were measured with a simple indicator, namely the size of the largest patch of grassland. The results showed that the diversity of farm types within the municipality area significantly influences both the rate in surface and the spatial arrangements of the managed grassland. Such results may also depend on the contributions of the farms in area to the municipality territory, and the way they stretch over the boundaries of

[115] https://www6.inra.fr/programme-diva/DIVA-3/Les-projets-DIVA-3-retenus/TRAMIX

the municipality, as *e.g.*, the distance of the fields to the farmstead is a criterion in farmers' decision rules of land-use allocation. Finally, according to the simulations, the spatial arrangement of the managed grassland as regard other green infrastructures such as the small semi-natural grassland fields, may foster the emergence of larger ecological continuities. Hence, the maintenance of all these green infrastructures depending on very diverse stakeholders is at stake.

The principles and results of this simulation test have been presented as one case study in the introduction of a workshop of debate on the theme "Farming practices and biodiversity preservation in the implementation of spatial planning policies"[116]. The participants were (beside teachers-researchers and students), actors from chambers of agriculture, local authorities, environmental associations and engineering offices. We report now some issues underlined by the participants from the listening of the simulation case study. *The participants first emphasized that GBC schemes indeed call out of a logic of zoning opposing (roughly said) areas of nature with biodiversity experts versus areas of agriculture with farmers more and more "disconnected from their environment". In fact, agricultural areas should be seen as multifunctional areas, and so called "natural areas" should not exclude farmers. Nevertheless, these principles of GI design and management face several operational challenges, mainly linked to the territorial scales (municipality, inter-municipalities) at which GI should be implemented to be functional. Most often agriculture-biodiversity projects have been developed at small site scales with voluntary farmers; and even at these scales, an ecological follow-up is not always performed. To deal with GI issues at broader "territorial" scales, it is necessary to both enhance the capacities for action of the different actors at their respective level of work, and their capacities for collective commitments in a collaborative frame for reworking landscape mosaics. Yet this is clearly at these scales that farming dynamics are difficult to figure out and biodiversity difficult to monitor. To sum up, at these territorial scales it is difficult to conceive what is played out and what is at stake: means should indeed be developed to support actors of local territories to appropriate the subject and relay the issues.*

3. Developing a GI design approach with multiple stakeholders at county scales (case study nr3).

In the perspective of implementing the GBC scheme in Bretagne Region, *local stakeholders raised the issue that no methodology was provided to implement such schemes at sub-regional scales. Yet, Green Infrastructures are supposed to be consistently designed from regional to local scales, across the administrative boundaries, and they concretely concern numerous diverse people.* From this starting point, a project has been initiated in close partnership between research and open environmental education[117] (referred to below as the project team). The purpose of the project was the participatory design from multi-actors experiences in pilot areas, of a methodology for accompanying these actors from raising awareness about biodiversity and Green Infrastructures, to operational implementations of GBC schemes[118]. The project team proposed experiences and tools to be tested in pilot territories to local technical committees composed by voluntary participants (of *e.g.*, chambers of agriculture, farmers' associations, tasks officers of local authorities, environmental associations, hunting federations, water catchment syndicates), and collect feedbacks during these experiences. From those feedbacks, the project team proposed novel experiences and tools or a deepening of what has been proposed. The project was therefore organized in an iterative process of learning from the experiences.

The experiences that have been proposed during the project were for instance: i) on-field experience of carabid-beetles' observations to discover ecological functions and movements across the landscape, ii) a workshop for testing different methods for identifying and mapping GI-

[116] http://www.groupe-esa.com/les-rencontres-esa-inra/
[117] URCPIE Bretagne: Regional Union of Permanent Center for Environmental Initiatives
[118] https://tvbchemins.com/

networks, or iii) training sessions about "how to tackle Green Infrastructures issues with different publics", or "how to implement GBC-schemes on territories". Some feedbacks from these experiences are illustrated hereafter. *Recurrent questions were in fact about how to identify ecological continuities (with what indicators), how to mobilize the actors of the territories and how to build up an action plan. The participants to the local committees expressed that it was difficult for them to grasp such notions of ecological continuities. During on-field experiences bringing together farmers and other actors of the local committees, farmers were surprised to discover so many carabid beetles in the pitfall traps on their land, especially the differences between the center of the fields and the field margins; from this experience, they better understood this notion of movement of species across the landscape. The participants of the workshop for testing methods had difficulties to relate the proposed maps to the reality of the field from their viewpoint in their working context; also such maps should be realistic enough but without entering into too fine spatial details.*

The succession of experiences allowed us to identify three major stages for a GBC project approach, namely a first general diagnosis stage (for identifying the main issues of the local territory), then a specific technical diagnosis stage (for identifying, mapping and choosing the GI) and finally an operational stage for the definition and implementation of the action plan. Partners of open environment education particularly emphasized that guiding the actors shall be envisaged as a process that goes through all stages of the GBC project approach, with ongoing development of competencies (actors from open environmental education and other novel actors) and tools. The project team has been developing a tool kit in this purpose; it contains for instance educational tools, practical guides or documents depicting experiences. For instance, we have been participating to the elaboration of a practical guide presenting methods for identifying and mapping Green Infrastructures: we particularly emphasize the assets and limitations of the different methods according to the context.

4. Discussion

In this paper, we report the way we contributed to learning arrangements for GI sustainable design and management in the frame of projects in partnership with different stakeholders. We had a special attention about the role of farmers as key managers of landscape resources since they largely determine the way landscape elements and mosaics may evolve in their structures and functions hence associated ecosystem services. In this section, we discuss about the complementarities between the three case studies. Prior to that, we want to point out that difficulties in GI design and management approaches were encountered as in former studies (see introductive section), such as gaps between policy schemes and local initiatives, between stakeholders interests, also socio-technical locking experienced by farmers (Pinto-Correia and Azeda, 2017). In terms of research approaches, sometimes misunderstandings arose because researchers were rather expected as experts than as active contributors to co-learning approaches.

Through the three case studies, our contribution to support methods for the design and management of Green Infrastructures may be structured as first synthesized by Liu *et al* (2002) according to three proposed shifts in natural resource management (Liu and Taylor, 2002).

The first proposed shift is from single-scale to multi-scale management (Liu and Taylor, 2002). The proposal we made in this set of studies was to bring explicitly to stakeholders different scale perspectives. In the first case, as the design and management of elementary GI was at stake, we proposed to involve farmers into a scaling down perspective. For this, we helped them to take into account in their observations the nearby landscape and territorial environment in terms of drivers of ecological functions and in terms of resources or constraints to change or maintain their practices. In the second case, the simulation process was proposed to stakeholders for a scaling up experience: the issue was to be able to represent with sufficient realism and simplicity, the emerging properties of the landscape mosaics at a municipality level starting from decision processes within farms. In the third case, scaling-up and -down experiences were proposed to stakeholders with *e.g.*, on-field observations and tests of mapping methods, to help them understanding how ecological processes but also how drivers of these processes were developing from one scale to another.

The second proposed shift is from within-boundary to cross-boundary management (Liu and Taylor, 2002). This is an issue as the spatial-scale mismatches between ecological and managerial processes hamper the understanding and assessment of the way they interact (Pelosi *et al*, 2010). Such mismatches were multiple in our context, since several managerial areas partially overlapped with each other (*e.g.*, farm territories with administrative territories and other project areas) and with ecological patterns. In the first study case, the farmers of the association themselves proposed a first "cross-boundary step". Considering the hedgerows as part of their farming systems, they asked for better understanding the ecological interactions between the fields and hedgerows alongside, as driven by their management practices. This is why we proposed a diagnosis setting, which firstly aimed at accounting explicitly for these interactions. A second "cross-boundary step" for the farmers was about taking into account the resources and constraints of their surrounding other territories. In the second case study, the simulation procedure emphasized that the fragmentation and stretching of farm territories beyond the municipality boundaries played a role in landscape patterning within the municipality, which would not have been fully understood from *e.g.* the intrinsic characteristics of the fields. In the third case study, the experiences with the various stakeholders (including farmers) were organized to make them perceive and understand these mismatches between ecological and managerial processes, so that they could consider them in GI design and management.

The third proposed shift is from static to adaptive management (Liu and Taylor, 2002). The principle is that static objective-driven management cannot be operational when the system to be managed, here the landscapes with these GI components, is highly complex and changing. Shifting to adaptive management supposes to be able to reformulate the objectives and adapt the practices and mobilized resources according to the changes of the system. Such a management approach supposes to place a great emphasis on the on-going acquisition of knowledge by actors to deal with uncertainties, variability in time and great changes in the system. This notion of adaptability may be questioned, not only as regard the management but also the design of GI (as illustrated hereafter). In all study cases, we put the emphasis on developing tools and methods to support stakeholders in such capacities of on-going knowledge acquisition. In the first study case, the farmers' questioning about the directions they were undertaking with their innovating practices, encouraged us to formulate with them a diagnosis-observatory arrangement. In this first case, the question of adaptability was also addressed as regards the design of GI: the type of trees or the way they were planted (*e.g.*, in one or several rows) were discussed in the association as regards their adaptability to *e.g.*, climate changes or also long run changes of production needs. In the second study case, the simulations of the consequences on landscape patterns of the different combinations of farm types were mimicking, to some extent, the consequences of possible changes of the local agriculture. In the third case, the project was based upon the principle of an adaptive learning arrangement between stakeholders to formulate a GI design approach that could be itself adapted in time.

5. Conclusion

The experiences from the three case studies confirm the interest of "entering" with stakeholders into the complex causal relationships between their activities, the dynamics of landscapes and multiple associated functions. These co-learning principles differ from some assessments principles where these causal relationships largely remain in a black box for the stakeholders. Participatory observatories and simulations/scenarios of such causality chains may foster stakeholders' innovations for more sustainable GI design and management across territories (Spanòa *et al.*, 2017; Schmidt and Hauck, 2018). In this perspective, information, education and cooperation/networking are important instruments to support farmers' landscape management (Primdahl *et al.*, 2013). Considering this key position of farmers among stakeholders, we underline the interest of inviting them in a scaling- up and -down learning approach as regards landscape issues, *i.e.*, considering the effects of their field-scale practices on the landscape structure and functions, and the effects of the landscape environment on field-scale practices and functions.

References

Hauck, J., Schmidt, J., Werner, A., 2016. Using social network analysis to identify key stakeholders in agricultural biodiversity governance and related land-use decisions at regional and local level. Ecology and Society 21, 49.

Hodge, I., Hauck, J., Bonn, A., 2015. The alignment of agricultural and nature conservation policies in the European Union. Conservation Biology 29, 996–1005.

Liquete, C., Kleeschulte, S., Dige, G., Maes, J., Grizzetti, B., Olah, B., Zulian, G., 2015. Mapping green infrastructure based on ecosystem services and ecological networks: A Pan-European case study. Environmental Science and Policy 54, 268-280.

Liu, J., Taylor, W.W. (Eds.), 2002. Integrating Landscape Ecology into Natural Resources Management. Cambridge University Press, Cambridge.

Opdam, P., Coninx, I., Dewulf, A., Steingröver, E., Vos, C., van der Wal, M., 2016. Does information on landscape benefits influence collective action in landscape governance? Current Opinion in Environmental Sustainability 18, 107-114.

Pelosi, C., Goulard, M., Balent, G., 2010. The spatial scale mismatch between ecological processes and agricultural management: Do difficulties come from underlying theoretical frameworks? Agriculture Ecosystems & Environment 139, 455-462.

Pinto-Correia, T., Azeda, C., 2017. Public policies creating tensions in Montado management models:Insights from farmers' representations. Land Use Policy 64, 76-82.

Primdahl, J., Kristensen, L.S., Busck, A.G., 2013. The Farmer and Landscape Management: Different Roles, Different Policy Approaches. Geography Compass 7, 300-314.

Schmidt, J., Hauck, J., 2018. Implementing green infrastructure policy in landscapes—scenarios for Saxony-Anhalt, Germany. Reg Environ Change 18, 899–911.

Spanòa, M., Gentilea, F., Davies, C., Lafortezza, R., 2017. The DPSIR framework in support of green infrastructure planning: A case study in Southern Italy. Land Use Policy 61, 242-250.

Xu, H., Plieninger, T., Primdahl, J., 2019. A Systematic Comparison of Cultural and Ecological Landscape Corridors in Europe. Land 8, 1-32.

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REWILDING THE RISK SOCIETY ON SMALL FARMS

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Abstract: Sustainable Development Goals around environmental goals to both mitigate anthropocentric climate change and promote biodiversity typically involve productivity tradeoffs for the agricultural sector as it is currently configured. Feeding the world's burgeoning population has been historically met with initiatives to significantly increase food production by extending agriculture at the expense of wilderness and has included the suppression of wild animals alongside an engineered reduction in biodiversity. Arguably this has been the global pattern over the millenia but, more than ever before, Food and Nutrition Security agendas are framed in terms of raising global farm production between 50-100% by 2050.

Farmers, who have traditionally seen wild nature as a risk to their livelihoods, have achieved increases by controlling wild predators and taming the wilderness. Radical rewilding supporters promote rebalancing traditional agricultural practices in favour of widespread restoration of wilderness areas and purposive reintroductions of wild species including the same predators that farmers have hitherto controlled. Rewilding, as a tool to promote environmnetal goals, tends to have decreased agricultural productivity even where some food production is encouraged; conversely, increasing farm productivity has not been generally approached through rewilding.

The SALSA project[119] has engaged with small-scale food system actors cultivating land and raising livestock accross Europe and Africa, often in remote or less favoured areas (LFA). Their farms are often considered prime sites for rewilding and afforestation initiatives, or are adjacent to spaces already subject to special deignation, for example National Parks and wildlife reserves. This is partly owing to what has been viewed as the marginal contribution of small scale agriculture to wider food systems.

SALSA stakeholders accross europe and africa, when interviewed about constraints to food production, complained about predatory and destructive wild animals. More food could be produced, many contended, through de-wilding rather than re-wilding particularly in relation to predator control for livestock. Even small farmers advocating rewilding recognised corresponding production constaints.

'The Risk Society' contextualises risks within modernity offerring a lens to explore what have been perennial risks for farmers, yet can be seen as products of advanced farming systems, modern institutional contexts, contemporary values, and neo-liberal political strucures. Our paper examines the self-reported experience of small farmers in dynamic landscapes and the rapidly evolving governance environment reshaping the small farming world.

[119] SALSA is a Horizon2020 project conducting research into small farms, small food businesses and sustainable food and nutrition security http://www.salsa.uevora.pt/en/

INTERACTIONS BETWEEN BEEKEEPING AND LIVESTOCK FARMING SYSTEMS IN AGROPASTORAL LANDSCAPES: A CASE STUDY IN THE SOUTHERN MASSIF CENTRAL, FRANCE

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Abstract: From columns to "save the bees" to calls to "conciliate beekeeping and agriculture", agriculture is often pointed out as responsible for pollinators decline and the beekeeping sector difficulties. At the same time, agriculture, as a major factor of landscape constitution, is an unavoidable lever to solve these very issues, namely through the floral resources it shapes. However, knowledge about the impact of agropastoral farming systems on floral resources for beekeeping is still scarce. How do various livestock farming system contribute to the construction of floral resources in agropastoral landscapes? What are the consequences of this construction for various beekeeping-farming systems?

In order to answer these questions, we led an agrarian diagnostic in a middle mountain massif of southern France. We identified various livestock farming systems and beekeeping farming systems, and their respective impact on and dependence to floral resources. This led us to reveal livestock-beekeeping farming systems technical-economical interactions at various spatio-temporal scales:

cultivation practices (choose of cropped species, irrigation, fertilization, mowing) in the short term,

"open" landscapes maintenance in the medium term

land intensification and land abandonment in the long term

Beekeeping farming systems have adapted to changes in floral resources and to the global changing beekeeping conditions. They did so by adapting their uses of traditional floral resources or by shifting to new ones.

Accounting for floral resources and beekeeping farming systems dynamics is helpful to inform agropastoral landscapes management, in order to elicit beekeepers and farmers cohabitation.

THE HEARTLAND PROJECT: HEALTH, ENVIRONMENT, AGRICULTURE, RURAL DEVELOPMENT: TRAINING NETWORK FOR LAND MANAGEMENT

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Abstract:

Ruminant livestock production is often criticised for its negative impacts on the environmental and human health. For example, it can be associated with land use change such as deforestation, methane emissions and associated climate change, NH_3 deposition and biodiversity loss. At the same time livestock protein is the main source of protein in most European Member States. However, it is increasingly recognised that ruminants convert biomass unsuitable for direct human consumption into valuable food, including essential proteins and micro-nutrients. In addition, while high input and intensively managed systems may have negative environmental consequences, less input dependent systems are recognised as central to the retention of culturally important landscapes, High Nature Value Farmland (HNV), biodiversity and associated regulating ecosystem service provision such as carbon sequestration, nutrient and water cycling, pollination and pest control.

An on-going Marie Skłodowska Curie project called HeartLand (Health, Environment, Agriculture and Rural development: Training on LAND management) which is taking place in Ireland and the Netherlands is attempting to understand the challenges and opportunities arising from livestock farming for human and environmental health. This European Industrial Doctorate (EID) programme will connect one of the most notable industry initiatives (at the Lands at Dowth (Ireland) of Devenish Nutrition) to the cutting-edge scientific knowledge on sustainable and healthy food production (being generated at Wageningen University and Research, University College Dublin and University of Gloucestershire). The impact of this EID programme will be maximised by working closely alongside experts in communication in the European Food Information Council (EUFIC) and the Bord Bia (Irish Food Board).

Introduction:

Livestock farming is increasingly in the spotlight of scientific literature, the popular media, and the public opinion because of its impacts on the environment and human health (Garnett et al., 2017). At the same time, global population is predicted to increase by between 70-100% (relative to 2005-2007 levels (FAO, 2009)) increasing the demand for healthy food production (Burney et al., 2010). Thus far, the livestock industry worldwide has largely responded defensively to this dual challenge, often questioning the validity of these concerns.

Indeed, ruminants can convert biomass unsuitable for direct human consumption (e.g. grass resources from land that is unsuitable for arable farming) into valuable food, including essential proteins and micronutrients for human consumption. Therefore, grazing systems are a vital indirect source of these essential nutrients for the world's growing population (Boland et al., 2013), which is predicted to increase to approximately 10 billion people by 2050 (Smith et al., 2013). Coupled with the necessary increase in quantity, food quality will also have to improve (Smith et al., 2013). Achieving the necessary increase in food production will be a challenge due to the combination of limited additional land availability, coupled with the on-going and historical depletion and degradation of natural resources (Smith et al., 2013). Meeting this challenge will require livestock production systems to become more environmentally, economically and socially sustainable and key to this is resource use efficiency (O'Brien et al., 2016).

Within temperate areas, improved agricultural grasslands are heavily dependent on perennial ryegrass (PRG) (*Lolium perenne* L.) (Grogan and Gilliland, 2011) with small quantities of legume species such as white clover (*Trifolium repens*) also included (Waghorn and Clark, 2004). In Ireland, PRG accounts for 95% of forage grass seed sales (DAFM, 2018). Perennial ryegrass swards can be highly productive, capable of producing 12-15 tonnes of DM ha^{-1} yr^{-1} in Ireland under appropriate management (O'Donovan et al., 2011) and are of a high nutritional value (Fulkerson et al., 2007). Maintenance of PRG swards however is dependent on the supply of large quantities of nitrogen (N) (Whitehead, 1995) and it quickly disappears when N becomes limiting (Sheridan et al., 2008). Nitrogen inputs represent a significant direct cost to farmers (CSO, 2017; Dillon et al., 2017) and also contribute to wider environmental problems such as water pollution, increased nitrous oxide emissions, NH_3 deposition and loss of biodiversity (Stark and Richards, 2008). The EU Nitrate Directive; Council Directive 91/676/EEC was introduced to address these environmental concerns through placing limitations on both the quantity and timing of N application allowed in Member States.

Most productive grassland research in temperate regions has focused on the use of PRG over the last number of decades. However, there has been an increasing interest in the role of multispecies swards comprised of grasses, legumes and forage herbs, for the development of more sustainable grazing systems in recent years. Multispecies swards grown under reduced N input conditions (relative to PRG monocultures) have also been shown to have positive effects on herbage quantity, quality, animal performance (Grace et al., 2018a; Grace et al. 2018b) and biodiversity. The increased biomass production compared to monoculture swards, is primarily due to complementarity between the different species included within these swards (Kirwan et al., 2007).

A Marie Skłodowska Curie European Industrial Doctorate project called HeartLand which started in October 2019 is addressing the contemporary industry challenge to develop livestock production systems that simultaneously enhance environmental sustainability. The role of multispecies swards will be examined in terms of sustainable livestock productivity, product quality, delivery of ecosystem services to society and efficient resource use. HeartLand is based at the Devenish Lands at Dowth which is within the Brú na Bóinne UNESCO World Heritage Site. Throughout its history this site has been maintained as a single large landholding and as such represents the evolution of farming over 6,000 years in a single holding.

Methods:

The project will consist of 5 PhD students who will collate data from two main experiments described below. From the experiments, analysis on soil, swards, animal performance and the social impact of the experiment will be examined as well as a data modelling exercise conducted as described below:

Experiments

There will be two main experiments conducted: a component (Exp. 1) and a systems research experiment (Exp. 2). The component research is in the form of experimental plots and will take place at the Devenish Lands at Dowth. The experiment will consist of a factorial arranged experiment with four sward types, two establishment methods (direct drill and a cultivation and sow method) and with/without slurry application. Swards types being examined are; a permanent pasture sward which was the old permanent pasture that existed in Dowth, a PRG only sward, the 6 species sward containing; two grasses (PRG and timothy (*Phleum pratense*), two legumes (white and red clover *(Trifolium repens and pratense))* and two herbs (ribwort plantain (*Plantago lanceolata*) and chicory (*Cichorium intybus))* and the 12 species sward containing cocksfoot *(Dactylis glomerata)*, greater birdsfoot trefoil (*Lotus pedunculatus*) sainfoin *(Onobrychis viciifolia)*, yarrow (*Achillea millefolium*), salad burnet (*Sanguisorba minor*) and sheep's parsley (*Petroselenium crispum*) in addition to the six species listed for the 6 species sward.

The systems research will be an experiment with same four sward types as the plot experiment at Dowth (permanent pasture, PRG only sward, a 6 species sward and a 12 species sward, replicated four times) which will be rotationally co-grazed by sheep and cattle stocked at 2 LU ha^{-1}.

Soil studies

Analyses will be done to profile the impacts of the plot experiments (above) on:
1) Delivery of the five soil functions i.e. production of food, feed and fibre, provision of habitats for both functional and intrinsic biodiversity, carbon sequestration, regulation and provision of clean water, and the provision and cycling of nutrients, will be carried out using the methods and indicators developed in the SQUARE and LANDMARK projects (Schulte et al., 2014). 2) The role of soil biota in enhancing the nutritional quality of sward herbage and the soil's ability to minimize losses to the environment. 3) the impacts of sward composition, establishment method and soil improvement on soils, nutrient losses to the environment and nutritional quality of the sward. This part of the project will focus on maximizing synergies between sward composition and soil functions. The aim is to design, implement and evaluate the effect of sward type on the provision of habitats for both functional and intrinsic biodiversity, carbon sequestration and regulation of water (through soil structure). The impact of the different sward compositions on soils will be monitored in terms of: 1) Earthworm densities, species and activities, and knock-on effects on soil structure including soil stability and drainage. The sward researcher and the soil researcher will work together to fully develop this part of the experiment. 2) The soil nematode community as indicators for soil ecosystem functioning 3) Functional biodiversity of the soil microbial community 4) Carbon stabilization (as an indicator for carbon sequestration) and 5) Micronutrient availability to the herbage.

Sward studies

This researcher will profile the impacts of the plot experiments (Exp. 1 and 2) on 1) sward: dry matter yield production, nutritional value, species establishment and persistence in the swards over time. A baseline botanical composition of the existing permanent pasture at Dowth will be undertaken. Botanical composition of the multispecies versus monoculture swards will be identified and changes in the botanical composition will be tracked over two growing seasons. The dry matter yield of the swards will be determined and the effects of establishment method, soil improvement and N fertiliser regime will be determined to investigate if transgressive over-yielding occurs. The effects of sward composition, establishment method, N fertiliser regime and soil improvement on earthworm abundance and diversity and water infiltration will also be investigated.

Model development

This reseacher will explore pathways for healthy farm management (economic, social and environmental sustainability), based on healthy soils, healthy swards and animals in the context of societal requirements for healthy people and a healthy planet. The researhcer will analyse and design options for farm management systems, integrating soil management, grassland management, animal management, labour management and financial management. The FarmDESIGN programme as per Groot et al., (2012) will be used to 1) describe, 2) explain, 3) evaluate, 4) design - solution spaces for healthy farm management based on results collected from both experiments.

Animal nutrition and Human Health studies

This researcher will examine the impact on animal growth performance, parasitic burden, enteric methane emissions, beef and lamb meat quality and nutrient content of grassland management system as influenced by sward composition and soil quality. This will generate meat nutrient profiles which will be modelled on their potential health impacts of consuming higher nutritive content beef and lamb, using dietary intake data provided by the European Food Safety Authority's Comprehensive Food Consumption Database on food consumption habits and patterns across the E.U. They will quantify the impact of sward and soil management system on animal performance, animal health and product quality. The researcher will model dietary intake of consumers consuming conventional beef and lamb compared to HeartLand beef and lamb.

Environmental Health studies

This researcher will explore how the creation of healthy farms that produce healthy food can potentially deliver and contribute to a healthy society and a healthy planet. They will elevate the findings at the research farm beyond the farm boundaries, and place them in the context of the societal requirements at a regional scale and they will apply the Functional Land Management (FLM) framework currently employed in the H2020 project LANDMARK (Schulte et al., 2015).

Discussion:

Through a series of interlinked experiments and collaborations with the various universities and industry groups this project aims to explore fully the development of more sustainable animal production systems, from soil to society. It brings together plant, soil, agricultural ecology and animal scientists as well as social scientists from leading universities (Wageningen University, University College Dublin and University of Gloucestershire) and industry involvement (Devenish Nutrition, Bord Bia and the European Food Information Council (EUFIC)). Collaboration involving industry and universities will ensure a good vehicle for enhancing knowledge transfer, intersectoral mobility and mutual understanding.

The HeartLand project will address the following challenges: it will unlock the potential of multispecies grasslands; aims to improve human health through improved soil health and establish production systems that contribute to both human health and agricultural sustainability. While in recent years there has been more research into more diverse swards, to date, there has been no comprehensive assessment of the role of diverse grasslands or multispecies grasslands in creating (potentially additional) economic advantage to farming systems. As well as this, there has not yet been an assessment into the full chain, from soil quality to herbage quality to the quality of the animal products produced. The question also remains to be answered if management aimed at healthy food production aligns with management aimed at sustainable food production. The challenges and unknowns of this project will be examined through the following research objectives: 1) To assess and integrate the relationships between grassland diversity and farm economics 2) To assess and integrate relationships between soil quality and meat quality through the full production chain 3) To provide integrated assessment and management systems that deliver healthy farms, healthy people and a healthy planet.

The HeartLand project aims to provide ruminant production systems that will to be impactful on the environment, economics and human health. It is well known that the agricultural sector has been challenged to increase agricultural productivity while simultaneously providing ecosystem services such as the provision of clean water, habitats for biodiversity, recycling of nutrients and mitigation against climate change (Schulte et al., 2014). The Heartland project will examine the effect swards have on water infiltration, earthworm abundance (and diversity) and through the Catchment Challenge workshops delivered as part of the project will examine how functional land management may be possible in Ireland.

The European Union has a long tradition of incentivisation, largely through payments under the Common Agricultural Policy, including payments for Less Favorable Areas and payments under various national Agri-Environment Schemes, which are aimed at providing a financial incentive to farm in a more environmentally manner. If improvements were made in the provision of the aforementioned ecosystem services in the grazing systems that are being investigated within this project, coupled with reduced N requirement, there may be scope to potentially incentivise farmers to adopt these management systems.

Within the project, the nutrient quality of the meat produced from these sward types will be investigated and nutrient density scores will be calculated, similar to work carried out by Smedman et al. (2010). Comparisons in nutrient density scores will be made across sward types. Nutrient density scores will be given to meat products taking into account their nutritive quality and the green house gas emissions per kg of product produced.

The HeartLand projects will impact on the careers of the PhD students involved and train them with comprehensive knowledge into sustainable food production. It will enhance the career prospects and employability of researchers and contribute to their development. It is increasingly clear that the resolution of complex environmental and human health problems requires interdisciplinary, intersectoral expertise and cooperation from academic and industry.

The findings and results of this project will be disseminated through scientific publications in peer-reviewed journals to target the scientific community, presented at conferences and at HeartLand seminars that will be held at The Devenish Lands at Dowth. A Heartland website has also been developed to disseminate the research to scientific and non-scientific audiences. Furthermore, HeartLand will use Twitter to provide regular updates on everyday activities from the project to engage with the farming community and other industry personnel.

The Heartland project offers a unique approach to the investigation of potential solutions to address many of the challenges currently facing ruminant production systems. Our future prosperity depends on increasing food production in harmony with nature while using the food we grow effectively for nutritious, varied and safe diets. The bold proposition underpinning HeartLand is that sustainability and health are inextricably linked, all the way “from soil to society”.

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References:

BOLAND, M. J., RAE, A. N., VEREIJKEN, J. M., MEUWISSEN, M. P., FISCHER, A. R., VAN BOEKEL, M. A., RUTHERFURD, S. M., GRUPPEN, H., MOUGHAN, P. J. & HENDRIKS, W. H. 2013. The future supply of animal-derived protein for human consumption. Trends in Food Science & Technology, 29, 62-73.

BURNEY, J. A., DAVIS, S. J. & LOBELL, D. B. 2010. Greenhouse gas mitigation by agricultural intensification. Proceedings of the National Academy of Sciences, 107, 12052-12057.

CENTRAL STATISTICS OFFICE, C.S.O. 2017. Price of Nitrogen Fertilisers [Online]. Available:http://www.cso.ie/px/pxeirestat/Statire/SelectVarVal/Define.asp?MainTable=AJM05&TabStrip=Aseek&PLanguage=0&FF=1

DEPARTMENT OF AGRICULTUTRE, FOOD AND THE MARINE (DAFM) 2017. Grass and White Clover Recommended List Varieties for Ireland 2017

DILLON, E., MORAN, B., DONNELLAN, T. (2017) Teagasc National Farm Survey 2016 Results. Teagasc Publications, Athenry, Co. Galway. Available from URL: https://www.teagasc.ie/media/website/publications/2017/NFS-2016-Final-Report.pdf

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO), 2009. How to Feed the World in 2050, Available at URL: http://www.fao.org/fileadmin/templates/wsfs/docs/expert paper/How to Feed the World in 2050.pdf. FULKERSON, W., NEAL, J., CLARK, C., HORADAGODA, A., NANDRA, K. & BARCHIA, I. 2007. Nutritive value of forage species grown in the warm temperate climate of Australia for dairy cows: grasses and legumes. Livestock Science, 107, 253-264.

GARNETT, T., GOODE, C., MULLER, A., RÖÖS, E., SMITH, P., DE BOER, I.J.M., ZU ERMGASSEN, E., HERRERO, M., VAN MIDDELAAR, C.E., SCHADER, C. & VAN ZANTEN, H.H.E., 2017. Grazed and confused?: Ruminating on cattle, grazing systems, methane, nitrous oxide, the soil carbon sequestration question-and what it all means for greenhouse gas emissions. FCRN.

GRACE, C., BOLAND, T.M., SHERIDAN, H., LOTT, S., BRENNAN, E., FRITCH, R. & LYNCH, M.B., 2018 a. The effect of increasing pasture species on herbage production, chemical composition and utilization under intensive sheep grazing. Grass and Forage Science, 73(4), pp.852-864.

GRACE, C., LYNCH, M.B., SHERIDAN, H., LOTT, S., FRITCH, R. & BOLAND, T.M., 2018 b. Grazing multispecies swards improves ewe and lamb performance. animal, pp.1-9.

GROGAN, D. & GILLILAND, T. 2011. A review of perennial ryegrass variety evaluation in Ireland. Irish Journal of Agricultural and Food Research, 50, 65-81.

GROOT, J.C., OOMEN, G.J. & ROSSING, W.A., 2012. Multi-objective optimization and design of farming systems. Agricultural Systems, 110, pp.63-77.

HOOPER, D. U., CHAPIN, F., EWEL, J., HECTOR, A., INCHAUSTI, P., LAVOREL, S., LAWTON, J., LODGE, D., LOREAU, M. & NAEEM, S. 2005. Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. Ecological Monographs, 75, 3-35.

HUMPHREYS, J., O'CONNELL, K. & CASEY, I. 2008. Nitrogen flows and balances in four grassland-based systems of dairy production on a clay-loam soil in a moist temperate climate. Grass and Forage Science, 63, 467-480.

KIRWAN, L., LÜSCHER, A., SEBASTIA, M., FINN, J., COLLINS, R., PORQUEDDU, C., HELGADOTTIR, A., BAADSHAUG, O., BROPHY, C. & CORAN, C. 2007. Evenness drives consistent diversity effects in intensive grassland systems across 28 European sites. Journal of Ecology, 95, 530-539.

LÜSCHER, A., MUELLER-HARVEY, I., SOUSSANA, J. F., REES, R. M. & PEYRAUD, J. L. 2014. Potential of legume-based grassland–livestock systems in Europe: a review. Grass and Forage Science, 69, 206-228.

NITRATES DIRECTIVE. 1991. Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal, 375, 12.

O'BRIEN, D., BOHAN, A., MCHUGH, N. & SHALLOO, L. 2016. A life cycle assessment of the effect of intensification on the environmental impacts and resource use of grass-based sheep farming. Agricultural Systems, 148, 95-104.

O'DONOVAN, M., LEWIS, E. & O'KIELY, P. 2011. Requirements of future grass-based ruminant production systems in Ireland. Irish Journal of Agricultural and Food Research, 50, 1-21.

STARK, C.H., RICHARDS, K.G. 2008. The continuing challenge of agricultural nitrogen loss to the environment in the context of global change and advancing research. Dynamic Soil, Dynamic Plant 2 (1), 1-12. Global Science Books.

SCHULTE, R. PO, R. E. CREAMER, T. DONNELLAN, N. FARRELLY, R. FEALY, C. O'DONOGHUE, & D. O'HUALLACHAIN. 2014. "Functional land management: A framework for managing soil-based ecosystem services for the sustainable intensification of agriculture." Environmental Science & Policy 38: 45-58.

SCHULTE, R.P., BAMPA, F., BARDY, M., COYLE, C., CREAMER, R.E., FEALY, R., GARDI, C., GHALEY, B.B., JORDAN, P., LAUDON, H. & O'DONOGHUE, C., 2015. Making the most of our land: managing soil functions from local to continental scale. Frontiers in Environmental Science, 3, p.81.

SHERIDAN, H., FINN, J.A., CULLETON, N., O'DONOVAN, G. 2008. Plant and invertebrate diversity in grassland field margins. Agriculture, Ecosystems and Environment, 123, 225-232.

SMEDMAN, A., LINDMARK-MÅNSSON, H., DREWNOWSKI, A., & MODIN EDMAN A.K. 2010. Nutrient density of beverages in relation to climate impact, Food & Nutrition Re search, 54:1, 5170.

SMITH, J., TARAWALI, S., GRACE, D. & SONES, K. 2013. Feeding the World in 2050: Trade-offs, synergies and tough choices for the livestock sector. Tropical Grasslands-Forrajes Tropicales, 1, 125-136.

WAGHORN, G. C. & CLARK, D. A. 2004. Feeding value of pastures for ruminants. New Zealand Veterinary Journal, 52, 320-331.

WHITEHEAD, D. C. 1995. Grassland Nitrogen, CAB international

ARE FARMERS WILLING TO PAY FOR REGIONAL FARMERS' NETWORKS? - IN SEARCH OF BUSINESS MODELS

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Summary

A new regional farmers' network approach, *The Cropping School*, was launched in Brandenburg, Germany. The main goal of the *Cropping School* is to empower farmers to identify cropping system problems and to improve their cropping systems in a facilitated peer-to-peer setting. Today farming is highly affected by climate change and market fluctuations. In order to be able to adapt to the changing conditions, regional problem solving approaches and specific innovation are required. Therefore, a high demand on regional farmer's research networks could be identified in Brandenburg, Germany. By calculating the current cost of such a farmer network, identifying the farmers' stated willingness to pay for this service via face to face interviews and by evaluating the federal state specific framework for advisory services, we developed a business model to continue the network after project funding. Results show that three different business models are possible for a farmer network in Brandenburg, Germany.

Introduction

Farmers' networks – a tool for developing individual methods for strengthening farm resilience.

European and German agricultural research policy increasingly focuses on networking projects. By October 2019, the European Innovation Partnership's *Agricultural Productivity and Sustainability* program (EIP-Agri) had launched 201 networking projects in Germany alone (BLE, 2019). Numerous other funded network projects have arisen from national strategies and programs, financing research and innovation propositions in cooperation with scientific institutions as well as with business, advisory and practical professionals (BLE, 2014).The motivating force behind this increase in networking and network approaches in agricultural research policy is threefold: a) to accelerate innovation, b) to increase farming productivity while using a minimum of resources, and c) to thereby strengthen farms' sustainability (BLE, 2019).

In agricultural practices knowledge, especially explicit and implicit knowledge as well as garnered experience plays a vital role (Lehmann 2005). According to Thomas, Hoffmann and Gerber (1999, cited by Lehmann 2005), this comprehensive claim on competence can only be met by integrating varying forms of knowledge transfer. Important elements are experience and practical learning on one's own farm as well as exchange with colleagues. Informal gatherings among colleagues create an open space; a casual atmosphere that can be shaped individually or collectively (Luley 1996). Group structures inspire exchange relationships, promoting innovative action (Luley 1996, Luley, et al. 2015). Hands-on experiments are one of the elemental learning strategies (Kummer et al. 2012), they are an effective instrument for making appropriate decisions (Scooby 2001), which introduce new methods and innovative activities to specific agricultural conditions (Bloch et al. 2016, Kummer, et al. 2012). Regular exchange opportunities between farmers can promote the development and practical application of individual solutions. A *Cropping School* is such a group approach by which an active farmers' network is supported by scientists and advisors (Scholz et al., 2018) in a facilitated peer-to-peer setting. A *Cropping School* enables farmers to identify problems and to take appropriate action, thereby improving their cropping systems. Typically, farmers discuss self-identified agricultural problems during regular meetings, which take place in turn on participating farms. Applying a farmer-to-farmer learning approach, the network helps to identify cropping problems and to develop practical solutions.

Consistency and long-term financing is one of the greatest challenges networks face. Reliable network structures are necessary to provide farmers continuing support for sustainable innovation processes.

This paper examines business models, which could be appropriate to ensure networks' continuity. Furthermore, this paper explores the cost of and the willingness of participants to pay for a *Cropping School*.

Background

Networks, cooperation and alliances

The terms *network, cooperation* and *alliance* are often used synonymously. Due to the term *network*'s abundant application, Kappelhoff speaks of (2000, cited by Bornhoff and Frenzer, 2006) a *compact term*, applicable to a wide range of definitions. The word's copious usage has given rise to countless compound terms such as *strategic network, organizational network, regional network* and *innovation networks* that circumscribe a network's function, thereby specifying the term's definition (Morschett 2003; Bornhoff and Frenzer 2006).

In this paper, *farmers' networks* are understood as a link between several legal and economically independent organisations which have been conceived for long-term continuity. Resources, knowledge and capabilities are donated and/or shared voluntarily among the participating members. The participants are rather loosely connected (i.e. there is no economic or legal links), yet there is an elemental, mutual dependency (i.e. the network would not exist without a mutual exchange of knowledge, or without a network coordinator).

Farmers' networks in, or in addition to, agricultural advisory services

All over the world farmers' networks approaches like *Farmer Field School*, *Farmer study circles* or *Farmer study groups*, *Farmer to Farmer Network*, *Innovative Farmers* or *Stable School* can be found. These networks differ widely in terms of network concepts structures. Common to all approaches is their objective to empower farmers to improve their businesses (Table 1).

Due to its federalist structure, Germany's advisory systems are highly diverse (Knierim, et al. 2017). In some federal states, like Brandenburg, advisory systems are dominated by private enterprise consultancies. Farmers' networks or group advisory formats are unknown. In other federal states, group advisory formats and farmers' networks are predominantly subject-specific farmer discussion groups offered by state-funded advisory organizations or farmers' associations. *Stable Schools* are piloted by research institutes in cooperation with advisory organisations. Selected examples of current farmers' networks or group advisory offers in Germany are shown in Table 1. By evaluating these examples, conclusions can be drawn for a long-term *Cropping School* business model in Brandenburg, Germany.

Table 1 Examples of farmers' networks and their business models, according to Kahl (2019), revised; used references: Scholz et al. (2018), Soil Association (2020); Farmer's Business Network, Inc.(2020), (USAID) (2020), Buller et al. (2019)

Example	Summary of emphasis	Basic structure	Costs, sponsoring and funding models

	Farmer Field Schools	A form of adult education where farmers learn optimally in groups from field observation and experimentation. In regular facilitated meetings (often weekly) groups of neighboring farmers observe and discuss dynamics of their cropping ecosystem.	It was developed from the Food and Agricultural Organization of the United Nation (FAO). The program started 1989 in Indonesia and rapidly expanded.	• Financed by international donor programs or temporary projects
Outside Germany	Innovative Farmers	Farmer led Innovation approach: Network of farmers and growers who are running on-farm trials, on their own terms. Groups of farmers can work directly with a researcher to design 'field lab's: the group decides on the topic and the researcher helps design a trial.	It was launched in 2015 in Schottland. It is a partnership programme, with Linking Environment And Farming, Innovation for Agriculture, Organic Research Centre and Waitrose, led and managed by the Soil Association. Soil Association is a registered charity and certification business made of several entities	• Free for farmers • Innovative Farmers is part of the Duchy Future Farming Programme, funded by the Prince of Wales's Charitable Fund through the sales of Waitrose Duchy Organic products. • The network is backed by a team from LEAF (Linking Environment and Farming), Innovation for Agriculture, the Organic Research Centre and the Soil Association. • There are different

				sponsors supporting the program • Many of the UK's top agri-research organisations have been involved in field labs, or have registered their interest in collaborating with groups.
	Stable Schools	Participatory advisory approach: individual farm and herd strategies through a participatory process using farmer groups (5-6 farms) for mutual advice and common learning. Facilitated, monthly groups meetings on a private farm of a group member.	The concept was developed in 2004 in Denmark by a large group of organic farmers.	• Project funded
	The RIO approach	Specific form of participatory technology assessment that adopts design of both the technical and social features of societal systems for production and consumption. Definition of the problem and the solution takes	Reflexive Interactive Design approach was 2001 initiated in the Netherland. It was applied and tested in several projects like the Well-Fair Eggs project. Buttom – up approach facilitated from above.	• Several project funding • Initiated to be a relatively simple and cheap financial instruments that governments can help to create a conducive environment

		places in a reciprocal and iterative argumentative exchange.		
	Farmers Business Network [SM]	Farmers wanted to develop an independent, unbiased, and objective farmer-driven information source — no marketing fluff. They knew that if they could share their agronomic precision data with one another, they could all make better decisions on seeds and agronomics.	The Network started 2014 with farmers, technologists, scientists and entrepreneurs. As a member, you get access to all of the *FBN* analytics products, crop marketing opportunities and Profit Center, *FBN Direct* product pricing, financing services, and events.	• Membership fees: 700$ for 1 year; 1100$ for 2 years; 2500$ for 5 years
	Farmer to Farmer Programm	Support farmers and agribusiness professionals in developing countries to improve their livelihoods and food security by sharing knowledge and skills with farmers. Farmer-to-Farmer sends U.S.-based volunteers on technical assignments to provide hands-on training to communities, cooperatives, agribusinesses, and educational institutions.	The Farmer-to-Farmer Program leverages the expertise of volunteers U.S. farms, educational institutions, cooperatives, private agribusinesses and nonprofit farm organizations to respond to the local needs of host-country farmers and organizations. Farmer-to-Farmer volunteers work in over 30 countries around the world. Each volunteer assignment is facilitated by one of eight U.S.-based NGOs that implement the Farmer-to-Farmer Program	• is USAID-funded and implemented by ACDI/VOCA, Catholic Relief Services, CNFA , IESC, Land O'Lakes Venture 37, National Cooperative Business Association CLUSA International, Partners of the Americas, Winrock International, Grameen Foundation, and High Atlas Foundation.
In Germ	Mentoren-Netzwerk	Cooperative advisory	An online networking platform	• First two sessions gratis, 3rd session

	Ökolandbau [*Mentor network: Organic farming*]	approach: Organic farmers offer mentoring to those seeking advice, sharing their experience and knowledge; exchanging information on farm situations and offering support with structural issues.	(https://mentoring.bio/) initiated by the Kompetenzzentrum Ökolandbau Niedersachsen GmbH [*Lower Saxony Organic Farming Competence Center Gmbh*] and the Bäuerliche Bildung und Kultur gGmbH [*Agricultural Education and Culture GmbH*] open to farmers working in northern Germany.	onwards, 75€ an hour • The network is financed by the Software AG Trust Fund
	BioRegio Betriebsnetz [*BioRegio regional organic farms network*]	Network of typically regional, best-practice and demonstration organic farms in Bavaria, focusing on knowledge transfer at collegial gatherings, farm tours and educational events at participating farms with the intent to expand organic farming and strengthen existing enterprises.	A project supervised by the Bayrische Landesanstalt für Landwirtschaft [*Bavarian Minstry of Agriculture*] (LfL) and carried out by the above in cooperation with the Landesvereinigung für den ökologischen Landbau in Bayern e.V. [*Bavarian Association of Organic Farmers*] (LÖV)	• Participation in gatherings, tours and educational events is free • Funded by the Bavarian Ministry of Nutrition, Agriculture and Forestry, implemented by the *BioRegio Bavaria 2020* initiative • BioRegio farms receive an expense allowance from the state
	Hopfenring e.V. (*Hops Circle Society*)	Advisory and educational offerings, both individual and group formats for members.	The Society is a member of the Landeskuratorium für pflanzliche Erzeugung in Bayern e.V. [*State Advisory Board for Vegetable Cultivation*]	• Membership fees: 22€ + 1,29€ per hectare of cultivated hops • Additional cost for probes such as soil analyses

				• No state funding
	Öko-Beratung Baden-Württemberg. e V. [*Eco-Consulting Baden-Wuerttemberg*] (ÖBBW e.V.)	Offers individual advisory services as well as networking with researchers, scientists, institutes and businesses.	Cross-association advisory organization in Baden-Wuerttemberg.	• Consultancy fees 104€ /h • Plus, travel costs • State funding available

Materials and Methods

Case study

To understand the extent of regional farmers' demand for network approaches, such as farmer's discussion groups a single case study (Yin, 2018) of a *Cropping School* in Brandenburg, Germany was explored.

The *Cropping School* was initiated with funds from the European Agricultural Fund for Rural Development (EAFRD) and will face the challenge of how to continue after the funding period. It started with nine actively involved farmers and grew to 21 actively involved farmers within one year. Participants agreed to tackle legume cropping and nitrogen management as the main topics in the first year. In the second year, they conducted two on-farm field tests on legume management and varying tillage systems. When appropriate, meetings or field tests are supported by visiting scientists or professional advisors. All activities are facilitated by a network coordinator and supported by an agricultural-technical assistant.

A case study protocol was designed to guide the investigation, including research questions (problems and objectives of the analysis) and the methods of data collection (Yin, 2018; Mayring, 2002; Bochardt et al., 2009). Costs of all *Cropping School* activities were assessed and face-to-face interviews with network participants were performed.

Cropping School activities and their calculated costs

To estimate total costs per network participant, the costs for the services and activities shown in Table 2 were calculated for the *Cropping School* case study.

Tab. 2 Cropping School services and activities

Services	Activities
Staff	• network coordination • plan, organize and moderate regular meetings (4 meetings within the 8-month calculation period at approximately 3.5 hours per meeting) • field assessments • conduct and analyze on-farm trials (3 - trials and 1 field assessment within the 8-month calculation period) • generate reports (meeting protocols, results reports, scientific status quo)

	• public relations • network administration (public procurement, etc) • networking: participation in various events to a) maintain and establish contact with cooperation partners; b) keep abreast of current agricultural issues/topics
Scientific/advisory expertise	• attend network meetings
Travel expenses	• travel to and from network meetings or networking events
Materials	• moderation material and paper for network meeting reports • project flyers and posters • soil assessment and/or plant analyses (material and lab costs) • hospitality costs • **costs not calculated include** office supplies, stamps, current internet, telephone, room rental and acquisitions, i.e. telephone, computer, desk and chair

From January 2019 to August 2019, labour hours required for all activities were documented. All other costs, such as expert fees, travel and materials were recorded from April 2018 to August 2019. Personnel costs were calculated at the average gross rate for German public service staff members.

Farmers' willingness to pay

A farmer's willingness to pay for services is an essential component in assessing potential financing and business models for *Cropping Schools*. Guided face-to-face interviews were conducted with 10 farmers, representing 50% of *Cropping School* participants. The sample was selected according to membership duration and participation intensity during network meetings.

Results and Discussion

The case study reveals a high demand for a regional farmers' network, like the *Cropping School*, that supplements other advisory services (individual consulting or field days). In the case study, group of participants doubled in the first year. More farmers would like to join the *Cropping School* or establish more *Cropping Schools* in their region, suggesting a high demand for *Cropping School* services. In the long term, *Cropping Schools* cannot rely on permanent funding that provides free services. Farmers will need to develop self-sustaining business models financed by network members.

The calculated costs for a *Cropping School* ran to approximately 1,500€ per year, per farmer (with 20 farmers per network) (Table 3).

Tab. 3 calculated costs for a Cropping School

	Network activities with individual services	Network activities without individual services
Required labour (hours)		
Project coordination	402	158

Project administration	49	49
Public relations and networking	100	100
Training of staff	3	3
Total staff hours	**554**	**310**
Costs		
Labour costs	17.174,00 €	9.610,00 €
Costs of experts (scientists or advisors)	1.925,00 €	1.925,00 €
Travel costs	2.500,00 €	1.890,00 €
Material costs	2.670,00 €	1.090,00 €
Total Costs per month for a network participant (with currently 20 members)	**130,00 €**	**75,00 €**

*****valued at 31€ per hour.

If costs were calculated without practical research services, i.e. conducting on-farm trials, assessing fields, analyzing laboratory results and generating reports, come to approximately 900€ per year, per farmer. Other farmers' networks in Germany quote prices from 75€ to 104€ per hour for facilitating group meetings, without practical research services (Table 1). Four meetings of 3,5 hours would cost 1,000€ to 1,500€ per year, per farmer. These results show that the cost of the *Cropping School* are similar to the membership fees in established networks. A self-financed business modell of the *Cropping School* can be considered as a realistic option.

Interviews showed that all ten *Cropping School* participants interviewed were interested in a continuation of the network once project funding was depleted. All participants were also willing to share the costs, as long as some funding from project sponsors was included. Six farmers considered network continuation via project funding more feasible. Only four participants considered to independently shoulder all network costs and three of them are willing to cover more or less the total cost (Figure 1). However, interviews also revealed that all surveyed participants would contribute to enable a continuation of the network in combination with additional funding. One option being state, national or EU-funded projects, which, in turn, depending on further programs. Alternatively, existing advisory organization could offer such network services. Thereby the networks would benefit from certain efficiency gains within the existing services of these organizations.

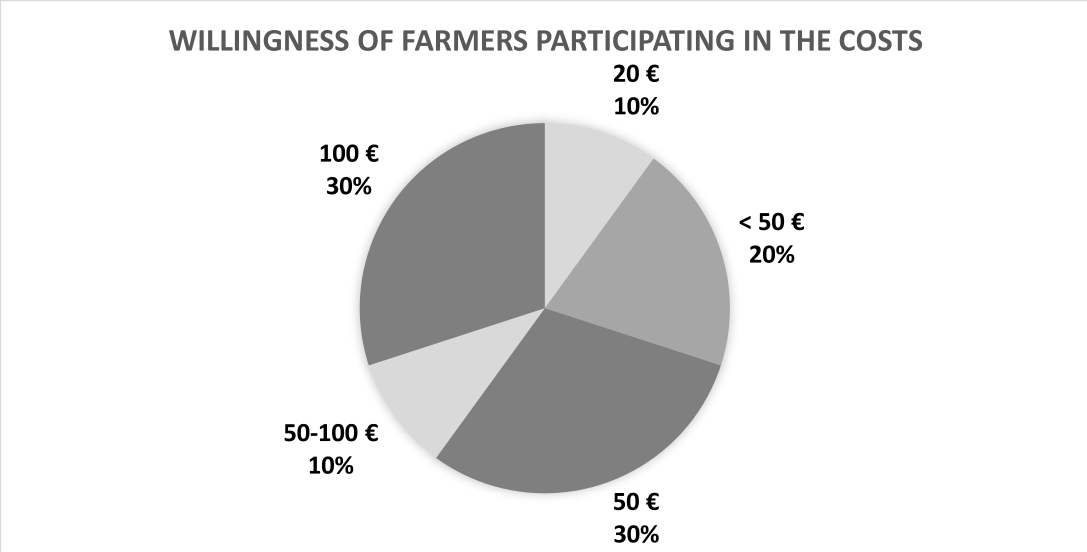

Fig. 1 How much are farmers willing to pay per month for a Cropping School?

In Brandenburg situation state-funded advisory organizations or farmers' associations do not exist. The advisory systems are dominated by private enterprise consultancies. Farmers' networks or group advisory formats are unknown. In comparison with other farmers' networks approaches (within and outside Germany), this suggest the following business option to institutionalise the *Cropping School* in Brandenburg:

I) establish a new/own association or which is financed by membership fee and/or funding programs

II) join existing private associations

III) join academic research project as project partners, no self organized network

All three options have advantages and disadvantages for a self-sustained network.

Tab. 4 Advantages and Disadvantages of busines models

Option	Âdvantages	Disadvantages
I) Own association	• Cropping School group of the study case knows each other and can continue to exist • Cooperation with different research institutions in Brandenburg established • Group determines own mission	• Knowledge, human resources and time requirements to establish the legal structure of an association

	statement and topic setting • Regional networks with cross-association advisory organization are possible • Financing through membership fee and/or funding programs possible	
II) Join existing association	• Existing structures can be used • Cropping School group of the study case has no need for knowledge, human resources and time to establish a legal structure of an association • Larger associations mostly use financing options like membership fees, donations, sponsors or funding programs: this could reduce cost for farmers (membership fees) compared to option I	• Association's mission statement must be adopted • Topic and group composition can be determined by the association • Cross–association advisory organisations do not exist in Brandenburg; Cropping School group of the case study are operate cross – association • Risk of not finding a model for cooperation with research partners
III) Join academic	• Guaranteed cooperation	• no permanent network structure; always

research project	with research associates • No membership fee for farmers	limited in time and often with only one thematic topic • research projects will not interest all participants in a group • Universities should not compete with advisory services (distortion of competition) – long-term advisory services are not traditionally part of University structures in Germany.

Conclusion

The case study reveals a high demand for regional farmers' networks, in addition to individual advisory services, in Brandenburg, Germany. Farmers appreciate the opportunity to exchange and interact with colleagues and experts. This interaction and mutual learning empowers farmers to venture new cropping system methods. Results suggest three potential business models for regional farmer's networks in Brandenburg, Germany. Establishing an own association which is financed by membership fees and/or funding programs seem to be the most promising approach. But results also show that farmers are not willing to bear the entire cost of these services alone. As these networks are an excellent tool to encourage learning, while enabling farmers to identify farming system problems and to take action for improvement, we recommend further investigation into different funding models.

References

Borchardt A., Gothlich S. E. (2009): Erkenntnisgewinnung durch Fallstudien in
Methodik der empirischen Forschung [*Gaining Knowledge through Case Studies in Empirical Research Methodology*] In Albers S., Klapper D., Konradt U., Walter A., Wolf J. (2009): Methodik der empirischen Forschung [*Methodology of empirical research];* (Pages 33-48), Gabler, GWV Fachverlag GmbH, Wiesbaden

Federal Office of Agriculture and Food (BLE) Deutsche Vernetzungsstelle Ländliche Räume [*German Rural Networking Office*] (DVS) (2019): Projekte der EIP-Agri in
Deutschland [*EIP-Agri Projects in Germany*]. URL: https://www.netzwerk-laendlicher-raum.de/themen/eip-agri/eip-datenbank/

Federal Office of Agriculture and Food (BLE) (2014): Forschung fördern –
Wettbewerbsfähigkeit stärken [*Support Research - Strengthen Competitiveness*], MKL Druck GmbH & Co. KG, Ostbever

Bloch, R.; Knierim, A.; Häring, A.; Bachinger, J. (2016): Increasing the adaptive capacity of organic farming system in the face of climate change using action research methods. Organic Agriculture 6, pp. 139–151

Bornhoff, J., Frenzer, S. (2006): networkarbeit erfolgreich gestalten [*Successfully Shaping Networks*] In Landesinstitut für Qualifizierung NRW (2006) networkarbeit erfolgreich gestalten. Orientierungsrahmen und Impulse [*Successfully Shaping Networks – Orientation and Impulses*], (Pages 43 – 79), W. Bertelsmann Verlag GmbH & Co KG, Bielefeld

Buller, H.; van Dijk, L.; Fieldsend, A.; Varga, E.; Augustyn, A. M.; v. Münchhausen, S.; Redman, M. (2019): LIAISON Better Rural Innovation: Linking Actors, Instruments and Policies through Networks

Farmer's Business Network, Inc. (2020) Farmer's Business Network (FBN). URL: https://www.fbn.com/

Kahl I. (2019): Mögliche Geschäfts- und Finanzierungsmodelle einer Cropping School [*Business and Financing Model Options for a Cropping School*], Bachelor Thesis to acquire the academic degree of Bachelor of Science at the Eberswalde University for Sustainable Development

Knierim, A., Thomas, A., Schmitt, S. (2017): Beratungsangebote in den Bundesländern [*German State Advisory Services*] In B&B Agrar 4/2017. URL: https://www.bildungsserveragrar.de/fileadmin/user_upload/Bilder/ Literatur/BuBAgrar/Online-Spezial/BB_Agrar_04_2017_Online_09_ September_Bundesl%C3%A4nder_mit_Schutz.pdf

Kummer, S.; Milestad, R.; Leitgeb, F.; Vogl, Ch. R. (2012): Building Resilience through Farmers' Experiments in Organic Agriculture: Examples from Eastern Austria. Sustainable Agriculture Research 1(2), doi:10.5539/sar. v1n2p308

Lehmann, I. (2005): Wissen und Wissensvermittlung im ökologischen Landbau in Baden-Württemberg in Geschichte und Gegenwart [*Organic Farming in Baden-Württemberg: Knowledge and Knowledge Transfer, Past and Present.*]. Kommunikation und Beratung. Sozialwissenschaftliche Schriften zur Landnutzung und ländlichen Entwicklung. Volume 62, Margraf Publishers

Luley, H. (1996): Information, Beratung und fachliche Weiterbildung in Zusammenschlüssen ökologisch wirtschaftender Erzeuger [*Information, Advice and Professional Development in Organic Farmers' Associations*], Margraf Verlag, Weikersheim

Luley, H.; Kröger, M.; Rieken, H. (2015): Beratung ökologischer Erzeuger/-innen in Deutschland [*Advisory Services for Organic Farmers in Germany*], Margraf Verlag, Weikersheim

Mayring, P. (2002): Einführung in die qualitative Sozialforschung [*Introduction to Qualitative Research*], Beltz, Weinheim

Morschett D. (2003): Formen von Kooperationen, Allianzen und networken [*Kinds of Cooperations, Alliances and Networks*] In Zentes, J., Swoboda, B., Morschett, D. (2003) Kooperationen, Allianzen und networke [*Cooperation, Alliances and Networks*]; (Pages 387-413), Gabler, GWV Fachverlag GmbH, Wiesbaden

Scholz S., Bloch R., Münchhausen S., Häring A. M. (2018): "Cropping School" in Brandenburg, Germany - An Alternative to Advisory Services?

In: Farming systems: facing uncertainties and enhancing opportunities. 13th European IFSA Symposium - 1th -5th July 2018, Chania (Greece) Sooby, J. (2001): On-farm research guide. Organic Farming Research Foundation. http://ofrf.org/sites/ofrf. org/files/on-farm_research_guide.pdf, Zugriff am 10.12.2018

Soil Association (2020): Innovative Farmers. URL: https://www.innovativefarmers.org/

Sooby, J. (2001): On-farm research guide. Organic Farming Research Foundation. URL: http://ofrf.org/sites/ofrf.org/files/on-farm_research_guide.pdf

United States Agency for International Development (USAID) (2020):USAID-funded John Ogonowski and Doug Bereuter Farmer-to-Farmer Program. URL: https://farmer-to-farmer.org/

Yin R. K. (2018): Case Study Research and Applications: Design and Methods. Sixth Edition. Sage Publications, Inc, California