MAP Position Paper

SHERPA

Rural Science-Society-Policy Interfaces

CLIMATE CHANGE AND ENVIRONMENTAL SUSTAINABILITY

SHERPA has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 862448. The content of the document does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).

Authors

Consulai | Pedro Santos and Pompeu Pais Dias

Contributors

MAP Members and Bruno Caldeira

Citation: Santos, P., Pais Dias, P. (2021) MAP Position Paper (Portugal, Alqueva) - Climate change and environmental sustainability. DOI: 10.5281/zenodo.5920899

Paper finalised in October 2021

Find out more about the Alqueva Multi-Actor Platform in Portugal!
https://rural-interfaces.eu/maps/portugal-alqueva/

Topic and headline messages

The theme of Climate Change and Environmental Sustainability is central in one of the regions most affected by climate change, facing increases in the frequency and intensity of droughts, heat waves, erosion and extreme precipitation events.

The region covered by the Alqueva project in Portugal has very relevant challenges related to water (its availability and optimal use), energy (and the challenge of energy transition), soil (and the need to promote an increase in organic matter content and enhance the role of agricultural carbon sinks), the territory (and the need to establish compatibility rules for different types of agriculture and environmental objectives), sustainability (and the need to enhance the value of "Montado" and the regional genetic heritage, as well as issues related to the landscape) and, in addition, to focus on communication (and how to transmit a more complex message to new "audiences").

Problem being addressed and key questions

In a region that has experienced an enormous change in its productive structure, with the installation of recent agricultural projects, with scale and profitability, resulting from public investment in irrigation, and which is subject to increasing pressure from desertification, it is essential to think, and act, on the possible impacts of climate change and environmental sustainability of existing activities in the region.

Throughout the work of the Alqueva MAP, we sought to answer some questions, namely:

- What are the challenges and opportunities in the reality of the region?
- What policies and solutions should be promoted to address these challenges and opportunities?
- What questions does research not yet fully answer so that the necessary transitions can be accelerated?

In recent years we have seen increased public and regulatory pressure on agricultural production to respond quickly to climate change and the adoption of environmentally-sustainable practices. The sector has responded very clearly to this challenge, but much remains to be done. The discussions at the MAP should help to identify some future paths.

1. Brief background on climate change in the Alqueva region

In the MAP discussions the importance of contextualizing the climate change problem to the national and regional reality was highlighted, to have a better understanding of some of the measures indicated in the document.

According to the IPCC, the most severe climate scenarios for Portugal (RCP 8.5), predict that the temperature increase may reach +5°C in 2100, particularly during the summer and in the interior of Portugal. The high temperatures are reflected in an increase in very hot days (Tmax 35°C), especially in the southern interior, an increase in the number of tropical nights (Tmin 20°C), and longer and more frequent heat waves.

Although the precipitation scenarios are more uncertain, the patterns are also expected to change, with a significant reduction in annual values across the territory, with losses of between -10% and -50% by the end of the century in spring, summer, and autumn. In addition, the number of extreme precipitation events is expected to increase at the expense of a reduction in days with low to medium/high precipitation.

The reduction in annual precipitation, the increase in its variability and the consequent change in runoff regime will reduce river flows, and will also affect aquifer recharge, and may even dry out the sources of important rivers in the Iberian Peninsula for longer or shorter periods of time. These changes may be accompanied by water quality problems, intensification of drought events (Figure 1) and increased pressure for desertification, promoting biodiversity loss associated with altered ecosystem structure and dynamics.

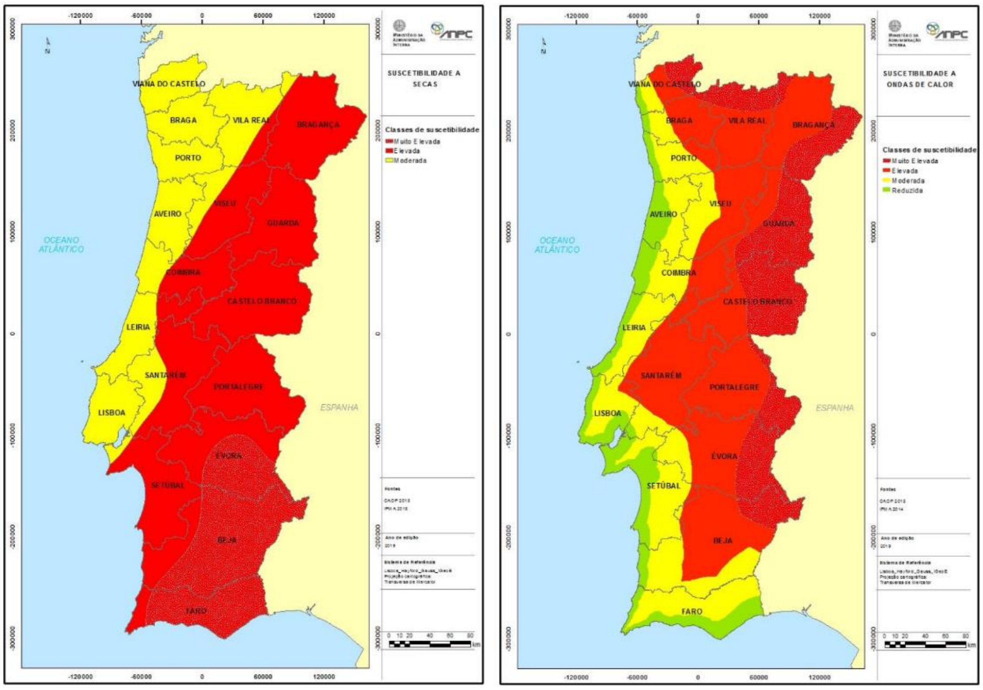


Figure 1. Drought susceptibility map (left) and heat wave susceptibility map (right) (Source: National Authority for Emergency and Civil Protection, 2019)

The new temperature and precipitation regimes associated with climate change bring with them an increase in the number of heat wave occurrences, particularly in the interior of the country (Figure 1), their duration and intensity; the intensification of the number and intensity of large rural fires and extreme, unpredictable, intense and localised meteorological phenomena, such as torrential rain, hail, cyclones and tornadoes, among others. In addition to the tendency for heat waves to be more intense and frequent, or spatially extensive, it is also expected that there will be a change in their seasonal distribution. Typically, heat waves occur in spring and summer, however, it is expected that this phenomenon will gain equal expressiveness in autumn. In this context, it is important to note that climate change scenarios predict a significant increase in weather conditions conducive to large areas throughout the territory of Portugal.

1.1. Some regional specificities to be taken into account

In addition to the previous framework, it is important to mention some more national and regional specificities, which also interfere with the whole discussion held under the Alqueva MAP:

1.1.1. Alqueva Multipurpose Project (EFMA)

Sometimes, when people talk about the Alqueva dam, they make an univocal relationship with agricultural use and with the agricultural "revolution" that has occurred in the region. However, the "Alqueva" project (Figure 2) is based on the concept of multiple purposes and the integrated management of its strategic water reserve.

EFMA is a structuring project in the South of Portugal, conducted as an anchor investment for regional development, but above all it is a strategic investment to increase national resilience to the phenomenon of climate change and a strategic reserve of water.

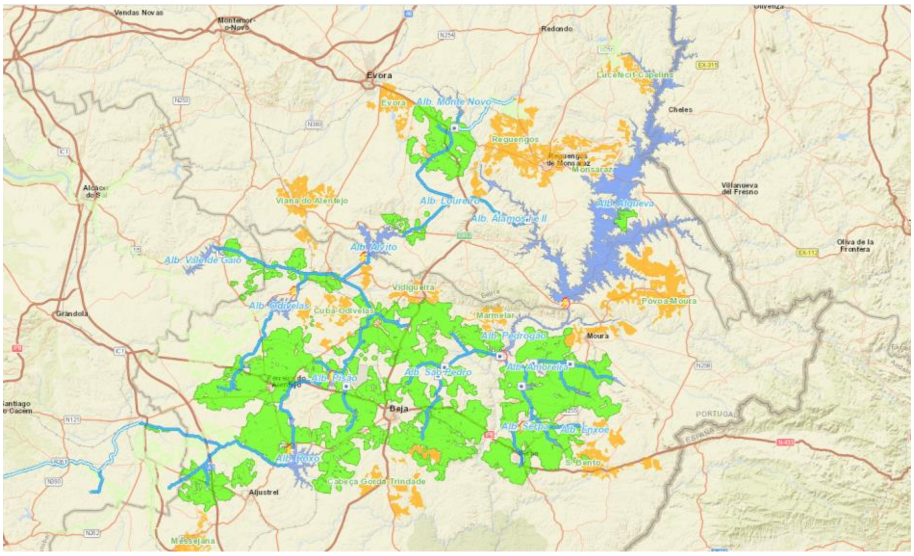


Figure 2. Territorial coverage of the EFMA project (Source: www.edia.pt)

EFMA is a project focused on the Alqueva dam, the largest strategic water reserve in Europe. The Alqueva reservoir, the largest artificial lake in Europe, stretches 83 km along the counties of Moura, Portel, Mourão, Reguengos de Monsaraz and Alandroal, occupying an area of 250 km^2. The total storage capacity of the Alqueva reservoir is 4 150 million m^3, and its usable volume in normal operation is 3 150 million m^3, corresponding to a national public investment of approximately €2.5 billion. The challenge facing the region is proportional to its size, opening unique perspectives for the relaunch of economic and social development, and creating conditions for an effective increase in regional Gross Domestic Product.

In addition to having allowed the infrastructure for an irrigated area of 120 000 ha, EFMA guarantees the public water supply for about 200 000 inhabitants, the production of enough renewable energy for a city with 500 000 inhabitants, facilitates industrial projects and the promotion of tourism.

1.1.2. Importance of water reserves

According to the drought susceptibility chart (Figure 1), almost the entire territory of mainland Portugal shows high susceptibility to droughts, with particular emphasis on the Algarve and the inland region of Baixo Alentejo (location of Alqueva MAP), where susceptibility is extremely high. To resist periods of intense drought, water storage systems assume great importance. This a very evident reality for irrigated crops, but it applies in the same way in rainfed crops, because water is needed for all activities on the farm.

1.1.3. Soils with low levels of organic matter

One of the main negative impacts, to which Portugal is vulnerable, is on the soil and on its organic matter content, which is a component of special importance for the performance of environmental, ecological and soil functions, and therefore directly related to agricultural productivity. Most soils in Portugal have a very low organic matter content (<2%).

In Mediterranean ecosystems, the warm climate naturally encourages the decomposition of organic matter in soils, something that does not happen, at the same rate, in other regions. The amount of organic matter is also one of the main measures used to measure the performance of an economy that wants to decarbonise and therefore needs not only to reduce its emissions into the atmosphere, on the one hand, and on the other hand, needs to sequester and store the carbon it emits, to balance the two "plates" of the scales and thus achieve carbon neutrality.

The predicted temperature increases for Portugal and, consequently, the worsening of the conditions of greater dryness will tend to decrease the levels of organic matter, which in already vulnerable soils, will accelerate erosion and, consequently, desertification.

1.1.4. Extensive agroforestry systems

Agroforestry systems are part of the Portuguese rural mosaic mostly associated with extensive livestock or crop production. The ultimate symbol of these extensive agroforestry systems is the "Montado" or holm oak forest. These ecosystems have a high socioeconomic value and high biodiversity.

In Portugal, "Montado" are mostly concentrated in the southern region of the country, an area characterised by scarce water resources (Figure 3). However, in recent years we have witnessed an increase in tree mortality, a decrease in natural regeneration of "Montado" and a reduction in productivity. This decline has led to a reduction in the area covered by canopy, with major implications for biodiversity and extensive rainfed and grazing systems.

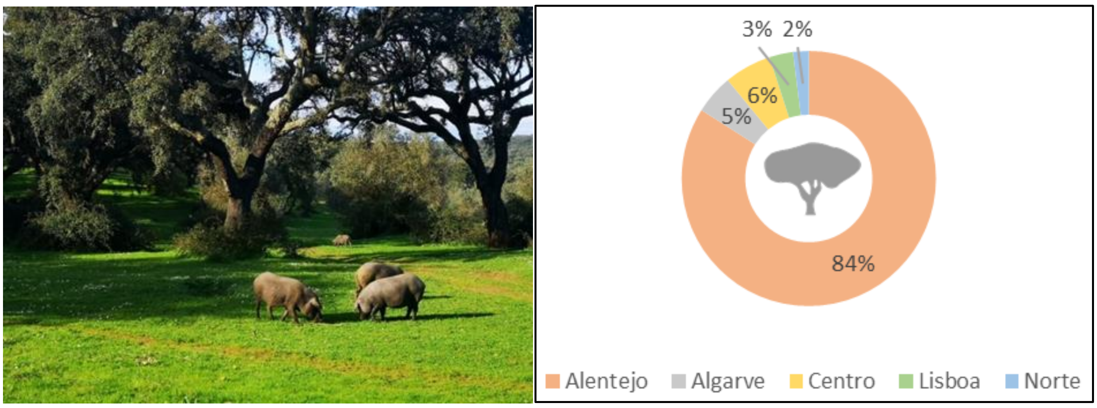


Figure 3. Image of the "Montado" system (left) and the distribution, by regions, of the "Montado" in Portugal (right)

1.1.5. Private forest and rural fires

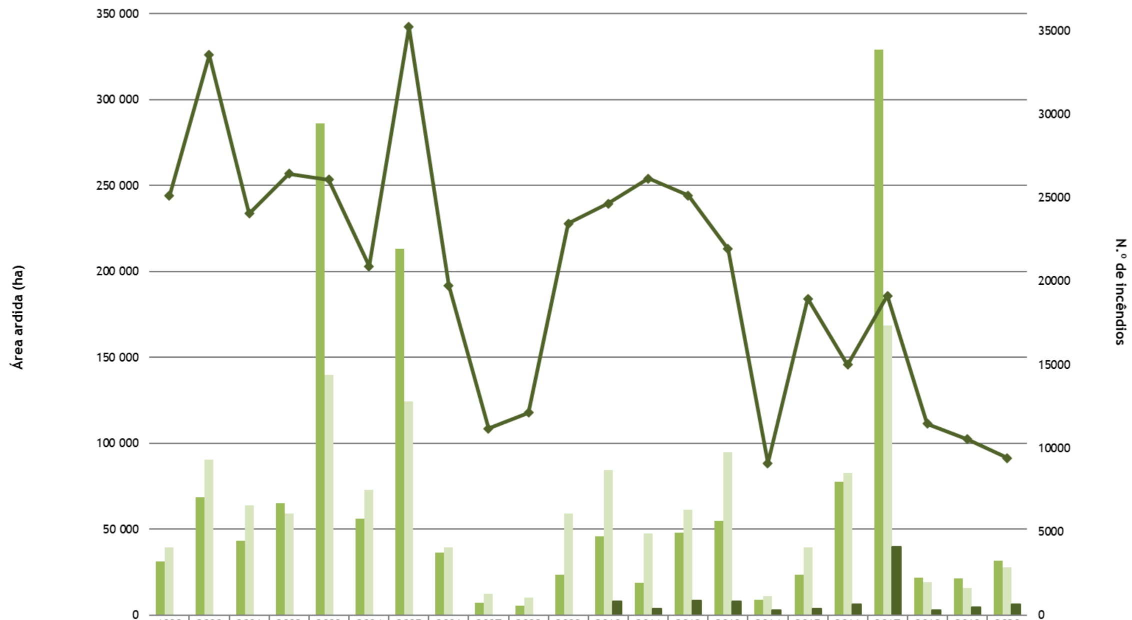
According to the *Global Forest Resource Assessment* 2020 (FAO, 2020), Portugal is among the 10 countries in the world (Figure 4) and the first in Europe with the highest percentage of private forest area.

Ranking	Country/territory	Forest under private ownership	
		Area (1 000 ha)	% of total forest area
1	American Samoa	17	100
2	Marshall Islands	9	100
3	Niue	19	100
4	Papua New Guinea	35 974	100
5	Vanuatu	442	100
6	Uruguay	1 906	99
7	Portugal	3 215	97
8	Yemen	522	95
9	El Salvador	548	90
10	Samoa	148	90

Figure 4. 10 countries and territories with the greatest percentage of private forest area (Source: FAO, 2020)

Over the past few years, we have witnessed a high frequency of rural fires, mainly associated with the lack of human occupation of rural areas. These rural fires correspond, on average, to 130 876 ha per year, and there are "outlier" years that deviate greatly from the "typical" pattern. For example, if we consider the burnt area of 2003, 2005 and 2017, these three years alone, represent 47% of the entire burnt area of the last 22 years (Figure 5).

Rural fires, in addition to all their direct economic impacts, have environmental effects of dimensions more than proportional to the affected areas. Fire releases carbon stored in the wood and soil of forest stands and surrounding vegetation. With the predictable intensification of fires resulting from climate change, the regeneration capacity of ecosystems decreases, biodiversity loss increases, and soil erosion increases. The Baixo Alentejo area is not subject to high pressure from rural fires, but the renaturalisation of some areas (and possible abandonment) may lead to an exponential increase in this risk.



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Povoamento	31026	68572	43394	65136	286030	56050	213345	36316	7037	5252	23315
Matos	39444	90562	63755	59230	139627	72887	124421	39155	12407	10008	59285
Agricola											
Nº de Incêndios	25095	33528	24038	26416	26059	20884	35195	19731	11161	12126	23441

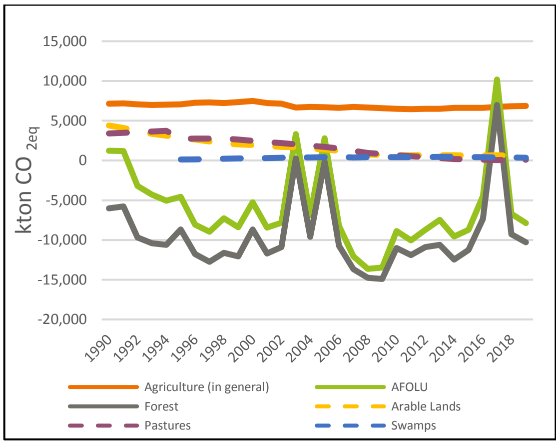
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Povoamento	45777	18631	48002	54905	8701	23461	77390	328863	21873	21411	31803
Matos	84391	47704	61239	94564	10889	39538	82505	168611	19114	15831	27824
Agricola	8223	3825	8629	7858	2954	3796	6290	39669	3091	4608	6260
Nº de Incêndios	24630	26127	25107	21917	9095	18945	14980	19105	11450	10528	9394

Figure 5. Number of rural fires and burnt area in Portugal, by year, between 1999 and 2020 (Source: Autoridade Florestal Nacional, 2009 and ICNF, 2020)

2. Promoting Climate Change Mitigation and Adaptation

2.1. Main scientific evidence

The current CAP proposal, with a focus on reducing GHG emissions and increasing carbon sequestration, is oriented towards the promotion of a "greener" architecture translated into more equitable payments to farmers oriented towards the environment, climate change and territory. This will necessarily involve the valorisation of the sector that is a net CO_2 sink (with the integration of the forestry sector), except for the years with major rural fires (Figure 6, left), although we have seen an increase in GHG emissions in the agricultural sector in the Alqueva region (Figure 6, right), as a result of the increase in the agricultural area irrigated by the Alqueva dam.



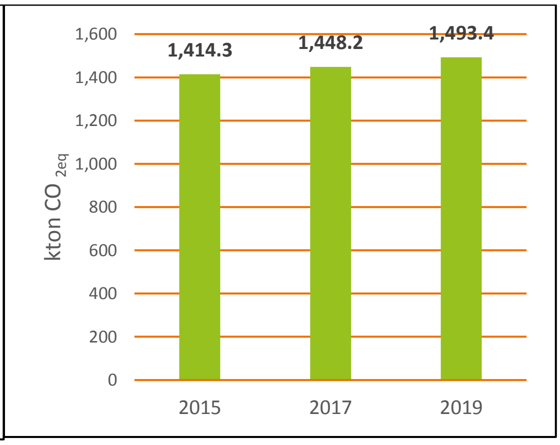


Figure 6. National emissions of AFOFLU (left) and emissions from agriculture in the Alqueva MAP area (right) (Source: APA, 2021)

Over the last years, and as mentioned in the initial framework, we have witnessed an increase in the frequency and intensity of droughts, with impacts on the economy and public water supply. Table 1highlights some of the occurrences, in recent decades, with greater impact on public water supply to the population.

Table 1. Major recent drought events (Source: National Authority for Emergency and Civil Protection, 2019)

Hydrological year	Note
2017	100% of the affected territory for several months.
2004-06	100% of the territory in meteorological drought, for more than 18 months.
1994-95	One of the most intense meteorological droughts of the 20th century. 100% of the territory in meteorological drought, for more than 12 months.
1990-92	One of the most intense meteorological droughts of the 20th century. 100% of the territory in meteorological drought, for more than 18 months.

Climate change has already led to some impacts on different existing sectors in the area of influence of Alqueva, some of these impacts are listed in Table 2, although the sector has been doing an exceptional job of eco-efficiency in the use of production factors, which can be proven in the data collected by the Centro Operativo e Tecnológico do Regadio (COTR) regarding the improvement of the Coefficient of Uniformity of water distribution in irrigation systems used in the region (Figure 7).

Table 2. Some of the current and potential impacts of climate change by sector in the region (Source: adapted from Ministry of Agriculture, 2013)

Crop	Meteorological events	Some impacts that already occur or may occur
Cereals	Higher average temperature	Use of varieties with shorter cycles and earlier sowing
		Reduction in the productive potential of crops
	Increased intensity and frequency of heat waves	Abrupt increases in maximum temperature during grain filling can lead to yield losses of more than 50%.

Crop	Meteorological events	Some impacts that already occur or may occur
Vineyard	Higher average temperature and more intense and frequent heat waves	Change in phenology (faster development), reduced photosynthetic activity and reduced wine quality (less accumulation of photo-assimilates, for example)
		Emergence of new diseases and/or pests or increase in importance of existing diseases/pests
		Increased intensity and frequency of problems such as grape scald
Fruit	Higher average temperature	Anticipation of the beginning of the vegetative cycle, with negative impact on the quantity and quality of production, including conservation capacity.
		Productivity conditioning in species with higher cold requirements
	More intense and frequent droughts	Increased water consumption for irrigation and increased production costs
Extensive livestock farming	Higher average temperature (consecutive days with temperatures above 35°C)	Increased risk of abandonment of the activity, which is very important in the territory and which, from the environmental point of view, leads to an increase in the area of brushwood and the risk of fires
	Decrease in precipitation (mainly in spring)	Lower production of total dry matter in pastures, due to less water in the period when the temperature is more favorable for plant growth
Olive	Higher average temperature / More intense and frequent heat waves	Conditioning of fat accumulation (in the early stages of the vegetative cycle)
		Changes in olive ripeness
	Increase in episodes of intense precipitation and winds	During flowering, the incidence of rain, high temperatures and strong, dry winds reduce the chances of successful setting.
Forest ("montado")	Increase in the frequency and severity of drought situations	Increased likelihood of pest and disease incidence
		Increased difficulty in regenerating "Montado" stands, with consequences for stand density
	Extension of the summer period	Increase in "Montado" mortality

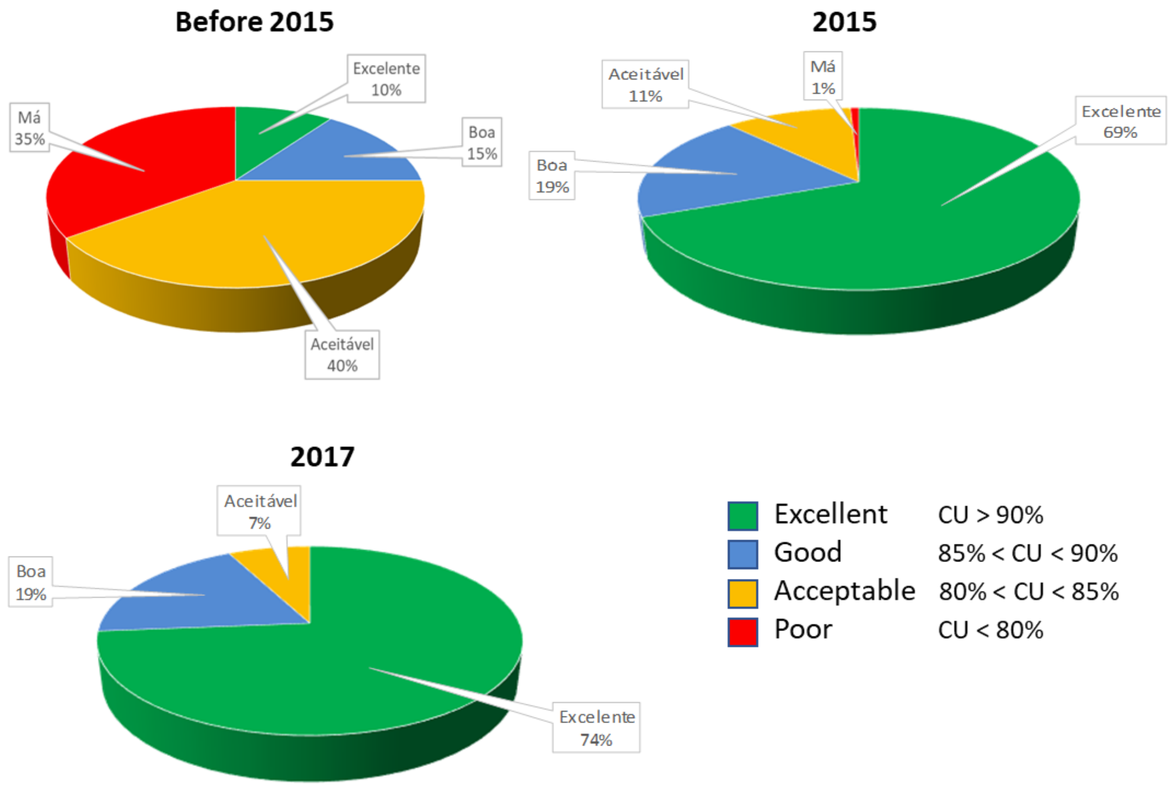


Figure 7. Evolution of the Coefficient of Uniformity (CU) of irrigation water in the Alqueva region (COTR, 2019)

2.2. Summary of Alqueva MAP's position

2.2.1. Identification of opportunities and challenges

From the discussion held in the MAP, we can highlight the following transitions pointed out as priorities to mitigate and adapt the agricultural activity, and agri-food, to climate change and leading to carbon neutrality:

- Investing in a real energy transition of agricultural activities, focusing on renewable energy sources (photovoltaic, wind, biogas, etc.) in equipment and machinery and energy efficiency of farms.
- Continue to focus on maximising the efficiency of the use of factors to the detriment of the exclusive maximisation of agricultural productivity, above all through investment in the use of technology and precision agriculture and irrigation.
- Promote the reuse of wastewater in agriculture and in systems that promote water retention in soil to improve ecosystem services.
- Promote the use of by-products from regional industries (e.g. olive bagasse, green nut shells, organic waste from horticulture) in crop fertilisation and in improving the organic matter content of soils.

- Enhance agricultural carbon sinks (e.g. permanent crops, biodiverse grasslands) and agricultural practices that maximise carbon capture and retention in soil.
- Continue to promote conservation agriculture practices, including stubble maintenance, direct seeding or minimum tillage systems, inter-row greening of permanent crops, among others.
- Invest in improving the population's awareness of the importance of water retention and irrigation as a tool to minimise the impacts of climate change.
- Ensure the presence of extensive livestock farming in areas where agricultural profitability is very low or negative, in order to avoid abandonment of these territories and an increased risk of fire.
- Encourage the adoption of practices/initiatives that contribute to the reduction of food waste throughout the food value chain.
- improving the perception of agriculture in society by highlighting the sector's role in mitigating the effects of climate change and its role in food production and providing ecosystem services; one of the measures will necessarily be to 'open' the doors of farms to partnerships with environmental NGOs and society in general.

2.2.2. Public policy proposals

Regarding policies that can promote these transitions, and based on the discussion within the MAP, we highlight the following:

- Valuing the ecosystem services produced by farmers and practices that contribute to carbon neutrality and water retention on farms (there should be public support mechanisms to complement European CAP funds, given that some of these services are of benefit to society as a whole).
- Adjust spatial planning and environmental instruments to allow for the licensing of "buffer" storage by farmers and for dam construction, including for non-agricultural purposes.
- Ensure a legal adjustment that allows the use of agricultural and agri-food by-products from the region as a form of organic fertilisation of soils and to promote an increase in their organic matter content.
- Support R&D linked to measures that contribute to mitigating and adapting climate change impacts, and ensure that there is an effective knowledge transfer process to farmers, as well as giving more predictability to the support of such projects, which often have no framework for further tasks/trials.
- Differentiate positively between producers who participate in R&D projects, information monitoring networks and data sharing; discriminate positively between producers who are willing to have "model farms" that can serve as a showcase for demonstration activities for other producers and other stakeholders.
- Ensure the existence of public funds, or public-private partnerships, that develop a medium- to long-term communication programme for the sector with society, including the revision of textbooks and the creation of content for social networks that are easily accessible to a more urban population and that promote the importance of the sector and of farmers.

- Ensure that spatial planning and management instruments are consistent with each other and that there is a one-stop shop to support producers, where they can find all relevant information to develop their activities.
- Include in investment support measures a way of enhancing farming practices that help farms maximise their role as carbon sinks, and offer greater support for investments linked to energy transition on farms (namely with the renewal of machinery or investment and/or use of renewable energy).
- Enable the "injection" of clean energy produced by farmers into distribution networks, and models that promote sharing with other regional consumers.
- Create specific support for the recovery and regeneration of "Montado" and its complementarity with other sources of income (for example, considering the extensive presence of pigs of indigenous breeds as a means of eligibility of these areas for direct aid) in order to ensure that there is a positive economic return and not just a social return.
- Promote the existence of specialised technical training for knowledge transfer agents, whether linked to academia or private entities (advisors).
- Promote models for valuing the career of teachers/researchers that are not based exclusively on the production of published scientific knowledge, but that also value the role of knowledge transfer to farmers and participation in projects in partnership with actors in the field.

2.2.3. Key Research Gaps

From the discussion on the main gaps related to the production of knowledge that can contribute to accelerating the transitions identified above, we highlight the following:

- Assess, based on climate models, the predicted impacts of climate change on the Alqueva irrigated area, as a result either of a reduction in inflows to the hydrographic basins or an increase in crop water requirements.
- Deepen knowledge on the impact of irrigation and productive systems on the retention of organic matter in soils.
- Develop models for the recovery of crop residues, identifying the necessary transformation processes, the most suitable soils for their application, and the appropriate quantities and best times for application.
- Demonstrate resource efficiency in more intensive production models and ensure this balance with the availability of these resources (e.g. water).
- Invest in irrigation efficiency, being fundamental to define optimisation models (e.g. seasonal, allocations) and quantify their effects on production and product quality.
- Monitor water quality (upstream and downstream of irrigated areas), analyzing run-off water, at farm level (measuring water quality).
- Define specific, clear and agreed parameters for water quality monitoring and promote a real monitoring network.
- Work on the definition of technical roadmaps that promote the maximisation of on-farm ecosystem services towards farm carbon neutrality.

- Assess the role of permanent crops as "agricultural forest", valuing their role as carbon sinks and in models for remunerating this role, ensuring that the value stays on the farm and in the sector.
- Quantify the carbon balance in crops (annual and permanent), taking into account the cultural practices carried out on the farm and defining/adjusting indicators (carbon retention, for example) to the crops and cultural practices of the region (indicators from other geographies are mostly used, which do not correspond to the regional soil and climate conditions).
- Simulate the medium- to long-term impacts of territorial specialisation and of models for making natural systems compatible with productive systems, and identify the best ways of promoting practices that contribute to improving this necessary compatibility.
- Deepen knowledge about models of decentralised water availability, and identify the advantages, disadvantages, investment needs and remuneration/compensation mechanisms between different users.

2.2.4. Main obstacles and facilitators

Obstacles	Facilitators
Legal framework for the use of agricultural and agri-food by-products that are considered waste and, therefore, with strong limitations on their use	Availability of by-products that can be used in agriculture and interest by farmers in using them
Current legal framework associated with the production of some renewable energy (e.g. biogas) on farms	Solar technology available for irrigation, water pumping and fertigation
Current framework for carbon sinks from farms	Willingness of the agricultural sector to improve the carbon performance of its farms
Lack of more examples, on the ground, of practices that can be demonstrated to other farmers and other stakeholders	Existence of a network of universities, R&D centres and organisations interested in working on projects related to climate change mitigation and adaptation
Negative image of the agricultural sector, especially linked to more intensive production models, among the urban population	The agroforestry sector is a net sink for carbon and, as such, should lead public policy concerns associated with the impacts of climate change on society

3. Promote environmental sustainability

3.1. Main scientific evidence

Portugal is ranked 10th in the EU-28 in terms of the percentage of area included in the Natura 2000 network and has 22% of all species described in Europe. In the Alentejo, 24.3% of the territory is classified as Natura 2000 network, of which 4.9% are Protected Areas, 15.4% Sites of Community Importance and 11.4% are Special Protection Areas.

The diversity of Portugal's landscape, climate and terrain means that it is recognised as a country rich in natural heritage, holding species of flora and fauna associated with a wide variety of ecosystems, habitats, and landscapes, with a very relevant diversity and richness of this heritage. In fact, 75% of the national territory belongs to the Mediterranean biodiversity "hotspot", concentrated mainly within the Tagus area to the south of the country, where the region of this MAP is located.

In the diagnosis made by the Portuguese office of Planning, Policy and General Administration (GPP) for the preparation of the CAP Strategic Plan (PEPAC) there is an important reflection on the impact of agricultural and forestry activities on environmental sustainability. According to this document, and in a generic way, this impact depends primarily on the lesser or greater diversity of land use as well as the degree of intensification or extensification of the practices used.

In the first case, usually associated with very intensive farming systems, essential for our food subsistence, but with large inputs of chemicals, high animal load and the use of large plots of crops, and which has associated with it low levels of diversity of species and habitats. Despite this, the growing technological development in the agricultural sector (precision agriculture) and the use of sustainable agricultural practices and the adoption of sustainable, efficient and integrated agricultural management models (organic farming, integrated production, effluent management) have created opportunities to minimise and mitigate the effects on biodiversity.

In the second case, it is based on agroforestry production systems characterised by more extensive agricultural practices, with low animal load and reduced inputs of nutrients and fertilisers, usually associated with habitats and species with conservation value. These extensive production systems, in recent decades have been negatively affected by the abandonment (people and/or agricultural activity) of some inland regions. This abandonment has the effect of reducing the area of agricultural patches, relevant to the existence of mosaics favourable to biodiversity, particularly in areas with a high rate of afforestation. It would be expected that in the latter case there would be maximum levels of biodiversity in the absence of agricultural activity. However, it should be noted that many species and habitats are dependent on regimes that only exist in a context of agricultural activity, and elements of biodiversity may disappear if there is over-extensification or even abandonment of agriculture (Moreira and Lomba, 2017). As proof of this, estimates indicate that 20% of declining bird species in Europe are affected by the abandonment of extensive farming systems, so it is necessary to ensure that, in many cases, it is essential to maintain extensive production systems even if these may not be economically viable.

In a study promoted by CAP in 2013, different agricultural holdings were evaluated, representing different sectors with relevant economic expression and characteristics of the region where they are located, and there were holdings from all over the country. In addition to the specific richness (diversity of different species typologies) differing between different production typologies (Figure 8), it was also concluded that the greater the number of natural structures (woods, hedges, riparian zones) or artificial structures (agricultural ponds, stone walls, boxes - nest/shelter), the greater the specific richness found.

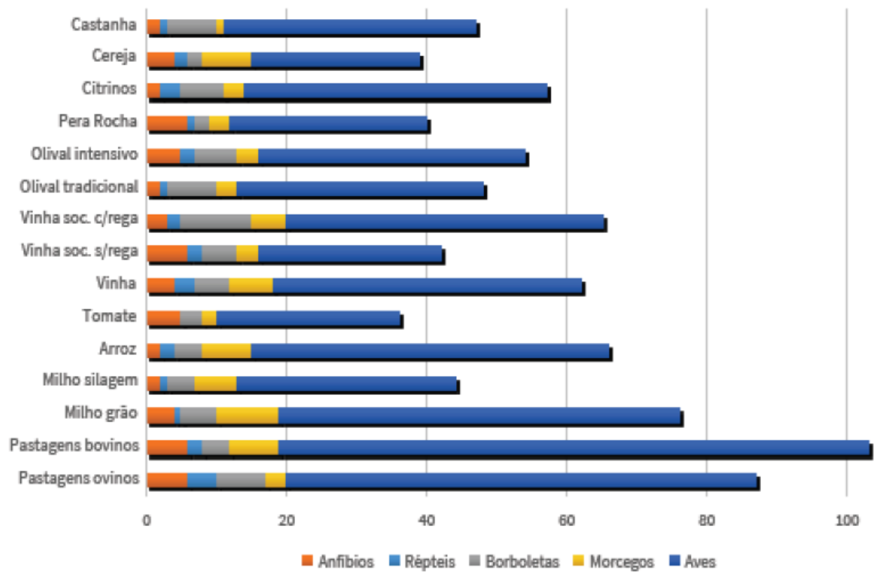


Figure 8. Overall specific wealth in different typologies of agricultural holdings (Source: CAP, 2013)

3.2. Summary of Alqueva MAP's position

3.2.1. Identification of opportunities and challenges

Some transitions highlighted as priorities for promoting environmental sustainability in the area of influence of the Alqueva MAP were highlighted:

- Protect and rehabilitate aquatic ecosystems and areas adjacent to them.
- Guarantee the regeneration and resilience of ecosystems, and increase the number of natural (woods, hedges, tree lines) or artificial (stone walls, nest boxes, shelter) structures that foster biodiversity.
- Promote local biodiversity through sustainable management of animal, plant and forest genetic resources, thereby promoting the use of native species fully adapted to the territory.
- Promote the creation of an ecological corridor in the agricultural Alentejo or maximise connectivity between different ecological focus structures.
- Enhance the role of "Montado" and its "excellence" as an agro-silvo-pastoral system with high biodiversity value.
- Differentiate producers who have programmes to promote environmental sustainability on their farms, which could include regional sustainability programmes (e.g. Alentejo Wine Sustainability Programme).
- Seek, whenever possible, to promote regenerative agriculture practices that can contribute to the restoration of ecosystems or ecological focus structures.
- Guarantee land management that allows different types of agriculture to be reconciled with each other, while maximising biodiversity; for example, it is important to ensure that there are extensive rainfed systems to guarantee the permanence of steppe birds in the area.

- Ensure that there are monitoring systems for the effects on biodiversity of different agricultural practices and production systems so that, with scientific data and known to stakeholders, interventions can be identified to improve the environmental performance of farms.

3.2.2. Public policy proposals

Regarding policies that can promote these transitions, and based on the discussion within the MAP, we highlight the following:

- Promote the installation of biodiverse greening, functional hedges and other ecologically focused structures at farm level, with approaches that maximise regional performance.
- Promote the existence of buffer zones (increasingly relevant in the relationship with the population and with other types of agriculture).
- Promote the installation and maintenance of permanent pastures (maintenance is generally not valued) associated with extensive livestock production systems.
- Consider, for the specific area of Alqueva, the creation of an Integrated Territorial Intervention (ITI) under the next Community Support Framework that can frame specific actions for a territory with such particular characteristics in terms of making intensive irrigated agriculture compatible with a set of environmental values.
- Provide greater predictability and continuity to research/demonstration projects in this area, most of whose results are medium to long-term.
- Enhance the participation of farms in regional/national initiatives associated with improving the environmental performance of farms, with particular emphasis on the participation of collaborative network models.
- Promote and review spatial planning models that respond more adequately to the dynamics of the territory and that support the compatibility of different interests, as well as the necessary monitoring.
- Adjust the funding amounts for ecosystem restoration actions, in order to increase their success rate, which implies high investment and careful maintenance.

3.2.3. Key Research Gaps

From the discussion on the main gaps related to the production of knowledge that can contribute to accelerating the transitions identified above, we highlight the following:

- Promote research associated with the use of indigenous genetic resources with the subsequent technological, and economic, valorisation of the primary production and agri-food sectors.
- Define technical standards for determining % of areas of natural vegetation that provide ecosystem services (and that can then be used in public policymaking).
- Further development/adaptation of varieties more resistant to water scarcity.

- Understand the reasons for the systematic reduction in "Montado" and to encourage its regeneration and/or replanting; the current reduction in the area of "Montado" has major implications for biodiversity and for rainfed and grazing systems.
- Model the impacts, in extensive rainfed areas, of the effects associated with the renaturalisation trend (arising from the inability to remunerate the agricultural activities developed there) which will tend to create two problems: increased risk of forest fires (so far, of low incidence in the region) and loss of habitats associated with steppe birds.
- Develop, and experiment with in the field, solutions based on Natural Engineering, adapted to the soil and climate conditions of the Alentejo region, and aimed above all at the area of influence of the hydrographic network.
- Quantify the beneficial effect of biodiversity-promoting practices, as well as the relationship between wild biodiversity and ecosystem services.
- Create dissemination materials (practical guides, videos, etc.) to promote environmental sustainability that is easy for producers to adopt.
- Greater transparency in the transmission of scientific knowledge and the language used.
- Study environmental restoration models that can guarantee higher success rates in their implementation and that are economically more competitive.

3.2.4. Main obstacles and facilitators

Obstacles	Facilitators
Lack of concrete data on the real impacts on the environmental sustainability of the territories	A territory that, despite the recent intensification of irrigated areas, maintains high levels of biodiversity
Lack of technical standards that can be implemented at the level of the region, and at farm level, to promote environmental sustainability	Ease of value perception by farmers, if the direct and indirect benefits of adopting many of the practices promoting ecosystem services are demonstrated
Difficulty in harmonising discourse among stakeholders, who often find it difficult to agree on practices and impacts	Existence of a vast regional genetic heritage with great potential for economic exploitation

Recommendations and Conclusions

As this was a subject that attracted a great deal of participation from MAP members, it was possible to produce a very broad and therefore very ambitious document. During the last meeting, one of the members said that "if half of what was mentioned here were done, it would be fantastic!" In these conclusions, we have tried to compile the most important and priority notes mentioned above, trying to concentrate on six key themes: Water, Energy, Soil, Territory, Biodiversity, and Communication.

Water

It is essential to promote an efficient management of water resources, ensuring the sustainability of this resource, and to promote water retention solutions in the territory and allow greater capillary connectivity between farms. These aspects are particularly sensitive in the non-irrigated area of Alqueva's area of influence. In the irrigated area it is essential to deepen knowledge about irrigation efficiency, which is fundamental to define optimisation models (seasons, water extraction, etc.), and to promote the use of monitoring technology that contributes to this efficiency.

Energy

It will not be possible to achieve carbon neutrality without making the energy transition for the different activities that consume fossil fuels. It is therefore essential to promote investment in renewable energy (photovoltaic, wind, biogas, etc.) on farms and to promote models that promote optimisation between producers and consumers of different types of energy sources, which may require legislative adjustments.

Soil

Cultural practices that promote the increase of soil organic matter are critical, namely the promotion of conservation agriculture techniques and the use of agricultural and agro-industrial by-products produced in the region. In parallel, it is important to value agricultural carbon sinks and farming practices that maximise carbon capture and retention in the soil, ensuring that the value created is internalised on the farm.

Territory

The Alqueva dam was built to allow the development of intensive and profitable agriculture. However, it is possible to promote greater compatibility of different types of agriculture in the territory, which is much larger than just the irrigated area, and lacks management instruments that adjust to a new and challenging reality.

Biodiversity

The Alqueva region has an enormous genetic heritage that is worth investing in and ensuring its maintenance, starting with an unequivocal commitment to the recovery of the "Montado" forest. In addition, technical standards should be defined to promote environmental sustainability at farm level, particularly for the most intensive farms.

Communication

The need to strengthen the image of the agricultural sector in society means that all those involved must be called upon to enhance the activity and its practices. New ways of communicating to new audiences must be a priority, as well as the promotion of model farms that can be visited and that involve other entities in the development of projects and initiatives.

Acknowledgements

To the members of Alqueva MAP and those responsible for the SHERPA project.

References

Portuguese Environment Agency (2021). Portuguese national inventory report on greenhouse gases, 1990 - 2019

National Forestry Authority (2009). *Interim report No. 11/2009 - 1- Jan. to 15 Oct. 2009.* Direcção de Unidade de Defesa da Floresta.

National Authority for Emergency and Civil Protection (2019). Avaliacao Nacional de Risco. Retrieved from http://www.prociv.pt/bk/RISCOSPREV/AVALIACAONACIONALRISCO/PublishingImages/Paginas/default/ANR2019-vers%C3%A3ofinal.pdf

Bugalho, M. N., *et al.* (2011). Mediterranean "Montado" savannas require human use to sustain biodiversity and ecosystem services. *Frontiers in Ecology and the Environment*, 9(5), 278-286.

CAP (2013) Biodiversity in Agricultural Holdings: Pilot Project to Assess the Appropriateness and Impact of Implementing Biodiversity Enhancing Measures in Mainland Portugal, 2013.

Standing Committee on Prevention, M. e. (2020). Agrometeorological and Hydrological Monitoring.

COTR (2017). Technical Report on Soil Monitoring in the Ferreira-Valbom-Figueirinha and Brinches-Enxoé Irrigation Blocks.

FAO (2020). Global Forest Resources Assessment 2020: Main report. https://doi.org/10.4060/ca9825en

GPP (2020). CAP Strategic Plan 2021-2027 - Diagnosis OE6.

ICNF. (2020). *8th Rural Fires provisional report - 2020 - 1 January to 15 October.* Departamento de Gestão de Fogos Rurais / Divisão de Apoio à Gestão de Fogos Rurais.

IPCC (2018). *Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to.*

Ministério da Agricultura, d. D. (2013). Strategy for Adaptation of Agriculture and Forestry to Climate Change.

Moreira, F, Lomba, A. (2017). The importance of Agriculture in the preservation of Biodiversity. Cadernos de Análise e Prospetiva - CULTIVAR No. 8 - Biodiversity, June 2017, GPP, p. 39.

Appendix

Table 1. Compilation of projects / initiatives / tools / methods implemented

Name	Implementation time	Contact and Website
REUSE - REUSE OF WATER IN IRRIGATION	2019-2021	AdP website news
AGRO WATER SAVING - INTEGRATED WATER SAVING TECHNOLOGY AND ENVIRONMENTAL AWARENESS	2019-2021	C3i website news
VALORARES - VALUATION AND USE OF BY-PRODUCTS GENERATED IN THE EXTREME REGION'S AGRIFOOD SECTOR THROUGH COMPOSTING	2017 - 2020	Project Sheet
GORSAS - MANAGEMENT, CONSERVATION AND RECOVERY OF SOILS, WATER AND SEDIMENTS	2018 - ..	Project Sheet
STRIVER "EU PROJECT. RESEARCH ON INTEGRATED WATER RESOURCES MANAGEMENT (IWRM) IN AN ASIAN-EUROPEAN CONTEXT	2006-2009	Final Report Summary
AQUAQ2: SYSTEM DEMONSTRATOR FOR THE ACQUISITION, TREATMENT AND INTERPRETATION OF WATER QUALITY DATA AND WATER RESOURCES COLLECTED IN SENSOR NETWORK	2019-2021	Project Sheet
IMPEFAC - IMPACTS OF EXTREME CLIMATIC EVENTS ON THE AGRICULTURAL AND FORESTRY SYSTEMS. DEVELOPMENT OF RISK ANALYSIS MODELS	2018-....	Website

SIMG - INTELLIGENT MONITORING SYSTEM FOR THE GUADIANA RIVER	2020-2023	Project Sheet
NETA - NEW STRATEGIES FOR WASTEWATER TREATMENT	2021-...	Website
LIFE DESERT-ADAPT - PREPARING DESERTIFICATION AREAS FOR INCREASED CLIMATE CHANGE	2017 - ...	Website
CHANGETRACKER- TRACKING CLIMATE CHANGE IN DRYLANDS BASED ON ECOLOGICAL INDICATORS	2016-2019	Project Sheet
ADAPTFORCHANGE: IMPROVE THE SUCCESS OF REFORESTATION IN SEMI-ARID AREAS: ADAPTATION TO CLIMATE CHANGE SCENARIO	2009-2014	Website
PSVA - SUSTAINABILITY PROGRAMME FOR ALENTEJO WINES	2015 -	Website
BEYOND-RISK - NATURE-BASED SOLUTIONS TO MINIMISE THE EFFECT OF HEAT WAVES	2021 -	Website
AQUA-VINI - WATER REUSE IN IRRIGATION ACTIVITIES	2021 - 2022	Project Sheet
VALAGUA PROJECT - ENVIRONMENTAL ENHANCEMENT AND INTEGRATED MANAGEMENT OF WATER AND HABITATS IN THE CROSS-BORDER GUADIANA RIVER	2017 - 2020	Website

SHERPA
Rural Science-Society-Policy Interfaces

www.rural-interfaces.eu

SHERPA has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 862448. The content of the document does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the author(s).