Rural Renaissance, Multifunctional Landscapes and Climate Adaptation: a trilogy proposal from grassroots innovation and participatory action research projects

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Abstract
Portugal geographical location makes it vulnerable to climate change events like heat waves, wildfires, drought, floods and sea level rise. Inland Portugal is a low-density region due to rural exodus and migration. For long years traditional farming has produced cultural landscapes, some of which are classified as nature protected area and cultural heritage. As climate change is increasing extreme events, temperature, heat waves, drought and water scarcity, these areas are more exposed to wildfires accentuated by the lack of adequate local fire management and simultaneously facing depopulation and social changes. Preserving these landscapes requires in some cases a rural renaissance approach based on diverse multifunctional landscapes and climate adaptation strategies that enables restoration of ecosystems and an increase in labour and employment based on locals or newcomers. The chapter presents 6 case studies in Alentejo associated with grassroots initiatives that explore and demonstrate different aspects of how multifunctional landscapes and participatory action research can promote rural renaissance and climate change adaptation. Mértola has a history of integrated local development and is now innovating in solutions to create local food supply chain and support the diversification of the ecosystem protection and regeneration. Aldeia das Amoreiras developed a participatory model of a dream village and a Permaculture design to its implementation. Tamera is an intentional ecovillage focused on peace learning, which has implemented and disseminated an adaptation measure and approach called water retention landscapes. Herdade da Coitadinha, Herdade do Freixo do Meio and Herdade da Ribeira Abaixo adopted specific climate adaptation plans and crop plans were designed and implemented with support of EU LIFE funding. Herdade do Freixo do Meio is the most visible example and demonstration of diverse multifunctional landscape management in Montado.
Keywords: climate change adaptation, community's adaptation, inland rural areas, Grassroots movement.

1. Introduction

The consequences of climate change and the current environmental crisis are increasingly discussed under diverse perspectives, from the political-strategic context to civil organization movements, from the primary to the third sector and to academic research. The causes and potential impacts of climate change are based on multiple dimensions, which turn this into a structural problem that implies a response from global governance, making it one of the biggest challenges of our century for governments and international institutions. Given the size and structure of climate change, solutions need to be negotiated despite the complexity and uncertainty present on

the effectiveness of responses (Eriksen et al. 2011). Furthermore, it is necessary to think of it as a multi-scale process, which requires integrated solutions from macro to micro scale. Impacts and consequences of climate change span from global to local scales, from regional to context-specific effects, and take a toll on a variety of communities (Ng et al. 2016). Although the macro dimension is fundamental, this chapter chooses to focus on the micro, grassroots[1], civil society-oriented dimension in order to act as innovation and examples of good practice for potential scalability. Confronted with the hastening and intensification of global environmental and socio-economic changes, research into the adaptation of systems continues to grow. Scientists have sought to create theoretical-empirical frameworks that better help to understand it.

Adaptation to climate change seeks to moderate or avoid harm or exploit beneficial opportunities as an adjustment to actual or expected climate and its effects (IPPC 2014). In rural areas it aims at reducing the negative impacts on the environment and improving local conditions, supported by innovations towards sustainable agriculture (Odegard and Van der Voet 2014). Furthermore, rural areas also require a new approach to landscape use that should include the symbolic, productive, spatial and environmental reserve functions (Clemente 2016) and to rethink and integrate concepts, like multifunctional agriculture and ecosystem services (Huang et al. 2015). But economic drivers for rural economy and rural businesses depend also increasingly on digitization, as well as knowledgeable workers, who make the most of the digital transformation and enhance rural production in a sustainable manner. It is therefore critical to improve access to internet and foster entrepreneurship in traditional rural domains, as well as new sectors of the economy (European Union 2019).

In this sense, the main purpose of this chapter is to reflect on the impact and scalability of micro-scale innovations (or grassroots innovations) on climate adaptation in rural areas, highlighting the role of Landscape Multifuncionality[2] and Rural Renaissance[3] as adaptation strategies. The chapter will present case studies in Europe and in Portugal as an empirical phenomenon. The content is divided into four main parts. First, the text reflects and articulates the explanatory theoretical framework. Subsequently, some research results on European case studies are briefly presented, followed by in depth six national case studies. The chapter ends, then, with conclusions and policy implications.

3. A Brief Framework

3.1 Adaptation Strategies to Climate Change

Climate change debate has progressed from the problem of framing, namely climate science and identification of climate impacts, like the one developed by the International Panel on Climate Change (IPCC), to one more concerned with the societal responses (Brink and Wamsler 2018), such as mitigation and adaptation, and their

[1] Grassroots innovations (GI) emerge as "networks of activists and organizations generating novel bottom-up solutions for sustainable development; solutions that respond to the local situation and the interests and values of the communities involved. In contrast to mainstream business greening, grassroots initiatives operate in civil society arenas and involve committed activists experimenting with social innovations as well as using greener technologies" (Seyfang and Smith 2007:585).

[2] Multifunctionality lies within the operational role of sustainable development and is based on the assumption that land uses such as agricultural and forestry have always fulfilled more than just their primary aim of producing food, fibre, timber and fuel (Carvalho-Ribeiro et al. 2010). Landscapes are considered multifunctional when the diversity, abundance of landscape functions and ecosystem services are present or supplied at high levels in at least part of its area (Plas et al. 2019; Stürck and Verburg 2017).

[3] Rural Renaissance is considered a strategy for the preservation of Europe's manifold natural and cultural landscapes and heritage as rural resources are capable of delivering sustainable solutions to current and future societal challenges (European Network for Rural Development). The Cork Declaration from 2006 and 2016 states that Rural Europe is important for all citizens of the Union as it assures a safe and sustainable provision of quality food, developing the circular economy, broadening the bio-economy, fostering resource efficiency, combating climate change and reducing the reliance on fossil fuels (European Union 2016).

potential trade-offs. Mitigation efforts are essential since adaptation efforts alone cannot fully reduce our vulnerability to climate change and its tipping points. On the other hand, even if all the possible mitigation efforts would be put in place, adaptation will still be needed since we are already experiencing the effects of climate change and the greenhouse gas emissions of the present will continue to have a global warming effect in the next decades. The consequences of the climate crisis are acting therefore as a catalyst for adaptation.

Good adaptation planning can foster adaptation strategies and measures that are no-regret and contribute to both mitigation and adaptation. This has pushed the climate adaptation community to advance on the understanding and responsiveness of climate-change related problems with a regional and local focus. These advances have been associated, with quantifying climate change (Hansen et al. 2006) and developing and applying methods for assessing the vulnerability of communities and ecosystems (Coles and Scott 2009) in a more macro approach; and, on the other hand, providing general principles and broad strategies for adaptation (Hallegatte 2009).

The consequences of climate crisis affect countries, regions and communities in different ways and therefore differences must exist in terms of their adaptation strategies (Alam et al. 2017). On one hand, the factors responsible for the variation in adaptive responses across regions are the agro-ecological system, socioeconomics, climatic impact, and existing infrastructure and capacity (Brulle et al. 2012). On the other hand, adaptive capacity is influenced by many factors, such as: knowledge and awareness about climate change, access to appropriate technology or funding, and the institutional, political and governance environment (Haden et al. 2012). As a consequence of such complexity, real adaptation entails an institutional engagement that can enable collaboration and integration across different levels of government and different geographic scales.

Climate change adaptation strategies and measures aim to reduce existing and future vulnerability, commonly viewed as comprising three elements: exposure, sensitivity, and adaptive capacity (Diouf and Gaye 2014). In the adaptation planning community and literature, the perception that 'top down', usually expert-driven, hazard and climate impact-based approaches need to converge with what can be considered more 'bottom up' adaptation analysis and action, is growing (Feola and Nunes 2014). On one side communities and local groups are taking the initiative to adapt and on the other side, governments, institutions and the private sector are also taking initiative. Adaptation strategies and investments can face opposition from communities or may depend on their support, knowledge and engagement which has raised the need for the use of participatory methods in assessment and planning, giving rise to Participatory Action Research projects on the field.

The increasing importance of adaptation issues has made that the literature available had also increased. Two broad types of studies on adaptation practice are evident: direct assessments of adaptation practice, with a main focus on adaptation initiatives in developed countries (Berrang-Ford et al. 2011); and literature that reports actual and ongoing adaptation practices (including participatory action research), namely in agricultural contexts and in community initiatives in rural world (Makuvaro et al. 2014). This chapter relates to this last dimension.

In the case of adaptation in rural settings, the literature is either addressing adjacent causes of problems through incremental actions and improving the resilience of system functions or building the potential to transition to prevailing rules and decision processes. Most of the community-led adaptation examples have focused on rapidly realizing improvements in life quality of resource-dependent communities through changes to livelihoods and natural-resource management strategies (WRI 2011). In essence, all of these are focused on improving the capacity of communities to cope and adjust through approaches that guarantee the prevailing suite of ecosystem goods and services (Jones et al. 2012).

So, if, on one hand, climate adaptation requires the availability of tangible resources such as money and technology (Smit and Wandel 2006) to the development of large-scale change, on the other hand, the ability to adapt (adaptive capacity) also depends on resources more related to knowledge, governance, markets, logistics and networks that may depend on community engagement and grassroots innovations.

3.2 Rural Renaissance as a Grassroots Approach to climate adaptation

According to Axinn (1974), Rural Renaissance may be defined as the marriage between traditional patterns (values, norms, technologies, and behaviour) and those innovative patterns which result in the birth of change.

Rural Renaissance is considered a strategy for the preservation of Europe's manifold natural and cultural landscapes and heritage, as rural resources are capable of delivering sustainable solutions to current and future societal challenges caused by climate change (European Network for Rural Development). The Cork Declaration from 2006 and 2016 states that Rural Europe is important for all citizens of the Union as it assures a safe and sustainable provision of quality food, developing the circular economy, broadening the bio-economy, fostering resource efficiency, combating climate change and reducing the reliance on fossil fuels (European Commission 2016). Empowering local communities in rural spaces is critical for promoting rural renaissance. Some grassroots movement have been contributed for this goal as by definition these are community led initiatives that seek to renovate local conditions and bring social change as long as they are micro-scale (Nicolosia et al 2018) namely climate adaptation.

A distinctive aspect of grassroots innovation is not only their inclusive action-oriented practices, but also a possible effect at higher macro level namely in transforming the national or international system through their scalability (Seyfang and Smith 2007). In this sense, they contribute to possible sustainable transitions, which can be defined as a non-linear shift from one dynamic equilibrium to another, or the process of change from one state to another, or from one system state to another via a period of nonlinear disruptive change (Loorbach et al. 2017). The combination of different forms of transition adopts aggregation, consolidation and standardization of learning processes that reinforce the successful development and improvement of grassroots innovations (Feola and Nunes 2014). Furthermore, recent studies demonstrate that some arenas of grassroots innovations may be replicate and developed as a result of peer-to-peer knowledge dissemination (Seyfang and Longhurst 2016).

One common feature of grassroots innovations is the product of local experimentation. Places and scales of transition approaches or their emplacement enable futures narratives to hold together. Transition "does not work without (local) places because those places offer the milieu – and the affective attachments – through which generic senses of responsibility, resilience, and relatedness may be most easily imagined and held together" (Brown et al. 2012).

The emergence of grassroots, community-based, micro-scale innovation, however, is shrouded in difficulties. With reference to the links between these communities and the wider community of a place, the literature has highlighted several factors that hinder the diffusion of grassroots innovations (Feola and Nunes 2014). Among the most common difficulties encountered are to struggle with securing and sustaining participation over time (Seyfang and Smith 2007), to rely on volunteers' ability, to promote innovation in the community (Kirwan et al. 2013), and often to rely on low levels of financial resources (Middlemiss and Parrish 2010), which have been shown to be key to supporting learning processes (Seyfang and Longhurst 2016).

Learning processes are more easily disseminated if support mechanisms exist. In addition to the challenges already identified, these micro-scale initiatives are often fragmented resulting in duplication of efforts. Given this limitation, a number of initiatives and networks have emerged to bring them closer, both in practice and in knowledge. The emergence of transnational and trans-local networks such as ECOLISE has been addressing this challenge, although others still persist.

The analysis of the European and Portuguese case studies presented in the next sections seeks to clarify the innovation to climate adaptation among collective action and community led Initiatives (CLIs) and understand the potential and conditions for their emergence, resilience, lasting impact and replication.

3.3. Trans-local European Networks as Catalysts of Change

Community led sustainability initiatives (CLIs) are part of a network called ECOLISE created in 2014 in Belgium. ECOLISE's purpose is to engage in, support and facilitate accelerated learning and collaboration among community-led initiatives, their networks and partners in order to catalyse systemic transformation within and across society. Since 2019, ECOLISE has 46 member organizations. Members include the Transition Network (representing over 1200 Transition initiatives), the Global Ecovillage Network (15,000 ecovillages), the Permaculture movement (3 million practitioners globally) and ICLEI, the association of local governments for sustainability, national and regional networks and other specialist bodies engaged in European-level research, training and communications to support community-led action on climate change and sustainability. In the last report of ECOLISE, several projects and programmes involving CLIs are listed, namely the Grassroots innovation project, the TESS project, the FAST project, the Research in Degrowth, SEEDS of Good Anthropocene, the TRANSIT project, the KEEP project and the Grow Observatory (Penha-Lopes et al. 2019).

The most wide-ranging and systematic quantitative assessment to date of the implemented and potential contributions of CLIs to climate change mitigation was conducted in TESS (Towards European Societal Sustainability 2016). Based on case study research on the social, political, economic, technological and environmental impacts of 63 CLIs in six European countries (Spain, Italy, Romania, Germany, Scotland and Finland), TESS calculated their carbon emissions savings and compared with national baselines in each country in the following sectors: transportation, food, waste and energy. Results indicated that CLIs achieve the highest reductions in GHG emissions through heat and electricity generation, personal transportation and promoting vegan and vegetarian diets (Penha-Lopes et al. 2019).

A study done in 2017 reviewed 16 scientific publications that collectively assessed the ecological and/or carbon footprint of 23 ecovillages and cohousing initiatives. Results showed that in cases where ecovillage residents' carbon footprints have been measured, these are in average 35% lower than national averages. The most spectacular case was that of *Sieben Linden* in Germany, whose carbon footprint in 2004 was reported to be only 27% of the national average (Penha-Lopes et al. 2019). Estimates from the UK have suggested that low carbon community groups can achieve emissions reductions of up to 32% in one year, and households (e.g. Transition Town Totnes) with reductions of around ten percent.

In a survey of 29 showcase ecovillages worldwide by the Global Ecovillage Network, almost all respondents reported that they actively work to restore degraded ecosystems, the majority indicating that this is a significant area of their work. 90% of the respondents reported that they actively work to sequester carbon in soil or biomass, over a third dedicating substantial effort to these activities. Reported techniques include regenerative agriculture, reforestation, use of clean cooking stoves, farmland restoration, water saving, composting, farmland irrigation and creation of biochar (Penha-Lopes et al. 2019).

4. Context

4.1 The Portuguese Case

Portugal rural exodus started in the middle of the 20th century, which led to migration flows that left the countryside underpopulated (fig. 1). This exodus started during the 50's when the development of Oporto and Lisbon Metropolitan Areas attracted population from the very poor rural areas of the interior. During the 60s and 70s immigration flows towards Europe, namely to France and Germany, also contributed to further accentuate the depopulation of these regions. Besides that, the main urban centers of the rural interior regions small and dysfunctional were not able to retain part of these migration flows that went directly towards the Metropolitan Areas of Lisbon and Oporto and abroad. The double movement of rural exodus, towards the coast and main cities and the industrialized European countries, led to the depopulation of the most rural inland regions of Portugal. These regions tend to lose population, economic activities and public services in a process of depopulation that is difficult to counteract. This situation was also a consequence of decades of rural and interior regions being left

out by a strongly centralized State and its socio-economic model that disregarded rural development EU integration in 1986 brought, among others, rural development policies and funds to support agricultural activities, the construction of mobility infrastructures, the restoration of heritage and some development to rural areas, notably through tourism (Silva 2008).

With the growing tourism these areas attracted some urban dwellers who decided to return to the countryside inland, aiming to retrofit their family heritage in order to develop rural tourism projects or agricultural production. Although there are some programs promoting this return to the countryside, there is a lack of infra-structures (like health services, education and job opportunities) that keeps this movement with a low impact (LUSA 2018). Nevertheless, along with these grassroots innovation in urban context they created the ground for the emergence of new rural renaissance initiatives, especially in the beginning of the 21st century (Penha-Lopes et al. 2019).

Simultaneously initiatives linked to Transition and Permaculture are taking place in the countryside both by native and few foreign newcomers (e.g. Wildlings, Transition Portugal) (CC 2015). Since 2011 when the peak of the economic crisis occurred, communities started settling in cheap land properties located in forestland within central Portugal or *Montado* agro-forestry systems within southern Portugal*)* (CC 2015). To make their economic transition easier, some of these people become teleworkers, i.e. they continue to work to their companies although at distance, using digital technologies and internet, making critical the improvement of internet access in rural areas in order to foster entrepreneurship in traditional rural domains as well as new sectors of the economy (European Union 2019). The growth of these initiatives can be witnessed by the number of Portuguese Community led sustainability initiatives (CLIs), associated in the network *Rede Convergir*, that in 2018 included 34 transition initiatives, 46 permaculture initiatives and 19 ecovillages (Penha-Lopes et al. 2019). Some research studies addressed these CLIs (Nogueira 2018) and their socio-ecological impact.

However, these are regions where climate change has created new challenges such as drought and fire risk increase. In central Portugal there is an increase of fire where vast areas of pine and eucalyptus trees monocultures have been planted for timber, while in regions like Alentejo the precipitation has dropped almost 30mm in the last years (fig. 2) causing increased aridity and threating the Montado ecosystem (Pinto-Correia et al. 2011). In addition, the lack of mosaic structure in landscapes, discontinuity in dense shrubland or forests and adequate fuel management, namely through grazing, have been identified as factors that increase the fire spread and impact (Mateus and Fernandes 2014).

The management of fire risk from the government has been implemented through topdown approaches prioritizing fire suppression over fire prevention (Mateus and Fernandes 2014). Some of the emphasis has been on financial support for fuel management, on reforestation projects with native broadleaved trees - such as *Quercus robur*, in the Northwest part of the country - and cork oak - *Quercus suber* or holm oak in the southern part of the country, but also bringing people into the forest during the months of high risk, with fire fighters teams hired by the civil parishes, municipalities and farmers associations. (Ribeiro 2009). In an attempt to dynamize the economy of rural areas and attract new residents, several financial incentives, programmes and projects have been put in place by the national government or municipalities (often using European funds and programmes) but have still not been efficient in reversing rural exodus (see Figure 1), preventing the fire widespread or developing the mosaic diverse landscape that can alter the fire regime. The extent of large fires can be tackled by land-use planning, forest and fuel management (Fernandes et al. 2016) and all these are dependent on rural development. One indicator for this tension is the emergence of a political (transpartidarian) driven movement for the development of inland regions of Portugal, which has listed several actions such as further financial and pension incentives for moving public services and officials to these regions (Movimento pelo Interior 2018). Complementary, several grassroot initiatives are responding with concrete actions. One example at the national scale is the presence, since 2009, of a national program promoting participatory and voluntary foresting actions in Portugal (Plantar Portugal 2019).

Sociological changes documented under an action research project entitled CATALISE (Empowerment for Local Transition and Social Innovation), from 2014-2016, has mapped and studied Portuguese community-led initiatives (CLIs) in order to understand their characteristics, drivers, enablers and potential. The majority of projects were focused on education and community building, followed by sustainable agroforestry and farming.

Among CLIs and participatory action research projects we choose 6 case studies in Alentejo region where some climate adaptation strategies are being implemented connecting agroforestry, multifunctional landscapes and rural renaissance.

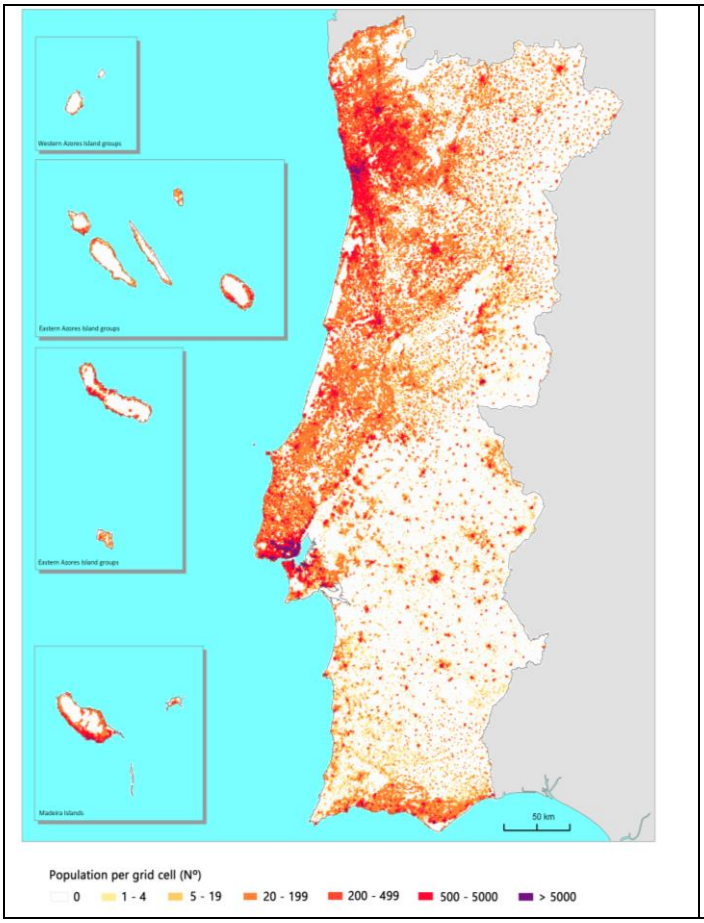

Figure 1. Map of population density (inhabitants km^{-2}) in Portugal, year 2011. (Source: INE 2011)

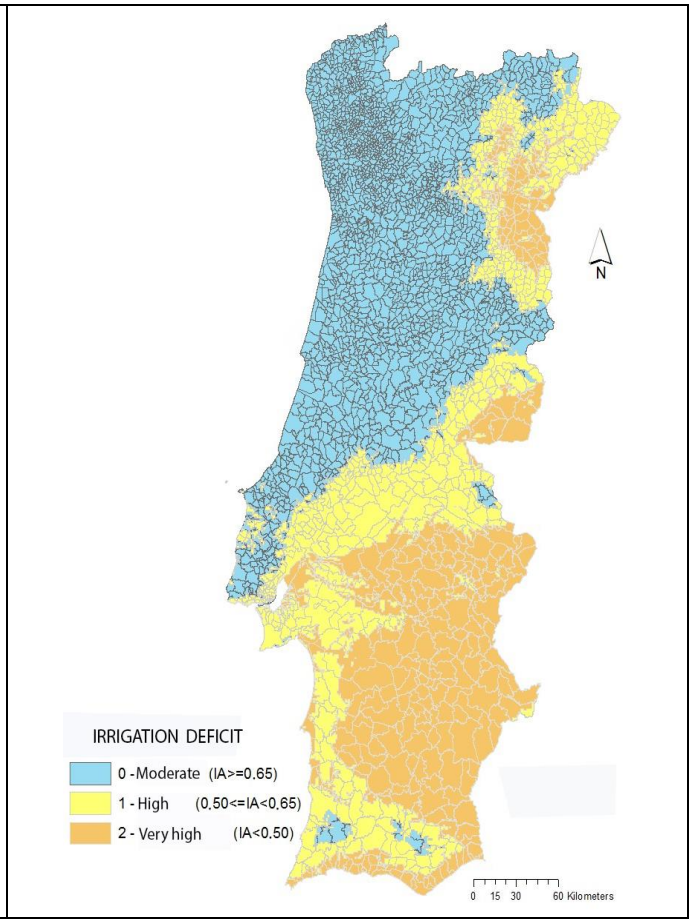

Figure 2. Map of Irrigation deficit / index of aridity in Portugal, 1980-2010 (Source: ICNF, 2014)

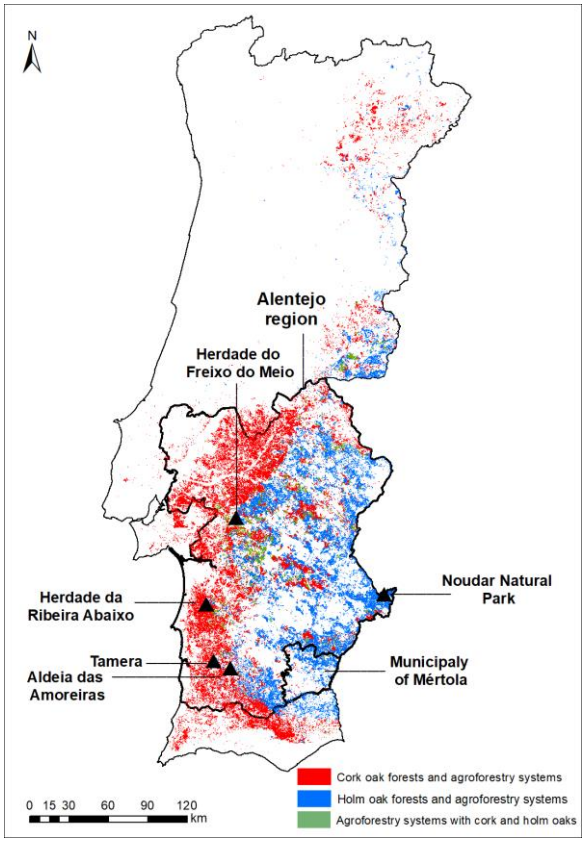

Figure 3. Montado distribution in Portugal and the Alentejo region (source: COS 2015).

4.2 The Regional Context – The case of Alentejo

The Alentejo region is characterized by high or very high irrigation deficit (aridity index below 0.5, see fig. 2), with high susceptibility to desertification and low net productivity landscape, except on the irrigated, riparian or valley areas, where water is not the limiting factor. Presently, the annual average precipitation is 630 mm and in the climate scenario RCP 8.5, for the year 2070-2100 a reduction of around 20% of rainfall is expected in average, which means a total accumulated rainfall of 519 mm. In the Lower Alentejo (sub region NUTIII), the rainfall is expected to decrease in the same scenario from present average of 500 mm to a future 400 mm. Under the RCP 8.5 scenario, for the period 2070-2100, maximum temperatures are expected to rise 4°C to 6°C, and in the month of august from 31°C to 36°C (IPMA 2018). The climate changes projected in the most likely IPCC scenarios (RCP 4.5 and RCP 8.5), combined with the high level of susceptibility to desertification and the low population density, reinforce this regions' vulnerability to climate change.

In the rainfed areas that occupy the majority of the area of the region, the prevailing natural landscape is called *Montado* (fig. 3), which is a traditional agro-silvo-pastoral systems with a savanna type structure with cork oaks (*Quercus suber*) or holm oaks (*Q. rotundifolia*) as the dominant trees, forming pure or mixed stands (Pinto-Correia et al. 2011). Other rainfed areas are occupied with other forests (namely Maritime pine) or extensive pastures, winter cereals, shrubland, and other permanent crops such as vineyards, traditional olive yards or annual crops. Since the rainfed agriculture is extensive and generates low income and labour per area, the population density and the real estate value are low, except in areas where other attractive potentials exist such as tourism, irrigation agriculture, industry or high number of institutions and urban development. Public transport is dysfunctional in most areas which also contributes to rural exodus.

Cork is the most important forest product from *Montado* systems, with Portugal producing 54% of the world cork. In addition to cork (harvested every 9-12 years), animal production fed in pastures and acorns are the basis of the

pastoral system that maintains the multifunctionality of landscape which can be complemented by honey, aromatic plants, wood, strawberry tree, hunting, mushrooms. In addition, these landscapes are typically complemented with smaller patches with other forest or permanent crops, such as above mentioned, maritime pine, olive yards, vineyards and orchards and horticulture in the valleys and close to the inhabited areas. The multifunctional management promotes structural diversity at the stand and landscape level, which combined to a large distribution area and spatial continuity results in high-level of biodiversity. The regulation of water and nutrient cycles and of soil erosion, as well as carbon sequestration are important services to be managed in *Montados*. From a cultural and recreational perspective, *Montados* are valued for the landscape aesthetics, natural values and cultural heritage (Pinto-Correia et al. 2011).

Montado is in sharp decline as a result of the rapid specialization of land management that, through simplification, undermines multi-functionality. *Montado* is currently threatened by intensification as well as by over extensification. In the first, the landscape is being transformed into a monoculture of cork oaks with little or reduced multifunctionality and in the second it is threatened by the declining trends in stand density caused by adult tree mortality and deficient tree recruitment. Soil degradation, changes in rainfall patterns, pests, diseases and fire are the main underlying pressures, with interacting effects (Pinto-Correia et al. 2018).

Strategic actions have been put in place to conciliate human use and biodiversity conservation, such as the publication of national regulations that legally protect the cork and holm oaks. One of the most significant might be forest certification, which has been promoting practices of responsible forest management in more than 70,000 ha of *Montado*, around 30% of the total certified Portuguese forest area (Wohner et al. 2019). To reduce the vulnerability to climate change, these actions are not considered sufficient, as made clear by National Adaptation Strategy (MAMAOT 2013) or the Spatial Plan for the Forests of Alentejo Region that points to the need for forests to supply at least five functions (production, protection, conservation, recreation, grazing, hunting and fishing) (ICNF 2019).

4.2.1 Adaptation and Multi-functional Landscapes

Multifunctionality is the simultaneous and interrelated provision of different functions from a single land use type. There is increasing evidence that landscape multifunctionality is associated to sustainable provision of multiple ecosystem services from a single plot of land (Ribeiro 2009). The region of Alentejo, in Southern Portugal is well known by its landscape multifunctionality.

The European BASE project collected several case studies where climate adaptation measures were implemented, identified cases of adaptation to drought in agriculture and forest in Alentejo (Ng et al. 2016) and developed a participatory state of the art, discussing the adaptation measures for the region based on the national strategy of adaptation and policy measures for the sector. BASE priority measures for policy are on the level of adaptive capacity, namely: rural renaissance (keep the population inhabiting rural areas; promote access to land and renovation of farmers); knowledge and education (increase the knowledge in climate change scenarios, rural extension/farmers counselling, environmental education in schools, create alert systems for environmental impact, create and disseminate useful knowledge and promote applied and interdisciplinary research); finance (agricultural insurances and pay farmers based on their ecological services); technology (develop appropriate technologies for the valorisation of spontaneous natural species adapted to future climate); and planning (promote a local and systemic view on farm and regional planning and adjust the cultures calendar to climate).

And on the level of ecosystem sensitivity, namely: water (preserve water resources, promote the efficient use of water, increase the capacity for water storage and irrigation, protect and restore water lines); soil (soil conservation and promotion of organic matter in soils, support the creation and adoption of precision models for animal grazing and soil restoration); and diversity (increase vegetation density with native species and value the animal, vegetable and microbe genetic heritage).

Adaptation approaches based on diversity, such as agroforests, silvo-pastoral systems, mixed tree crop systems, multi-strata forest gardens or vegetable gardens have been used for centuries by farmers to reduce vulnerability and ensure productivity in the face of climate uncertainty (Verchot et al. 2007). Diversity in the ecosystem can significantly regulate plagues, pests, fires and negative impacts on biodiversity (Gurr et al. 2003). In addition, a diversity of families, species, varieties and genetic diversity will increase the capacity of the system to survive and prosper in different climate conditions (Hoffmann and Sgrò 2011).

When compiling literature on adaptation measures it is possible to identify more than two hundred adaptation measures and the Portuguese adaptation strategy for agriculture and forestry alone presents 237 different adaptation measures (51 for public level and 181 for farm level) (MAMAOT 2013). Multifunctional landscapes are an effective strategy for climate adaptation but its implementation and management face several challenges such as: the size of land and economic viability; the motivation and knowledge of stakeholders to adopt polycultures; the technology for precise agriculture in polycultures; the (lack of) availability of workforce and skilled labour; the added value market for diversity production; the logistics and distribution for diverse products; the financial support for the transition of farmers; and the policy, regulations and subsidies that obstacle integration of agriculture and forestry. As an example, the decoupling of CAP (Common Agricultural Policy) payments leads production decisions and resources allocation to be more dependent on market prices and competitive advantages, which in turns favours monocultures and does not compensate multifunctional landscapes as the Mediterranean Montado ecosystem and high nature value farming (Fragoso et al. 2011).

5. Six Case studies in Alentejo

We present six case studies (fig. 3) that illustrate multifunctional landscapes as an adaptation strategy to climate change, its role, opportunities and challenges. The case studies are analysed based on three main dimensions: rural renaissance, multifunctional landscapes and climate adaptation. These dimensions are distinguished around the different scales of action from which they emerge. While rural renaissance approaches tend to manifest themselves in the micro context, in a bottom-up intervention logic, climate adaptation strategies usually emerge from the macro scale through top-down approaches. Although these differences exist, all three dimensions operate in an integrated logic of articulation and approximation between the scales. This means that innovative initiatives to respond to environmental problems (and not only) that arise from the micro scale must be enhanced by top-down approaches and vice versa.

To account for this fluidity and articulation of processes, the concepts of social innovation and ecological innovation are mobilized. Social innovation appears here associated with rural renaissance, in the sense that it comprises a set of stages ranging from the identification of the need, to the implementation of solutions to the introduction of systemic change. Ecological innovation appears associated with multifunctional landscapes and climate adaptation in the sense that it is more sedimented in the structuring of public policies. Articulation arises precisely from the importance of micro-based initiatives, better able to identify the real needs of territories and populations, in the creation of co-created and innovative responses. Subsequently, these initiatives, so that they can have some scalability, need a structural support that allows the introduction of changes in environmental ecosystems. As sustaining multifunctional landscapes is intimately connected with local and regional economy, thus with population density, the role of Rural Renaissance as an adaptation strategy, in these case studies, is also presented and discussed (fig. 4).

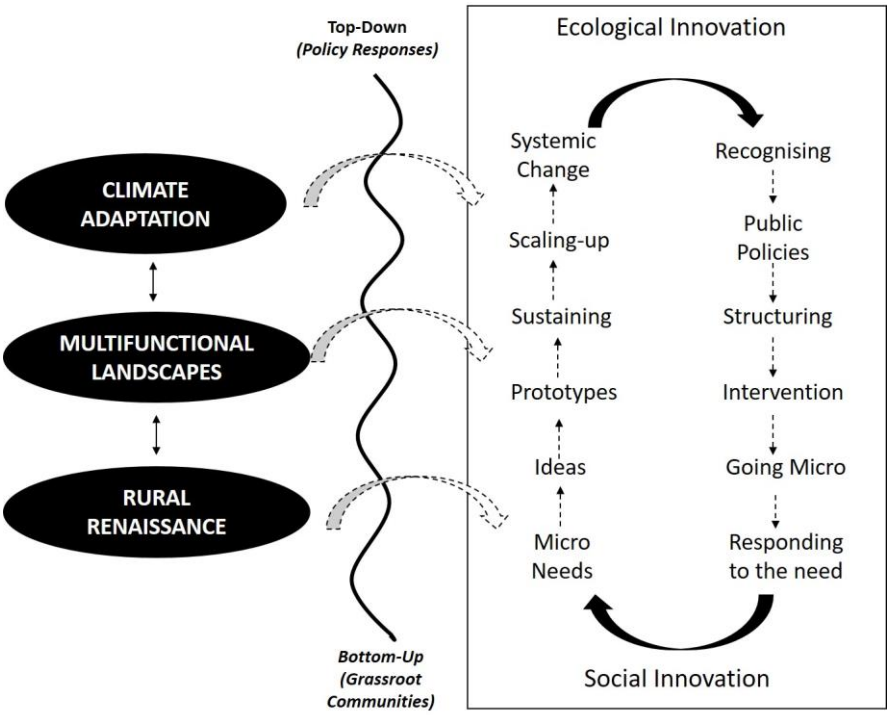

Figure 4. Integrated Process of Social and Ecological Innovation (Source: Own Elaboration)

In the first case study of Mértola municipality we highlight the climate adaptation plan for local forestry and agriculture developed in a participatory way and several other complementary initiatives, some bottom-up and others top-down, often involving EU funding and support. In the case studies of the Noudar Nature Park / Coitadinha farm, Herdade da Ribeira Abaixo farm and Herdade do Freixo do Meio farm, we present three Montado farms where specific climate adaptation plans and crop plans were designed and implemented with funds from EU LIFE programme. The adaptation and crop plans of these farms are also based on a multifunctional landscape approach and show replication potential. The fifth case study presents a grassroots initiative in the village of Aldeia das Amoreiras. The local development project included a Permaculture design plan for the whole village and nearby Montado area, based on a seven years long process of local participatory research. The sixth case study is the intentional community and ecovillage of Tamera, where the adaptation measure called Water Retention Landscape was accessed with a cost benefit analysis, providing more data to the discussion on cost benefit relation of structural investments to support multifunctional landscapes. The six case studies generate knowledge and, on the role, impact of multifunctional landscapes for climate adaptation. Furthermore, they provide data to discuss the role of grassroots initiatives, the support by EU projects and public institutions for its implementation, and the limitations, challenges and opportunities for replication (table 1).

Table 1. Comparative table for case studies in Alentejo.

Case studies	**Context variables** (legal status, dimension, values and mission)	**Social innovation** (rural renaissance)	**Outcomes of Social Innovation**	**Ecological innovation** (multifunctional landscapes and climate adaptation)	**Outcomes of Ecological Innovation**
Mértola	Municipality. Projects run by Municipality, University and local associations.	Decades of valuing local resources and identity through Archaeology centre, natural patrimony, cultural heritage,	Actions that arise from the identification of a micro need of the territory and gives place to a	In 2016, Climate adaptation plan for agriculture and forestry proposes multifunctionality in all five classes of	An advanced stage of the process of ecological innovation. The creation of structural

		natural park and environmental education projects. Recently adaptation plan developed in participatory method. New partnership for regenerative local food system.	participatory method based on the co-creation of solutions to address the needs identified. All these actions aim to create and sustain multifunctional landscapes, foster entrepreneurship based on endogenous resources and create social conditions to enforce it.	landscapes identified for the territory. In 2018, syntropic agriculture and local food supply chain are proposed as a socio-technical innovation for the implementation of regenerative multifunctional landscapes.	orientation in public policy empowers the capacity for local actors to act more effectively in the response of the micro needs they identify in their territories.
Aldeia das Amoreiras	Village project lead by grassroot initiative (association and informal group)	Convergence Centre is innovative project to experiment how to bridge rural and urban and bring new residents, visitors, animators and Rural Renaissance to an isolated village. A participatory project brings the population to dream their ideal village and create groups to make it happen. Transition town initiative.	Attracts urban citizens to live and contribute to rural areas. Intends to sustain this presence by developing, on the field, the experimentation of solutions through the inclusion of multiple actors, on multiple scales, in a systemic logic. It is replicated and replicating similar examples across the world (transition towns part of Transition Network)	Permaculture Design for the entire village and its territory integrates technical sustainability solutions and multifunctional landscapes with a socio-economic proposal. Promotion of adaptive capacity through information, training, raising awareness and experimentation of several solutions.	Reflection of a set of policies to stimulate innovation and co-creation of knowledge, also integrating climate adaptation policies and multifunctional landscapes. It operates at a stage of recognising the need for systemic change and encompasses intervention.
Tamera	Intentional community, grassroot initiative managed by community owned associations and company	Implementation of Rural Renaissance and creation of a new community / village through the promotion of peace, love and ecology. Innovative social model for community management and cohesion.	This example represents the implementation, sustaining and scaling-up of other similar examples across the world (ecovillages part of Global Ecovillage Network).	Water Retention Landscapes. A series of 19 lakes used for multifunctional purposes. Different ecological technical solutions that foster both mitigation and adaptive capacity (e.g. renewable energy production, conservation farming, community supported agriculture)	This example is supported by advanced stages of ecological innovation, integrating elements of public policy associated with multifunctional landscapes and climate adaptation.
Noudar Nature Park / Coitadinha farm	Public company	Participatory planning of climate adaptation. The farm and nature park brings tourism, environmental education, employment, diversification and	Implementation of activities that meet the needs identified. These responses innovate in the way they are constructed, through participatory processes. The interconnection	Increasing the diversity of species and uses on the farm creating a more multifunctional landscape. Diversification of income on Montado farms through the	Examples that represent intermediate stages of ecological innovation, inspired by science-based measures of multifunctional landscapes and

		new ways of living and valuing the territory.	between different sectors of activity enhances economic and social diversification and, consequently, the resilience of the solution and impacts.	production of fruit, aromatics, mushrooms and environmental services such as tourism and education.	climate adaptation. Namely, at the level of diversification and preservation of fauna and flora. It also combines a dimension of environmental awareness and education that will serve to feed the initial stages of the social innovation process, namely, in terms of increasing the capacity to identify needs and co-create responses.
Herdade da Ribeira Abaixo farm	Public administration farm managed by University	Participatory planning of climate adaptation. The plan includes diversification and to implement it an increase in the amount of people working and living in the land for which socio-economic innovation is needed.	Implementation of activities that meet the needs identified. These responses innovate in the way they are constructed, through participatory processes. The incentive to settle people in the territories also operates at a previous stage of the stages of social innovation as it is a necessary condition for building solutions that can generate change.		
Herdade do Freixo do Meio farm	Private farm, managed by cooperative	Cooperative is run by landowner, workers, consumers and other stakeholders such as hunters. Community Supported Agriculture scheme with direct selling to consumers who compromise for months ahead. More than 35 people work in this farm, a very high value in comparison to the average farm employment of the same size (>100ha) that employ typically less than six people for the same area (average 1 person /100hectares).	Innovative response in terms of participation, governance and management model, and in bringing together different actors in the territory. It leads to the generation of solutions that maximize the transforming potential of the activity. The diversification of products and incomes together with the consumer supported agriculture schemes sustain high number of workers that can sustain the multifunctional landscape.		

5.1 Mértola

Mértola is a town and a municipality, with more than 2000 years of history, that grew due to its strategic location as an inner harbour on the bank of the Guadiana river, but is suffering from rural exodus since the 1960s coupled with an increasing aridity and risk of desertification. The population of Mértola municipality reached its peak, in the year 1950, with 29,353 inhabitants, when the cereal agriculture employed a large percentage of the population. Presently, the municipality has 6,319 inhabitants, living in a territory with 1292.87 Km^2, which represents a density of 4.9 Inhabitants per km^2. There has been a trend of population decline and presently around 35% of the population is over 65 years old and only 9.4% is less than 15 years old. On the other hand some traces of rural renaissance can be seen by the fact that 1.8% of the population is composed by foreigners living in the territory (INE, 2018). The commercial balance is negative, and the unemployment rate is around 12%, (national average is 6%). A significant area of the municipality (47.4%) is located within the Natural Park of Guadiana Valley (612.68 km^2), created in 1995 as a result of the local development process initiated by ADPM (Association for Development and Patrimony of Mértola). In fact, this association has been working to promote rural renaissance since its beginning, through the promotion of natural and cultural heritage and the participatory creation of this Natural Park was in itself a process with a vision for the valorisation of the biodiversity and multifunctional landscapes traditionally occurring in the territory. This local development process, on ecology but also archaeology has a major role, has attracted several tourists but also newcomers, who moved to Mértola, many of them engaging in society to continue this work of valorisation of heritage or looking for solutions to promote and sustain multifunctional resilient landscapes.

Presently, water scarcity, eroded soil, desertification and rural abandonment are major environmental challenges in the region, aggravated by the rising temperatures which climate scenario RCP 8.5 for 2070-100 projects to be of 39.5^oC degrees of average daily maximum in the month of August (Vizinho et al. 2016). In this scenario, for this period, the average annual rainfall can decrease to 288 mm and the Kopper local climate classification will change from Mediterranean hot summer climate (Csa) to a hot semi-arid steppe (Bsh) (IPMA 2018). High temperatures not only strongly increase human discomfort, create serious health risk for a part of the population and have important negative economic but also have very significant impact on ecosystem, agriculture, forestry and water resources, leading to increased aridity, desertification, productivity loss, tree mortality and fires.

In this context a specific adaptation plan for the municipality of Mértola was done using a participative approach and the SWAP method (Scenario Workshops & Adaptation Pathways), resulting in a common vision accepted by all stakeholders, adaptation pathways for the main crops, zonal plans for the main agriculture and forestland uses, several objectives to improve the regional adaptive capacity and an analysis on challenges and opportunities for the future (Vizinho et al. 2016). Results showed an increase in the multifunctionality, biodiversity, water harvesting and diversification within the agroforestry landscapes planned namely in Montado, stone pine forests, pastures, hunting shrubland and also irrigated areas. The specific adaptation strategies included: higher trees density and shading area; more efficient rotation of animal grazing; increasing and diversifying forage crops, such as trees and shrubs; selective allocation of trees to microclimate; rainwater harvesting for infiltration, cooling and irrigation; increasing soil moisture and quality through terrain works, use of mulching and soil organic matter; diversifying crops; diversifying economic activities; solar energy production and export of local quality produce and local tourism with an added value (Vizinho et al. 2016). Furthermore, this plan includes strategies like attracting more inhabitants to the territory, lobbying for policy support for these adaptation strategies and creating a specific adaptation plan for municipal forest area.

The challenge of climate change and an innovative process of participatory planning led to vision and plan rich in multifunctionality that depends on Rural Renaissance for some of its implementation and viability. Lobbying is being led by the municipality in several specific symposiums and stakeholder meetings, and also by ADPM through the policy activities of two LIFE projects, both stakeholders working for the purpose of creating a more favourable regulatory context for local farming and the value of farming in this vulnerable natural park. A

municipal forest area plan is under development to implement an innovative concept of syntropic agroforestry, which combines medium and long terms trees with horticulture, and on-site production of organic material for local mulching and fertilizing. This initiative went beyond the technical implementation and through a recent association (Associação Terra Sintrópica) fostered knowledge exchange among school children and local farmers. It attracted newcomers, namely foreigners and urban dwellers who were interested in innovative, environmentally friendly concepts of agroforestry, permaculture and agroecology. Syntropic agriculture transfers natural processes concepts into farming interventions, such as form, function, and dynamics. Regenerative farming that creates highly productive agricultural areas, which tend to be independent of inputs and irrigation, resulting in the provision of ecosystem services, with special emphasis on soil formation, regulation of microclimate and favour water cycles. According to Association Terra Sintrópica, this activity which was supported by the municipality, has brought several newcomers and researchers to Mértola. Farmers continue to perform their autonomous adaptation investments now better informed and supported by these plans and projects that foster innovation.

The diversification of crops and the increase of multifunctionality promotes a loss in the economy of scale, which requires the recognition of an added value by consumers or markets. In order to promote a sustainable consumption chain, Mértola municipality is part of the international Local Food Network and together with other initiatives in Nepal, Kosovo and Switzerland has implemented a collaboration between local farmers among the 4 countries that work in regenerative agriculture. The Local Food Network Mértola is a partner of the research project DiverCrop in Portugal, which created a structured and regular dialogue platform on agricultural systems in the municipalities of Alcoutim, Mértola and Serpa. This project seeks to identify the main drivers of change from local to the Mediterranean basin, correlating changes in production systems with species diversity and availability of food for human consumption. Sustaining these multifunctional landscapes requires added value or new product or ways of marketing. Farmers and grassroots initiatives generate the ideas that can work at the micro level and produce prototypes that eventually can replicate to other farmers and places within the region. Mértola is presently a territory fertile in ideas, innovation and experimentation struggling to overcome the challenges of reduced population in a low density, semi-arid landscape pressured by geographical isolation and climate change.

5.2 Three Montado farms in the project LIFE Montado & Climate

As part of the EU LIFE project entitled *Montado & Climate: a need to adapt*, seven Portuguese Montado farms had their management adjusted to a climate adaptation plan (along with five more farms in Spain). The main goal was to maintain or improve these multifunctional landscapes in the context of climate change. Both the Noudar Nature Park/Herdade da Coitadinha farm and Herdade da Ribeira Abaixo farm joined a participatory planning process based on SWAP method (similar to Mértola case study). Among the seven farms studied in this project we highlight three farms as representative cases studies of different typologies in order to present the innovations and discuss relevant challenges and opportunities for upscaling and replication.

Herdade da Ribeira Abaixo

Herdade da Ribeira Abaixo is a 221 hectares Montado farm, public owned and managed by the Faculty of Sciences of the University of Lisbon. It is a farm dedicated to the conservation of Cork oak Montado, monitoring and preservation of biodiversity, education and research. The farm is located in the municipality and hilltops of Grândola, where cork oak Montado is dominant landscape but suffering from significant degradation and mortality. In the area, soils are extremely poor and tree death rate is very high despite the fact that average annual precipitation (828 mm) is higher than other neighboring regions, due to its relatively high altitude. The present state of vulnerability of the ecosystem is the result of several factors namely: the destruction of top-soil and superficial tree roots due to biomass management for fire prevention with disc plows; disease of *P. cinnamomic*; increase in temperatures and droughts. Under climate change conditions the vulnerability will

increase due to a rise on maximum temperatures that will bring the dominant tree, the cork oak, out of its survival thresholds. Presently the farm dedicates 60% of its area to conservation of biodiversity and other activities mainly include cork harvesting, rental of grazing rights, education and research. The biodiversity of the landscape is very high, but its sustainability is permanently threatened by fire as fuel management is extremely expensive. The preservation and maintenance of the forest and economic viability are therefore a big challenge as the main significant income is only cork harvesting. After the participatory adaptation plan was developed, the vision included continuing the past activities but also, among others, to increasing the human presence for a proximity management and a valorization of the diversity of products that can be found the landscape. In addition, the plan aimed to increase the diversity of crops in the landscape but also to increase the survival of afforestation and adult trees. Some of these measures that were implemented included: seeding biodiverse permanent pastures rich in legumes; planting orchard fruit trees and aromatics species in local microclimates; harvesting of rainwater and creating rainwater based deficit irrigation system with solar energy; planting trees with mulching or under the shade; planting complementary plants to fight pests; planting forage bushes, shrubs and trees; planting trees of other crops such as strawberry tree, stone pine, carob or almond; experimenting the syntropic agroforestry model with native plants; increasing the tree density in Montado.

These measures all constitute clear and significant investments for the increase of multifunctionality of the landscape and its conceptualization and design was supported by a multi stakeholder group of experts and also detailed planning based on robust methods (such as Adaptation Pathways, quantitative assessment efficacy of measures) (Vizinho et al. 2017a). The main challenges of this farm are related to the fact that as a public farm the bureaucratic and administrative processes are more complex than in private farms, which implies more time and effort to obtain the same result. One example is the creation of farm employment and farm sales which faces many administrative obstacles and resistance within the institution. The creation and maintenance of a multifunctional landscape is based on the commercialization of a diverse group of products which require both an added value and a governance strategy plan based on a simpler administrative structure that facilitates a needed flexibility in producing and commercialization stages. Due to these challenges the present services of the farm are still limited to disseminating technical and scientific results obtained through education, research and tourism. The multifunctional landscape is therefore put in place, but its sustenance is still threatened by the socio-economic aspects. The participatory planning was a part of the needed socio-economic innovation and attempted to engage and mobilize the decision makers of the Faculty to an agile implementation (Vizinho et al. 2017a). As the process continues time will tell if motivation from decision makers, supported by a robust plan and concrete investments on the ground are enough to sustain a multifunctional farm in the context of public administration bureaucratic constraints.

Noudar Nature Park / Herdade da Coitadinha

The Noudar Nature Park, also named Herdade da Coitadinha Farm, is a 957 ha property of EDIA S.A. (Empresa de Desenvolvimento e Infra-estruturas do Alqueva) a public owned company. The farm was bought in 1997 as a compensation mechanism for loss of natural habitats caused by the new Alqueva dam and EFMA (Empreendimento de Fins Múltiplos do Alqueva) irrigation infrastructure complex. This park/farm is located in the eastern Alentejo region, area landscape dominated by holm oak Montado/agro-silvo-pastoral landscape. Its main goal is the conservation of biodiversity associated with Montado landscape and promoting environmental education and eco-tourism. The area where it is located has an average precipitation of 590 mm which, in the climate scenario RCP 8.5, is projected to decrease 107 mm between years 2070-2100. Climate impact can be quite high since the most common tree, the holm oak, is expected to be outside its climate tolerance zone. The region's future vulnerability to climate change and the present vulnerability observed in the mortality of Holm oaks, erosion or fire motivates this farm to improve and increase the resilience of its multifunctional landscapes highly valued by tourists due to its beauty, cultural heritage, certified dark skies and biodiversity. This farm/nature park

is an organic farming producer of cattle which feeds on farms, pastures, black pig which feeds on pastures and holm oak acorns and other fewer produce such as cork, wood, aromatic plants, honey, mushrooms, fruits and vegetables (for its own restaurant). The farm also promotes tourism activities, environmental education and nature conservation projects. The participatory adaptation plan that took place within the LIFE project included stakeholders from national, regional, municipal and farm levels and all of them recognized, validated and integrated the need for climate adaptation in the future planning and short-term actions investments of the farm. The structuring of the interventions for climate adaptation attempted to merge the needs of the farm in terms of water, protection, production, conservation or education in a detailed or micro level planning that is feasible and adequate to the context of human resources, terrain, microclimates, management and marketing. As a result, the farm has increased the diversification of crops, has increased the production of aromatic plants and fruits and has implemented several measures to improve the success of afforestation and survival of adult trees.

The objective of making this farm an example for the region on how to successfully manage the Montado landscape in the context of climate change is enhanced by the fact that this public company has sufficient financial resources to invest and support demonstration and dissemination activities. On the other hand, the commercialization of their products must follow a more complex bureaucratic and administrative process that is an obstacle to some of the potential added value of their products. One example is the fact that the farm sells its organic beef production as conventional non-organic beef due to the difficulty in finding a distributor interested in buying the beef production due to the complex certification procedure. Complementarily, the existence of education, tourism and restaurant at the farm facilitates the added value for organic produce (Vizinho et al. 2017b). These sort of mechanisms and tools for the farmers are, nowadays, an innovative and effective approach to give value to a diverse multifunctional landscape. Public funds dedicated to innovation, environment and adaptation like LIFE are also a specific tool that Noudar farm, together with the other similar case studies here presented, have access to in order to prototype and experiment some of the existing ideas or innovative techniques for climate adaptation. With the public support for investment, it is easier for these farms to sustain multifunctional landscapes but also create and promote innovative solutions, markets and trends that can benefit rural renaissance and multifunctional landscapes in their contexts.

Herdade do Freixo do Meio

Herdade do Freixo do Meio is a 550 ha Montado farm, considered one of the most innovative ecological farms in the region that brings together into the Montado ecosystem, biodiversity conservation, agroecology, permaculture, syntropic agro-forestry, intensive and extensive diversified organic production and a plethora of socio-ecological innovations, from community supported agriculture, to the management done by a cooperative run by the land owner, members, workers, consumers, hunters and beneficiaries or to the environmental education projects (fig. 5). In contrary to the usual amount jobs created in a Montado farm, where in average there is one job per 100 hectares in farms larger than 100 hectares (INE 2018), the Herdade do Freixo do Meio employs more than 35 people due to the diversification of products, the transformation and direct commercialization to the public. The farm presently sells 157 organic products which include: cow, black pig, lamb, chicken, turkey, eggs, milk, horticulture, fruit, wine, bread, mushrooms, acorn products (coffee, flower, honey), aromatic plants, olive oil, tomato pulp, cereal cookies (Freixo do Meio 2020). In order for this production to happen, several decades of experiments took place, supported by a growing number of consumers and interest in organic farming but also with co-financing from CAP funding that was used with the vision of agroecology and multifunctionality, to continuously invest in the farm ecosystem and in the farm infrastructures for producing, transforming, commercialization and education. The vision for a regenerative agriculture, together with a proactive and pragmatical entrepreneurship approach, led the farm to experiment different ways of reaching out to consumers directly, in order to market and receive the added value of their produce (fig. 5). This involved opening a shop in Lisbon, distributing directly to other organic shops, creating box schemes and selling directly to

the consumer, creating community supported agriculture schemes such as contracts with consumers, open days and events at the farm and participating in seminars and public events. The adaptation measures implemented in the farm include measures such as: rainwater harvesting in lakes; keyline design; syntropic agroforestry or dynamic succession agro-forestry; holistic animal grazing management; increase of tree density; diversification of forage crops with trees and shrubs; wind breaks; living fences; planting on microclimates; permaculture design; increasing soil moisture and soil life with mulch, swales, organic matter increase; integrated pest management. Furthermore, on the adaptive capacity, the farm is clearly dedicated to improving markets, governance, financing and knowledge (LIFE Montado 2017).

Although this is a farm that was already considered a case study for multifunctionality and balanced ecological conservation with economic production, the process of participating in the LIFE Montado & Climate project gave it another opportunity to reflect in its future vulnerability in context of climate change and engage in another cycle of planning and investment to adapt, increase landscape and farm resilience, structure interventions according to efficacy and local needs, prototyping the new ideas for a context in change. Rural renaissance proposes a renewal of ideas and solutions for a rural context that is changing. As climate change creates pressure and potential impacts on ecosystems but also in society, innovation and flexibility are important tools, demonstrated in practice by this farm case study, which is evolving constantly, illustrating the best of farmers' capacities for autonomous adaptation but also to take advantage of structured adaptation planning efforts.

Figure 5. Promotional images from farms' website (Credit: Freixo do Meio 2020)

5.3 Aldeia das Amoreiras

Aldeia das Amoreiras is a small village of around 200 inhabitants (in year 2011), situated in the Odemira municipality, in the southwest of the Alentejo region. Similar to the pattern of rural exodus that occurred in Mértola municipality, this village reached is maximum population in the 1950s with around 600 inhabitants. Despite its relative short distance to the coast (38km) and the proximity to the train line with direct connection to Lisbon, the country capital, this village suffers, together with the district of São Martinho to which belongs, from geographical isolation, low population, low population density (7.0 inhabitants Km^{-2}) and high rate of unemployment (15.4%). The territory is characterized by the presence of three different landscapes: one defined by small hills and composed by Montado dominated by cork oak trees; a second one flatter and more dominated by pastures, winter cereal fields and olive yards; and a third with high relief, belonging to the beginning of the Mountains of Espinhaço de Cão and Monchique where eucalyptus monoculture plantations growing and in other areas some conserved cork oak forests can still be found. The degradation of the cork oak Montados is very significant together land erosion and land abandonment. Despite the fact that these landscapes are traditionally managed in multifunctionality, the socio-economic dimensions have been making difficult its maintenance.

From to 2005-2015 a grassroots initiative called Convergence Centre was started in this village to create a bridge between the urban and rural life, to convergence and attract youth and proactive people for the sustainable local development of this village, to put into practice Permaculture at the scale of a village and to create a sustainable village. This local development project, also branded as a transition town initiative, was observed and researched by several authors and projects, that further documented the innovations, challenges and opportunities from such grassroots initiatives (Campos et al. 2015; CC 2015; Mourato and Bussler 2019). One of the most relevant innovations from this grassroots initiative took place in the year 2010, when the Convergence Centre of Aldeia das Amoreiras started a project called sustainable village by bringing the population into small celebration meetings in which they were asked about their dream village and which were their dreams for the village. They made a video documentary of the dreams of the village and engaged the population to start creating groups around each dream to make them come true. A Permaculture design was created to support and provide a more robust and systemic proposal to the village and the territory around it. The design presents a zonal plan for a multifunctional landscape, intended to perform the different functions that are needed for the sustainability and quality of life of the village and its population (Vizinho et al 2014). As Henfrey and Penha-Lopes (2015) illustrate, Permaculture design uses a set of techniques and solutions that can be considered climate adaptation strategies and measures, and permaculture design can be considered an adaptation measure in itself as it proposes a systemic design aimed at increasing the resilience of the territory, embracing both the ecological and socio-economic dimensions, thus fostering adaptive capacity.

5.4 Tamera

Tamera is the most famous ecovillage in Portugal and was founded in 1995 by foreign newcomers. The property has 155 hectares (in year 2015) and around 200 permanent inhabitants. As an ecovillage, Tamera takes on some of the key basic characteristics that characterize an intentional community such as a design and implementation through locally owned participatory processes focused on holistic sustainability (social, culture, ecology and economy), with the objective of regenerating social and natural environments (Ergas and Clement 2016). This initiative addresses several social needs such as peace, sense of belonging and security for which it researches and experiments social innovations based on community living; it seeks sustainable technological development through the implementation of agricultural techniques, energy generation and use, resource reuse and construction; it uses planned architecture and landscape design (usually following the principles of permaculture); promotes local economy by acting as a consumer hub for ecological products produced in the region; it is a place for innovation, learning, generating and sharing knowledge and also a centre of activism for peace and ecology (Esteves 2019).

Despite having several permaculture and ecological solutions implemented, that can be considered climate adaptation measures to increase the resilience of the community, its most famous investment for regeneration and local resilience was the implementation of a Water Retention Landscape. The construction of the water retention landscape started in year 2005 and was mainly defined by the construction of 19 new lakes and several complementary measures such as the creation of terraces and contour swales where orchards and agroforests were installed with mulching in an effort to retain as much water as possible while controlling erosion and regenerating soil. The construction of this water retention landscape was subject to a cost-benefit analysis in the context of climate adaptation, for the period 2015-2050 (Alves et al. 2015; Santos et al. 2017) and several landscape functions were identified as being improved namely: local microclimate, local biodiversity, carbon sink, quality of life, water provision, food sovereignty and support for human activities. Furthermore, these lakes and additional measures increased the real estate value and increased the potential for tourism and education activities.

The result of this cost-benefit analysis indicated that the investment is worthwhile (Net Present Value positive) if the discount rate is 1% or less (meaning that the future is given similar importance to the present). When the

discount rate is 3% or higher (more conventional discount rate, reflecting that more value is given to the present than to the future) the investments are not worthwhile. These investments could be considered more worthwhile if, with replication and increased learning in the implementation, the high costs of construction could be reduced. Furthermore, if the benefits are valued with a higher value due to water scarcity and climate change (ecosystem services, water provision, etc.) or the period of analysis is extended to year 2100, these investments are also considered more worthwhile (Alves et al. 2015). Since the water retention landscape is a measure that implements landscape multifunctionality, supports human activities and attracts newcomers, thus constituting also an investment for rural renaissance, this cost-benefit analysis and this experience constitutes a valuable case study for its assessment and discussion.

Tamera inspired several other communities that were initiated after in the region such as *108* (started in 2010), *Vale Bacias* (started in 2013) or *Permalab* (2016). All these communities share an interest in Permaculture design and are investing in multifunctional landscapes, in several measures of the water retention landscapes strategy and also in rural renaissance. This makes Tamera, water retention landscapes and Permaculture design, a particularly interesting case as it reveals a potential for scaling-up. This scalability is important, not only in replicating the community or the water retention landscape approach, but especially in replicating, transferring and disseminating the knowledge produced in Tamera to other communities and, consequently, to other social actors enhancing the capacity to empower local communities to improve and regenerate local sustainability and foster resilience. Tamera's supporting infrastructures, collaborative and sharing networks, the involvement of its members, and collaboration and involvement with actors outside the community are all crucial factors for the development of innovation practices and, most importantly, for their dissemination.

The innovation produced in Tamera and in similar case studies, has the potential to be developed, tested and improved in other contexts as well. In fact, Oliveira and Penha-Lopes (2020) show that Tamera, together with Herdade do Freixo do Meio, Aldeias das Amoreiras and other few highlighted case studies in Portugal are all identified as reference projects implementing socio-economic innovations with the common base of Permaculture, that while implementing multifunctional landscapes and rural renaissance, experiment and are considered sources new solutions on the social, economic, ecological or educational dimensions.

As mentioned above, the importance of these community led initiatives relies on their natural and social environment, capable of improving the emergence of grassroots innovation and therefore, contribute to sustainable transition and social and environmental change.

Conclusion

The Portuguese climate adaptation strategy for the sector of agriculture and forestry declares the intention to maintain a multifunctional landscape but lack specific measures to prevent rural abandonment, promote rural renaissance and make viable with population, skill, innovation and markets, the sustenance of the multifunctional diversified landscapes that are more resilient to climate change. As climate change impacts are occurring sooner than expected, there is a need to generate faster and more efficient solutions in order to reverse the impacts of drought, tree mortality, soil erosion, fires, land desertification and rural abandonment. National, regional and local policies should promote rainwater harvesting measures, reforestation and increase tree density in the Montado areas, together with soil conservation practices. Furthermore, clear measures should be implemented to create markets, logistics, added value and general support for diversified agroecological products. Sustaining and increasing the population in rural areas (Rural Renaissance) is also considered essential for these changes and adaptation to happen. It is therefore recommended to foster greater alignment of new actor-networks with sustainability goals, particularly in view of the new sustainable development goals set for Portugal for the period up to 2030. In this context, the literature and case studies recommend that both irrigation and rainfed areas should be transformed into multifunctional diverse landscapes, reducing therefore the vulnerability to climate impacts. Overall, climate change adaptation and sustainable development objectives demand us to re-imagine

the role of irrigation in support of local social and ecological systems rather than promoting water intensive crops or varieties in an increasingly arid region, with emerging conflicts for water resources

There is often little recognition and acknowledgement that some ecosystems may transition to entirely different states providing different goods and services as a result of climate change, and that adaptation will increasingly be needed to facilitate transitions of governance arrangements and transformations of societal processes, norms and values. Many grassroots innovation movements have difficulty to achieve such widespread transformative change and also struggle with the challenge of being locally specific whilst also seeking wide-scale diffusion. Grassroots innovation often leads to a single solution that is limited to apply in other contexts, with other groups of stakeholders, or at other times. More evidence on replication, international comparisons and research on scaling up are still required. In Alentejo CLIs are still not sufficiently networked to create markets, technology and properly disseminate and upscale with engagement of the general public, farmers, institutions, investors or consumers in the face of climate change. Although some of the case studies are successful and resilient and have had some spin offs, the rate for scaling up needs to keep up with the rate at which climate change is taking place. Thus, more effort needs to be put on rural renaissance projects and their follow up, namely by supporting facilitators of innovation, so that towns and villages such as Mértola can continue to bring further their intentions of local and regional markets that support multifunctional landscapes. Low population density, low levels of employment in rural areas and specialization to compete in global markets are the main drivers for rural abandonment and investment in vulnerable monocultural and monofunctional landscapes. Diversity and Rural Renaissance require agricultural and rural development policies that foster employment, local and regional markets, and require regulations, networks, labelling, logistics, distribution and governance that support regional economy. Multifunctional landscapes require citizens that aware and motivated to support sustainable farming by consuming but also by consumer choices but also by valuing the landscape ecological and cultural services through innovation and integration in other sectors of the economy. For this, the engagement of society is essential and participatory visioning and planning of landscapes at different level is one of the proposals that case studies have demonstrated with success that are feasible and easily replicated, if further promotion and support by European and national funding and institutions is present.

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References

1. Alam, G.M., Khorshed, A., Mushtaq, S. (2017). Climate change perceptions and local adaptation strategies of hazard-prone rural households in Bangladesh. Climate Risk Management. 17. 52–63.
2. Alves, F., Penha-Lopes, G., Vizinho, A., Campos, I., Ulbig, C., Branquinho, C., Godinho, D., Santos, A. (2015). An economic analysis of rural climate change adaptation to droughts: The case of the Tamera Water Retention Landscape, Portugal. https://doi.org/10.13140/RG.2.1.1656.1044
3. Axinn, G.H. (1974). Rural Renaissance: A Perspective and a Process. Paper presented at the International Conference of the East -West Communication Institute on Integrated Communication for Rural Development, 20 pp. December 2-6th, Honolulu.
4. Berrang-Ford, L., Ford, J.D., Paterson, J. (2011). Are we adapting to climate change? Global Environmental Change 21 (1) pp 25–33.

5. Brink, E., Wamsler, C (2018). Collaborative Governance for Climate Change Adaptation: Mapping citizen–municipality interactions. Environmental Policy and Governance 28, pp 82–97. DOI: 10.1002/eet.1795.
6. Brown, G., Kraftl, P., Pickerill, J., Upton, C. (2012). Holding the future together: towards a theorisation of the spaces and times of transition. Environment and Planning A 44 (7) pp 1607–1623.
7. Brulle, R., Carmichael, J., Jenkins, J. (2012). Shifting public opinion on climate change: an empirical assessment of factors influencing concern over climate change in the U.S., 2002–2010. Clim. Change 114, 169–188.
8. Carvalho-Ribeiro, S.M.; Lovett, A.; O'Riordan, T. (2010). Multifunctional forest management in Northern Portugal: Moving from scenarios to governance for sustainable development. Land Use Policy, 27. 4, pp 1111-1122. Available on https://doi.org/10.1016/j.landusepol.2010.02.008.
9. Campos, I., Vizinho, A., Truninger, M., Lopes, G.P. (2015). Converging for deterring land abandonment: A systematization of experiences of a rural grassroots innovation. Community Development Journal, bsv051. https://doi.org/10.1093/cdj/bsv051
10. CC (2015) Documents of Convergence Centre and Research applied to Aldeia das Amoreiras village. In: Centro de Convergência webpage. https://centrodeconvergencia.wordpress.com/documentos/. Accessed 20 Dec 2019.
11. Clemente, S. C. (2016). Políticas de Desenvolvimento em Áreas Rurais Classificadas: O caso português. Phd thesis in Geography, CEG, University of Lisbon.
12. Coles, A., Scott, C. (2009) Vulnerability and adaptation to climate change and variability in semi-arid rural southeastern Arizona, USA. Natural Resources Forum 33, 297–309.
13. Diouf, A., Gaye, A.T. (2014). A Methodological Framework for Building an Index for Vulnerability assessment in Rainfed Agriculture. In: Leal, Filho W. (ed.). Handbook of Climate Change Adaptation. Springer, Berlin, Heidelberg, pp 1–11.
14. Esteves, A.M. (2019). Peace education for the Anthropocene? The contribution of regenerative ecology and the ecovillages movement. Journal of Peace Education, 17, 1–22. https://doi.org/10.1080/17400201.2019.1657817
15. European Commission. Directorate-General for Agriculture and Rural Development (2016). Cork 2.0 declaration: "A better life in rural areas." Publications Office, LU
16. European Union (2019). Report on the eighth meeting of the ENRD Thematic Group (TG) on 'Smart Villages'. Available at: https://enrd.ec.europa.eu/news-events/events/8th-thematic-group-meeting-smart-villages_en
17. Ergas, C., Clement, M.T. (2016). Ecovillages, Restitution, and the Political-Economic Opportunity Structure: An Urban Case Study in Mitigating the Metabolic Rift. Critical Sociology, 42(7–8), pp 1195–1211.
18. Feola, G., Nunes, R. (2014). Success and failure of grassroots innovations for addressing climate change: The case of the Transition Movement. Global Environmental Change. 24. Pp 232–250.
19. Fernandes PM, Monteiro-Henriques T, Guiomar N, et al (2016) Bottom-Up Variables Govern Large-Fire Size in Portugal. Ecosystems 19:1362–1375. https://doi.org/10.1007/s10021-016-0010-2
20. Fragoso, R., Marques, C., Lucas, M.R., Martins, M.B., Jorge, R. (2011). The economic effects of common agricultural policy on Mediterranean Montado/dehesa ecosystem. Journal Policy Model 33, pp 311–327. https://doi.org/10.1016/j.jpolmod.2010.12.007.
21. Freixo do Meio. (2020). Herdade do Freixo do Meio. https://www.herdadedofreixodomeio.pt/
22. Gurr, G.M., Wratten, S.D., Luna, J.M. (2003) Multi-function agricultural biodiversity: pest management and other benefits. Basic Appl Ecol 4:107–116. Available on https://doi.org/10.1078/1439-1791-00122.
23. Haden, V.R., Niles, M.T., Lubell, M., Perlman, J., Jackson, L. (2012). Global and local concerns: what attitudes motivate farmers to mitigate and adapt to climate change. PLoS One 7, 52882.

24. Hallegatte, S. (2009). Strategies to adapt to an uncertain climate change. Global Environmental Change, 19, pp 240–247.

25. Hansen, J., Sato, M., Ruedy, R., Lo, K., Lea, D.W., Medina-Elizade, M. (2006). Global Temperature Change. Proceedings of the National Academy of Sciences 103, pp 29.

26. Henfrey, T., Penha-Lopes, G. (eds.) (2015). Permaculture and Climate Change Adaptation Inspiring Ecological, Social, Economic and Cultural Responses for Resilience and Transformation. Permanent Pubns.

27. Hoffmann, A.A., Sgrò, C.M. (2011) Climate change and evolutionary adaptation. Nature 470:479–485. https://doi.org/10.1038/nature09670.

28. Huang, J., Tichit, M., Poulot, M., Darly, S., Li, S., Petit, C., Aubry, C. (2015). Comparative review of multifunctionality and ecosystem services in sustainable agriculture. Journal of Environmental Management, 149, pp 138-147.

29. ICNF (2014). Cartografia de Apoio ao PDR 2020—ICNF. http://www2.icnf.pt/portal/pn/biodiversidade/ei/unccd-PT/pancd/o-pancd-2014-2020/cartografia-apoio-pdr2020#content

30. INE (2018) Portal do INE - Instituto Nacional de Estatística. In: Caraterização sócio – económica dos municípios. https://ine.pt/xportal/xmain?xpid=INE&xpgid=ine_doc_municipios_cse. Accessed 16 Dec 2019

31. IPMA (2018) Portal do Clima. In: Instituto Português do Mar e da Atmosfera, Portal do Clima: Alterações Climáticas em Portugal. http://www.portaldoclima.pt/pt/. Accessed 26 Jul 2016

32. IPPC (2014) Glossary. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 1434 pp

33. Jones, H.P., Hole, D.G., Zavaleta, E.S. (2012). Harnessing nature to help people adapt to climate change. Nature Climate Change 2 (7) pp 504–509.

34. Kirwan, J., Ilbery, B., Maye, D., Carey, J. (2013). Grassroots social innovations and food localisation: an investigation of the Local Food programme in England. Glob. Environ. Chang. 23, pp 830–837.

35. LIFE Montado (2017) LIFE Montado & Climate: a need to adapt (website). http://lifemontadoadapt.com/. Accessed 22 Nov 2017.

36. Loorbach, D., Frantzeskaki N., Avelino, F. (2017). Sustainability Transitions Research: Transforming Science and Practice for Societal Change. Annual Review of Environment and Resource. 42:4.1–4.28.

37. LUSA (2018). Mais de 700 famílias foram desaconselhadas a mudar para o Interior. In: Notícias ao Minuto. https://www.noticiasaominuto.com/pais/1141069/mais-de-700-familias-foram-desaconselhadas-a-mudar-para-o-interior. Accessed 25 Nov 2020

38. Makuvaro, V., Walker, S., Munodawafa, A., Masere, T.P., Murewi, C., Chagonda, I. (2014). An overview of current agronomic practices of smallholder farmers in semi-arid Central and Western Zimbabwe. African Journal of Agricultural Research: 9, 35, pp 2710-2720. Available on http://hdl.handle.net/11408/1078.

39. MAMAOT (2013) Estratégia de adaptação agricultura e floresta às alterações climáticas - Portugal Continental (Fase 1). APA - Agência Portuguesa do Ambiente, Lisboa, Portugal

40. Mateus P, Fernandes PM (2014) Forest Fires in Portugal: Dynamics, Causes and Policies. In: Reboredo F (ed) Forest Context and Policies in Portugal: Present and Future Challenges. Springer International Publishing, Cham, pp 97–115

41. Middlemiss, L., Parrish, B.D. (2010). Building capacity for low-carbon communities: the role of grassroots initiatives. Energy Policy 38, 7559–7566.

42. Mourato, J.M., Bussler, A. (2019). Community-based initiatives and the politicization gap in socio-ecological transitions: Lessons from Portugal. Environ Innov Soc Transit 33:268–281.

43. Movimento pelo Interior (Álvaro dos Santos Amaro, António A. Fontainhas Fernandes, Fernando Campos Nunes, Jorge Paulo S. Almeida Coelho, José Albino da Silva Peneda, Manuel Rui Azinhais Nabeiro, Miguel José Ribeiro Cadilhe, Nuno André O. Mangas Pereira, Pedro Manuel Gonçalves Lourtie, Rui Jorge C. Gonçalves Santos) (2018). Relatório Final do Movimento pelo Interior 2018 e Informação Complementar. Edição Movimento pelo Interior. 60 pp. Available online on: www.animar-dl.pt/documentacao/pdf/111-doutrinarios-politicos-e-estrategicos/2935-relatorio-final-do-movimento-pelo-interior-2018.

44. Ng, K., Campos, I., Penha-Lopes, G. (eds.) (2016). BASE Adaptation inspiration Book: 23. European Cases of Climate Change Adaptation to Inspire European Decision-makers, Practitioners and Citizens. Lisbon: Faculty of Sciences, University of Lisbon. ISBN: 978-989-99697-6-6.

45. Nicolosia, E., Medina, R., Feola, G. (2018). Grassroots innovations for sustainability in the United States: A spatial analysis. Applied Geography, 91, pp 55-69.

46. Nogueira, C. (2018). Contornos e Tendências das Comunidades Sustentáveis Intencionais em Portugal – uma análise descritiva e exploratória. Chão Urbano, 6, pp 11-39.

47. Odegard, I.Y.R., Van der Voet, E. (2014). The future of food - scenarios and the effect on natural resource use in agriculture in 2050. Ecol. Econ. 97, 51–59.

48. Oliveira, H., Penha-Lopes, G. (2020). Permaculture in Portugal: Social-Ecological Inventory of a Re-Ruralizing Grassroots Movement. European Countryside, 12(1), pp 30–52.

49. Plas F., Allan, E., Fischer M., Alt, F., Arndt, H. Binkenstein, J., Blaser, S. Blüthgen, N., Böhm, S., Hölzel, N., Klaus, V. H., Kleinebecker, T., Morris, K., Qelmann, Y., Prati, D., Renner, S.C., Rillig, M.C., Schaefer, H. M., Schloter, M., Schmitt, B., Schöning, I., Schrumpf, M., Solly, E. F., Sorkau, E., Steckel, J., Steffan-Dewenter, I., Stempfhuber, B., Tschapka, M., Weiner, C. N., Weisser, W.W., Werner, M., Westphal, C., Wilcke, W., Manning, P., (2019) Towards the development of general rules describing landscape heterogeneity–multifunctionality relationships. J Appl Ecol 56:168–179. https://doi.org/10.1111/1365-2664.13260.

50. Penha-Lopes, G., Henfrey, T. (2019) Reshaping the Future: how communities are catalysing social, economic and ecological transformation in Europe. The First Status Report on Community-led Action on Sustainability and Climate Change. Brussels: ECOLISE. ISBN 978-2-9602393-0-0.

51. Pinto-Correia T., Guiomar N., Ferraz-de-Oliveira M.I., Sales-Baptista E., Rabaça J., Godinho C., Ribeiro N., Sá Sousa P., Santos P., Santos-Silva C., Simões M.P., Belo A., Catarino L., P. Costa P., Fonseca E., Godinho S., Azeda C., Almeida M., Gomes L., Lopes de Castro J., Louro R., Silvestre M., Vaz M. (2018). Progress in identifying High Nature Value Montados: relating biodiversity to grazing and stock management. Rangeland Ecology and Management, 71: 612-625, doi.org/10.1016/j.rama.2018.01.004.

52. Pinto-Correia, T., Ribeiro, N., Sá-Sousa, P. (2011) Introducing the Montado, the cork and holm oak agroforestry system of Southern Portugal. Agrofor. Syst. 82, pp 99.

53. Ribeiro, S. (2009). The role of multifunctional forests in sustainable landscapes: a case study from Portugal. University of East Anglia. PhD dissertation, University of East Anglia. ISNI 0000000426749589.

54. Plantar Portugal (2020) Reflorestação Nacional. https://www.plantarportugal.org/. Accessed 25 Nov 2020

55. ICNF (2019) PROF Alentejo - Plano Regional de Ordenamento Florestal da região Alentejo. Diário da República n.º 29/2019, Série I de 2019-02-11, Portaria nº 54/2019.

56. Thema J, Nanning S, Buhl J, et al (2015) PATHWAYS project: exploring transition pathways to sustainable, low carbon societies; deliverable D2. 1: Analysis of green niche-innovations and their momentum in the two pathways; country report 4: Green niche-innovations in the German heat system

57. Santos A, P. Godinho D, Vizinho A, et al (2017) Artificial lakes as a climate change adaptation strategy in drylands: evaluating the trade-off on non-target ecosystem services. Mitigation and Adaptation Strategies for Global Change. https://doi.org/10.1007/s11027-017-9764-x

58. Seyfang, G., Longhurst, N. (2016). What influences the diffusion of grassroots innovations for sustainability? Investigating community currency niches, Technology Analysis & Strategic Management, 28(1), pp 1-23.
59. Seyfang, G., Smith, A. (2007). Grassroots innovations for sustainable development: towards a new research and policy agenda. Environ. Polit. 16, pp 584–603.
60. Silva, L. (2008) Contributo para o estudo da pós-ruralidade em Portugal. Centro de Estudos de Etnologia Portuguesa, Arquivos da Memória, 4, pp 6-25.
61. Verchot LV, Van Noordwijk M, Kandji S, et al (2007) Climate change: linking adaptation and mitigation through agroforestry. Mitigation and adaptation strategies for global change 12:901–918
62. Vizinho A., Bastidas M., Santos P., et al (2016) Plano de Adaptação de Mértola às Alterações Climáticas - Sector da Agricultura e Florestas, Faculdade de Ciências, Faculdade de Lisboa, FCUL, Mértola.
63. Vizinho A, Fonseca AL, Oliveira H, et al (2017a) Plano de Adaptação da Herdade da Ribeira Abaixo às Alterações Climáticas. FCUL, Grândola, Portugal
64. Vizinho, A., Fonseca, AL, Oliveira, H., et al (2017b) Plano de Adaptação da Herdade da Coitadinha às Alterações Climáticas, Faculdade de Ciências, Faculdade de Lisboa, FCUL, Barrancos, Portugal.
65. Vizinho, A., Umann, M., Gonçalves, J., Santos, F., Crespo, J., Convergência, C. (2014) Amoreiras—Permacultura para uma Aldeia. GAIA, Grupo de Acção e Intervenção Ambiental. https://doi.org/10.13140/RG.2.1.3303.5922.
66. Wohner C, Peterseil J, Poursanidis D, et al (2019) DEIMS-SDR – A web portal to document research sites and their associated data. Ecological Informatics 51:15–24. https://doi.org/10.1016/j.ecoinf.2019.01.005
67. WRI (2011). World Resources 2010-2011: Decision Making in a Changing Climate— Adaptation Challenges and Choices, World Resources Institute (WRI) in Collaboration with the United Nations Development Programme and United Nations Environment Programme and World Bank. WRI, Washington, DC. http:// pdf.wri.org/world_resources_report_2010-2011.pdf.