Subgroup: Agriculture and Forestry

Case-study: Adaptation to Drought in Alentejo, Portugal

12-12-2015

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Project:

FP7/ Project BASE [2012-2016]

Date of release:

12/12/2015

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1. General Case Study Description

A. Location

GPS: 37,6 to 39,3 N , -8,6 to 7,3 W

Area: ~ 27223 km^2

B. Case Study Summary

The case study is developed along two levels of research.

At the first level, we investigate the adaptation measures for the agriculture and forestry sector in the semi-arid region of Alentejo in Portugal. We implement this research by unveiling the bottom-up and top down perspective through the following approaches: we bring together national and regional stakeholders and researchers to discuss and analyze the national climate adaptation measures for the sector; we interview farmers and different bottom-up rural initiatives that are autonomously adapting to climate change impacts, namely drought; we evaluate the bottom up adaptation measures in a multicriteria analysis with stakeholders from all levels. The main objectives of this research level are to compare bottom-up and top down perspectives on the measures, strategies and policies for adaptation in the sector of agriculture and forestry in the semi-arid Mediterranean and create a comprehensive overview of the adaptation in this sector and climate, providing a clear framework for future work and in-depth research on specific adaptation measures or specific barriers or opportunities identified. Within this research level we will:

- Do a participatory workshop to discuss climate change adaptation options for the region of Alentejo (on November, 2013) through the interaction of high level and local stakeholders, namely regional and national planners, decision makers, researchers, farmers and NGOs. We've called this workshop the Participatory State of Art of Climate Adaptation in Alentejo.
- A questionnaire to 20 farmers, to identify current and possible agricultural practices that support adaptation to agricultural drought.
- A participatory multicriteria workshop on the adaptation measures for agriculture and forestry in the Alentejo.
- A SWAP – Scenario Workshop and Adaptation Pathways to the adaptation of Agriculture and Forestry in one municipality I the region
- Within the second level of analysis, our focus is an in-depth study of innovative adaptation measures and projects in the region of Alentejo in areas without irrigation infrastructures. Within this research level, we have planned:
- an in-depth analysis of an autonomous adaptation project in the region, designated as the Convergence Center at Aldeia das Amoreiras that works with enhancing adaptive capacity;
- and a in-depth analysis of the adaptation measure "Water Retention Landscapes" developed in the Tamera ecovillage. This analysis includes a cost-benefit analysis, a participatory cost-benefit analysis and the use of the INVEST model to quantify ecosystem services.

BASE report

C. Context

Alentejo is a Southern region of Portugal characterized by a Mediterranean climate with temperate winters, very hot and dry summers with long periods of no rain; with a reduced annual precipitation (average about 600mm /m2 .year), high maximum temperatures in the summer (> 30C) and periodic droughts. The region is generally characterized by a high risk of desertification due to the present quality of soils, land use patterns and predicted increase in the frequency of droughts, reduced precipitation and heat.

In Alentejo, the original characteristics of the soil and landscape coupled with the effects of deforestation and intensive cereal cultures led to increased soil erosion and reduced agricultural productivity (MAMAOT 2013). This reduced productivity, and an increased mechanization, as well as the European open market and consequent competition with cereal cultures from other European countries and the world, led to a reduction in employment in agriculture in Alentejo and a massive migration from rural to urban areas (Belo et al. 2009).

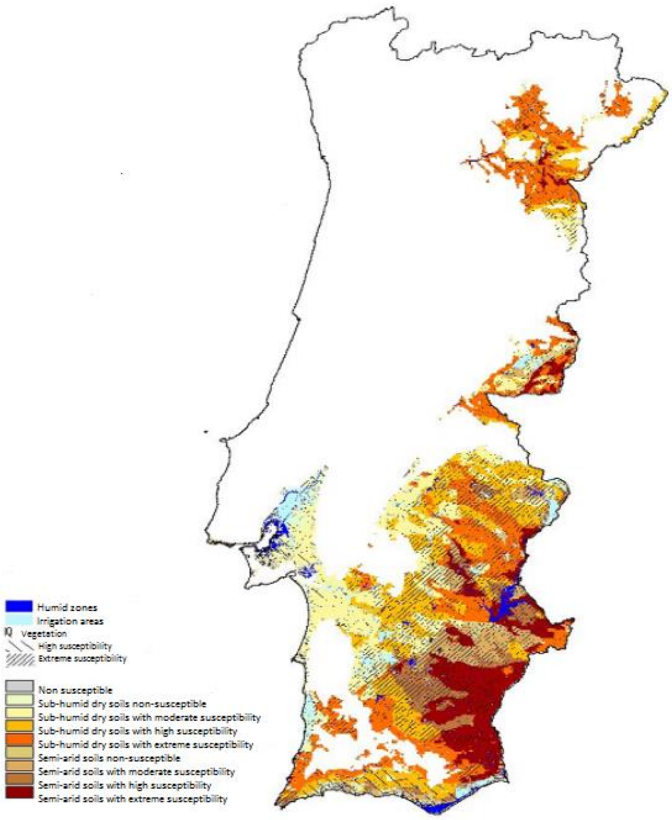


Figure 1 - Vulnerability to desertification (source: PANCD - National action plan to combat desertification (CNCDC 2011))

Therefore, in this region there is a strong need to identify and evaluate traditional or innovative adaptation options for water scarcity, drought and soil erosion in agriculture and forestry in order to support sustainable livelihoods and ecosystems, and prevent further land abandonment (Figueiredo & Pereira 2011), as well as further migration of people (MAMAOT 2013) . Because Alentejo is similar to many Mediterranean regions, the solutions identified here have a high potential of replication and adaptation to other Mediterranean regions.

From the 1930 until 1970s a national wheat campaign promoted the culture of winter cereals in the landscapes of Alentejo in flat but also in steep areas where soil erosion increased and resulted in reduced agricultural productivity.

This reduced agricultural productivity together with the increase in mechanization in agriculture, the open market and consequent competition with the cereal agriculture from other parts of Europe and the world, led to a reduction in employment in agriculture in the Alentejo and a massive migration from rural areas to urban areas.

Climate change predictions suggest additional difficulties to this region due to reduced precipitation, increase in droughts and water scarcity and temperatures and storms that indirectly cause increased soil erosion.

In this region there is, therefore, a strong need to identify and evaluate traditional or innovative adaptation options for water scarcity, drought and soil erosion in agriculture and forestry that can support human and ecosystems and prevent the desertification of the Alentejo region.

This region is similar to many Mediterranean regions and the solutions identified in this region have a high potential of replication and adaptation to other Mediterranean regions.

As a Bottom-Up research project, BASE, through FFCUL, will look at different bottom-up projects in Alentejo retrospectively and prospectively to identify innovative solutions and approaches for climate change adaptation. Two projects were identified and presented for BASE application:Tamera water Landscapes; Aldeia das Amoreiras sustainable community. Additionally, BASE will gather researchers doing research related to landscape regeneration in Alentejo, in a participatory state of the art meeting to join efforts in the common approach for producing knowledge for decision makers at all levels.

D. Brief General Information on Climate CHANGE and related issues

(Máx 2000 words) *Please state which is the European climate zone of the case study and insert any information regarding the current available information regarding the case-study, namely expected impacts, scenarios.*

Portugal has two major climate zones: the Mediterranean and the Atlantic. In the Mediterranean the main climate change predictable impacts are drought, water scarcity and increased temperatures and heat waves. The Portuguese region of Alentejo is part of the Mediterranean and is already on the present characterized by high and very high vulnerability to desertification. The Portuguese project of Climate Change modeling for Portugal "SIAM II" has modeled the trends of precipitation and temperature for Portugal estimating a reduction of 20% in precipitation and an increase of 4 to 8 degrees in the maximum temperatures in the summer to 2100 in a2 IPCC scenario.

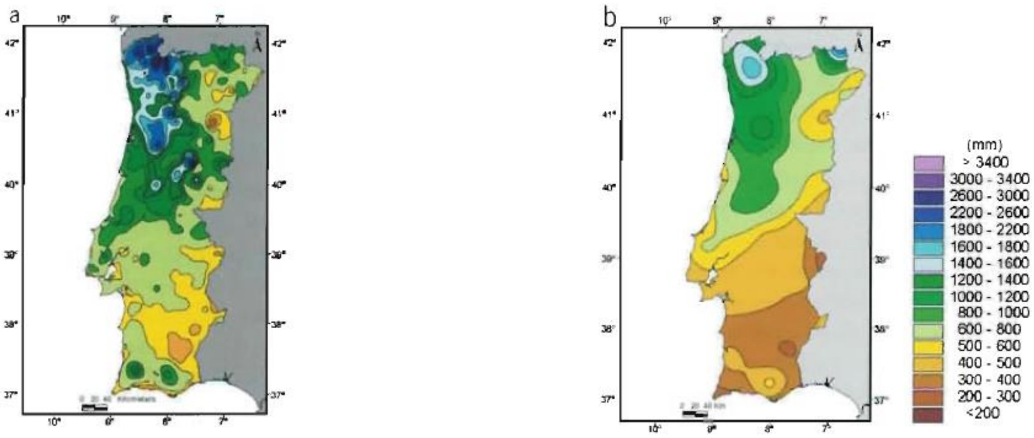


Figure 3 - Average medium precipitation in 1961-1990 and in 2100 in Portugal using scenario GGa2 (source SIAM II)

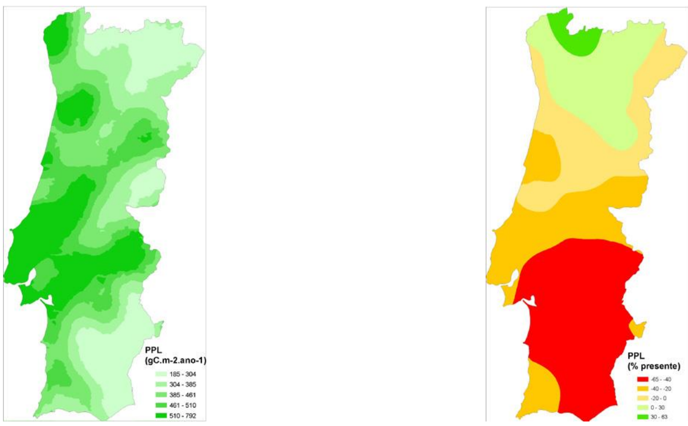


Figure 2 - NPP of Quercus Suber in 1961-1990 and in 2100 in Portugal (source: SIAM II)

This climate scenario can lead to a reduction of 40% of NPP (net primary production) of the main tree which supports the a vast area of the landscape: Cork Oak (*Quercus Suber*) (Santos & Miranda 2006).

E. Existing Information on Case Study's adaptation history

(Máx 2000 words) *Please insert a Short resume of the Case study existing information related to Climate Change Adaptation (major goals, plans, measures and timelines already defined or implemented), important Milestones in its "Adaptation Journey" as well as relevant state-of the art regarding the implementation of Adaptation Strategies and Specific Measure*

Based on the Portuguese national adaptation strategy (ENAAC)(MAMAOT 2013) a set of adaptation measures for the Agriculture and Forestry sectors are identified for the Alentejo region.

The official selection of adaptation measures for Portugal [Agriculture and Forests Sectorial Report of the Portuguese National Adaptation Strategy] drawn from the agriculture and forestry strategy, include:

- Increase the knowledge in climate change scenarios
- Promote the efficient use of water
- Reinforce mechanisms and instruments needed to improve forests and fight land abandonment
- Reinforce the role of agriculture and forestry in the protection of soil and water
- Soil conservation and promotion of organic matter in soils
- Preservation of water resources
- Agricultural insurances
- Increase the capacity for water storage and irrigation
- Protect and restore water lines
- Environmental education in schools
- Rural extension / farmers counselling
- Value the animal, vegetable and microbe genetic patrimony
- Promote access to land and the renewal of farm owners and workers.

This strategy is not specifically targeting the Alentejo region, but suggested measures have been the starting point for our analysis of potential adaptation options for Alentejo. The region does not have an adaptation strategy yet but bringing stakeholders to discuss this topic through participatory methodologies in BASE ca be an igniting factor to this end.

Additionally, in this case study several farms and projects are researched that have implemented adaptation actions in the past. Since adaptation aims at reducing the vulnerability to climate change, several activities of farmers can be seen in the perspective of autonomous adaptation to climate since farmers in the region face climate extremes such as droughts and heat waves from time to time. The interviews to farmers will further explain and explore the extent of this autonomous adaptation and its relation to the existing top down policies and subsidies.

Furthermore two projects will be analyzed in-depth: Water Retention Landscapes (WRL) in the ecovillage of Tamera and the Convergence Centre (CCA) in the village of Amoreiras. The WRL consist of a series of

interconnected lakes and some land use management changes and the objective of this action is among other things the protection against drought and water scarcity.

Finally, one further project that is researched in the context of this regional case study is the Amoreiras Convergence Centre, a rural development project that has worked towards the increase of adaptive capacity and also demonstrating several climate adaptation measures in a rural village in the Alentejo region. This project is also researched in this case study as a retrospective participatory analysis to draw lessons from the past into the future.

F. Connection with other research projects:

This case study interacts strongly with other cases in the BASE agriculture subgroup. Namely the questionnaire used for the farmers interviews has been co-designed by all case study owners in this group and is being applied to all case studies, though in some as an online questionnaire (in the Danish rural case studies) and in Alentejo as a structured interview guide.

Towards the end of BASE, the case study of Adaptation to Drought in Alentejo has connected with the adaptation project Adapt*For*Change where a SWAP – Scenario Workshop and Adaptation Pathways in the municipality of Mertola (region of Alentejo) was implemented. See the project link at http://echanges.fc.ul.pt/projetos/adaptforchange/ .

G. Case ID, Typologies and Dimensions

BASE OBJECTIVES
1. Compile and analyze data and information on adaptation measures, their effectiveness. (…)
2. Improve current, develop new and integrate methods and tools to assess climate impacts, vulnerability, risks and adaptation policies (…).
3. Identify conflicts and synergies of adaptation policies at different levels of policy making with other policies (including climate mitigation) within and between sectors. (…)
4. Assess the effectiveness and full costs and benefits of adaptation strategies to be undertaken at local, regional, and national scales using innovative approaches (mainly by integrating bottom-up knowledge/assessment and top-down dynamics/processes) with particular attention on sectors of high social and economic importance.
5. Bridge the gap between specific assessments of adaptation measures and top-down implementation of comprehensive and integrated strategies.
6. Use and develop novel participatory and deliberative tools to enhance the effective use of local contextualized knowledge in adaptation strategies to assess perceptions of adaptation pathways and their co-design by citizens and stakeholders.
7. Disseminate findings by sharing the results of the project with policy-makers, practitioners and other stakeholders. (…)

CASE STUDIES CATEGORIES	
A.	Public administration (municipality, regional, national, european)
B.	Research and education Centres (universities, research centres, projects and groups, schools)
C.	Public companies
D.	Companies (farms, SMEs, big businesses)
E.	Social enterprises (cooperatives, non profit companies, woofing farms, etc)
F.	Consortiums (partnerships, campaigns),
G.	NGOs (environmental NGO, local development NGO, charities, etc)
H.	Transition Initiative
I.	Ecovillage
J.	Informal groups, Movements

Case ID			Typologies and characterization				
Country & Name of CS	BASE Objectives to be answered by the CS	Category of case study	Territorial zones	Scale	Process Direction	Temporal Definition	Timescale[1]
	[x] Objective 1 [x] Objective 2 [x] Objective 3 [x] Objective 4 [x] Objective 5 [ ] Objective 6 [x] Objective 7	A E D G H I	[x] Rural [ ] Urban [ ] Coastal [ ] River Basin	[ ] Local [x] Regional [ ] National [ ] Transnational [ ] European /Global	[x] Bottom-Up [x] Top-Down	[x] Retrospective [x] Prospective	yyyy - yyyy

[1] Please insert year of start and year of end of case study.

H. Impacts, Sectors and Implementation

Please tick the relevant boxes for impacts and implementation and insert the number 1 for primary sector and the number 2 for secondary sector.

Impacts		Sectors		Implementation	
Primary CC Impacts (Climate-Adapt)	Primary CC Impacts (BASE)	Primary and Secondary Sector (Climate Adapt)	Primary and secondary Sector (BASE)	Implemented[2]	Phase of Implementation[2]
[x] Extreme Temperatures [x] Water Scarcity [ ] Flooding [ ] Sea level Rise [x] Droughts [ ] Storms [ ] Ice and Snow	[x] Extreme temperatures [x] Water scarcity [ ] Flooding [ ] Coastal Erosion [x] Droughts [x] Soil Erosion [ ] Vector Borne Diseases [ ] Damages from extreme weather related events (storms, ice and snow)	[x] Agriculture and forest [x] Biodiversity [ ] Coastal Areas [ ] Disaster risk reduction [ ] Financial [ ] Health [ ] Infrastructure [ ] Marine and Fisheries [x] Water Management [ ] Urban	[x] Agriculture [x] Biodiversity & Ecosystems [ ] Coastal and Marine systems [ ] Energy [ ] Health and Social Policies [ ] Transport [ ] Production Systems and Physical Infrastructures [x] Water resources [ ] Tourism	[ ] Yes [x] Ongoing [ ] No	[x] Assessment [x] Planning [ ] Implementation [ ] Monitoring [ ] Evaluation

I. Importance and Relevance of Adaptation

Please tick the relevant box for the case study.

[x] Case developed and implemented as a climate change adaptation measure

[ ] Case developed and implemented and partially funded as a climate change adaptation measure

[x] Case mainly developed and implemented because of other policy objectives, but with significant consideration on climate change adaptation aspects

Note: The case study includes several cases of autonomous adaptation that is typically implemented by farmers and land tenure projects without the concept of Climate Adaptation being before hand introduced. On the other hand the general research lead in this regional case study about the adaptation measures was specifically designed and implemented as participatory action research project on the topic of climate adaptation.

[2] When the case study consists of a public administration with a top down approach, implementation can be an approved legislation or regulation. When the case study is about practical adaptation measures like a sand dune, for example, implementation should be considered finished when the dune is built in situ.

2. Case study research Methodology

a) Research Goals

1. Evaluation of projects and Adaptation options to drought in Alentejo, based on the research questions of BASE
2. Promote the co-design of a regional/ municipal adaptation plan
3. Document and disseminate the effective adaptation measures.
4. Promote the creation of an action-research network for climate change adaptation for the Alentejo region.

b) Stakeholders involved

- Universities, research institutes and NGOs doing research on landscpape regeneration in Alentejo
- Farmers associations
- Group of Farmers interested in climate change adaptation
- Tamera ecological community
- Aldeia das Amoreiras (Centro de Convergência and sustainable village project)
- Transition town initiatives in Alentejo and Portugal
- Local and regional partners of Tamera, Aldeias das Amoreiras and Farmers
- Regional Public Authorities on land management, agriculture, forestry, environment and climate change.
- National authorities in Climate change adaptation

c) Methodology

The case study of Alentejo has 3 main goals. We present the work breakdown structure.

The general methodological approach is Participatory Action Research, where the stakeholder are involved in the creation of a local action-research group to support the research team in the creation of research questions but also in the integration of the research results in the context of research.

In concrete this case study works with specific adaptation projects in Alentejo led by farmers and communities and at the same time with the academic community. If possible and desired by these stakeholders FFCUL BASE team will integrate the findings and questions arising from the action research in these projects, with the regional and national planning authorities to confront the bottom-up adaptation solution and proposals with the top-down perspective.

1. Identification and Evaluation of climate Adaptation Measures in Alentejo
    1.1. Find in Alentejo, projects and innovative Adaptation Measures implemented by farmers and communities
    1.2. Evaluation of these autonomous adaptation measures
    1.3. In-depth evaluation of CC Adaptation Measures of specific projects (Water Retention Landscapes in Tamera and Convergece Centre in Aldeia das Amoreiras) through participatory action research.
2. Document and disseminate the evaluation of CC Adaptation Measures
    2.1. Report deliveries to BASE
    2.2. Generate gatherings, exchange and synergies between multi level stakeholders
    2.3. Identify and design the best possible way to disseminate climate adaptation measures to farmers
3. Promote the creation of an action-research network for climate change adaptation for the region.
    3.1. Organize a Participatory State of the Art of Climate Change Adaptation in Alentejo
    3.2. Gather farmers and farmers associations in the discussion of CC Adaptation in Alentejo
    3.3. Support the creation of monitoring procedures and indicators for future assessment of adaptation measures
    3.4. Generate participated moments of discussion on Agriculture and Drought Adaptation in Alentejo

METHODS to be used in Case Studies[3]	YES // NO
A) Methods for prioritizing adaptation options	
Cost-Benefit Analysis (CBA)	yes
Cost-Effectiveness Analysis (CEA)	
Multi-criteria Analysis (MCA)	Yes
Analytic Hierarchy Process (AHP)	
B) Quantification of impacts and relationships between factors affecting adaptation	
Causal Diagrams	
Influence Diagrams	
Process-based Modelling	
Welfare variation analysis under restrictions	
C) Uncertainty and sensitivity analysis	
Probabilistic multi model Ensemble	
Monte Carlo simulations (PRIMATE uses this method)	
Real option analysis	
Climate risk management process	
D) Participatory Methods	
Scenario Workshop	yes
Participatory Cost Benefit Analysis (PCBA)	yes
Participatory add-ons to CBA	yes
Participatory add-ons to Multi Criteria Decision Analysis	Yes
Participatory add-ons to Adaptation Pathways	
Other (add extra lines if necessary): Systematization of experiences	yes

[3] For descriptions and references of the Methods please refer to Milestone 8. For data requests from specific Work Packages please refer to Deliverable 4.1

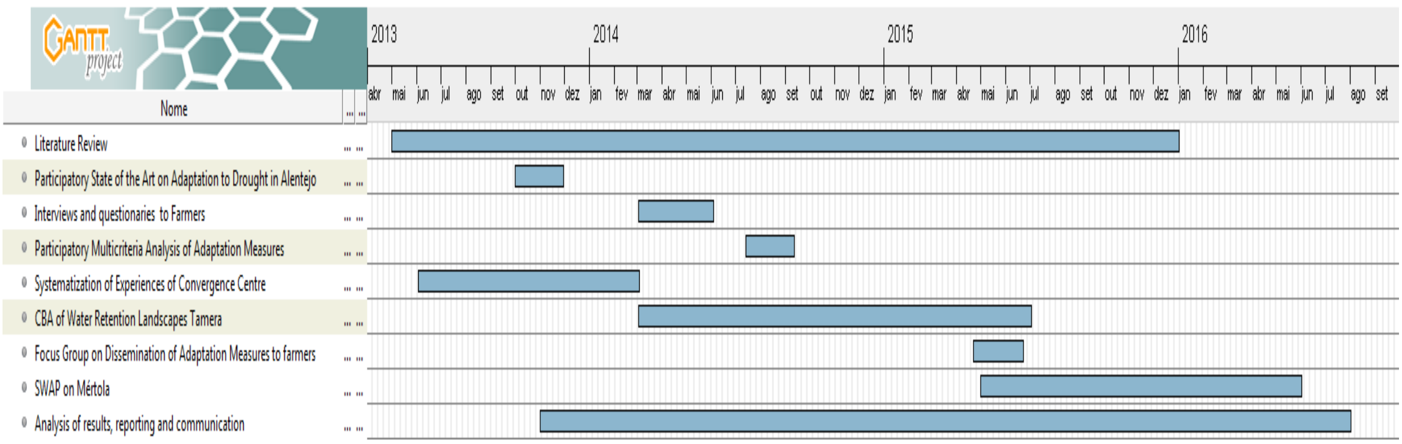
The methodologies listed above are referring to different levels of research within the case study.

At the first level, we investigate the adaptation measures for the agriculture and forestry sector in the semi-arid region of Alentejo in Portugal. Within this research level we implement:

- A participatory workshop to discuss climate change adaptation options for the region of Alentejo (on November, 2013) through the interaction of high level and local stakeholders, namely regional and national planners, decision makers, researchers, farmers and NGOs. We've called this workshop the Participatory State of Art of Climate Adaptation in Alentejo.
- A questionnaire to 20 farmers, to identify current and possible agricultural practices that support adaptation to agricultural drought.
- A participatory multicriteria workshop on the adaptation measures for agriculture and forestry in the Alentejo.
- A SWAP – Scenario Workshop and Adaptation Pathways to the adaptation of Agriculture and Forestry in one municipality I the region

  Within the second level of analysis, our focus is an in-depth study of innovative adaptation measures and projects in the region of Alentejo in areas without irrigation infrastructures. Within this research level, we apply:
- an in-depth analysis of an autonomous adaptation project in the region, designated as the Convergence Center at Aldeia das Amoreiras that works with enhancing adaptive capacity;
- and a in-depth analysis of the adaptation measure "Water Retention Landscapes" developed in the Tamera ecovillage. This analysis includes a cost-benefit analysis, a participatory cost-benefit analysis and the use of the INVEST model to quantify ecosystem services.

d) Case study Timeline



e) Collaboration with other Partners and Case studies

Collaboration with BASE case studies (see list in EMDESK):

Agriculture and Forestry case studies (e.g. Danish Rural)

Collaboration within BASE partners/researchers (EX: for a specific competence):

Name: __Volker Meyer and Oliver Gebhardt; Partner: _UFZ (CBA and Primate)

Name: __Bjorn Bedsted and Soren Gram_; Partner: DBT (Participatory methodologies)

Name_ Zuzana Harmácková ad Eliska Lorenckova (Czech Globe) (INVEST Model)

f) Research Outputs

a. Scientific Publications

- Interim reports + final case study report for D5.5 (Month 30)

- Scientific papers: #

Campos, I; Vizinho, A; Truninger M; and Penha-Lopes, G. (2015). Converging for deterring land abandonment – a Systematization of Experiences of a rural grassroots innovation. *Community Development Journal*. (in Press)

Santos A., Godinho D. P., Branquinho C., Vizinho A., Alves F, Pinho P, Penha-Lopes G., *Artificial lakes as a climate change adaptation strategy in drylands: evaluating the trade-off on non-target ecosystem services*, Journal of Environmental Management, Elsevier (Submitted, in review)

Huertas A. Master thesis "Co-designing a supporting tool for the dissemination and implementation of Climate Change Adaptation measures in the Council of Mértola, Portugal" (2015)

Provisional Title: ____Barriers and Opportunities for climate adaptation in the semi-arid Mediterranean;

Month/Year: _06__/_2017

b. Other Publications

c. Other

- Scientific conferences: # __1_

3. Participation in Climate Change Adaptation

a) Process overview

To develop a regional integrated assessment of climate change adaptation actions, by approaching the region's challenges in adapting to drought, and discuss an adaptation strategy (objectives 1 and 3– see section 2. c)), our methodology approach is based on farmers' interviews and stakeholder workshops.

21 semi-structured interviews have been done to Alentejo farmers, between May and July, 2014. Farmers were chosen based on their geographical location, size of their property and type of farming practices. Interview results are currently being analyzed. Information was collected on the farmers perceptions about climate change, and the problem of increased drought in Alentejo; on farming practices that support soil regeneration and irrigation, on the perceived impact of policies and regulations to support sustainable farming.

Six stakeholder workshops have been organized:

- one focusing on discussing existent adaptation knowledge for the region and possible adaptation solutions, took place on November, 20th, 2013 in Beja, Alentejo;
- the second focusing on a participatory multi-criteria analysis of adaptation measures for the agriculture and forestry of the region, took place on the 27th of November, 2014 in Beja;
- and the third and fourth workshop consisted on a SWAP-Scenario Workshop and Adaptation Pathways to an adaptation plan for the municipality of Mértola, one of the most vulnerable to desertification and climate change in the region Alentejo. The SWAP took place in Mértola on the 15th February and 5th April of 2016.
- The fifth workshop developed was a Systematization of Experieces developed with the stakeholders of the Convercence Centre of the village of Amoreiras. This process took during two preparatory workshops and a final session of four days that took place from 1st to 4th of November 2013 in Aldeia das Amoreiras, Alentejo.
- The sixth workshop was a participatory cost benefit analysis organized in Tamera with the stakeholders related to the Water Retention Landscapes. This took place on the 6th of June 2014 in Tamera, Alentejo.
- Another workshop was a focus group with associations of farmers that took place in Mértola on the 29th of July 2015

The November 2013 event brought together 36 stakeholders from academia; NGOs, regional and national authorities and decision-makers to map out the state of the art of the knowledge of climate adaptation in the region, highlighting its core challenges, barriers and opportunities.

The workshop was named "Participatory State of the Art on Adaptation to Climate Change in Alentejo" and focused on the Agriculture and Forestry sectors. The main objective was to present and discover the state of

the art knowledge and research on climate change adaptation of the agriculture and forestry sectors with researchers and different stakeholders, while at the same time discuss and prioritize the climate impacts, adaptation measures, projects and main points of contact for further work on the topic.

For an in-depth study of innovative adaptation measures and projects in the region of Alentejo (level 2 of our research approach - objectives 1, 2 and 3– see section 2. c), we started with an in-depth research of the Convergence Center of Aldeia das Amoreiras (CCAA), a local project against rural abandonment. Analysis of the Convergence Center took place between June and November, 2013. To understand the impact of Centro de Convergência da Aldeia das Amoreiras (CCAA) in promoting local adaptive capacity, and on sustainable adaptation actions for the region, we opted for a retrospective analysis of the case study where stakeholders were engaged from the beginning stages of the study. Our methodological approach followed the systematization of experiences method (Thede, 1999; Jara, 2010).

A full report of each stakeholder workshop mentioned above was produced and to know more please contact our team or case study coordinator (andrevizinho@fc.ul.pt).

b) Participation in the Process Phases

Process phases:

1. *Initiative/decision to act*

Like in other case studies and sectors, in the region of Alentejo and in the agriculture sector several adaptation measures are implemented without being specifically designed for adaptation to climate change. These measures are thus mostly considered as autonomous adaptation and are of initiative of local stakeholders. In this case, researchers analysed the autonomous adaptation of farmers, of the community of Tamera, and the village of Aldeia das Amoreiras. At the regional level there is not strategy for adaptation but only at the national level. A discussion and reflection on the impacts and measures at the regional level was developed in the context of BASE. In the end of the case study an adaptation plan to the municipality of Mértola was developed as mentioned above through the SWAP workshops. Furthermore another project, ClimaAdapt.Local developed, together with partner municipalities, 26 municipal adaptation plans for all sectors for 26 municipalities in Portugal, namely three in the Alentejo region (Odemira, Ferreira do Alentejo, Évora)

2. *Development of potential adaptation options*

At the regional level, the adaptation options were discussed during the action research process, namely over the two mentioned workshops - Participatory State of the Art and Participatory MultiCriteria Analysis. These

workshops benefited from the participation of several universities, research groups and researchers, farmers, private companies, local development and environmental NGOs, a public company responsible for the management of the Alqueva dam and the national agency of environment.

At the farm level, the adaptation options are developed by farmers, who receive information mostly from farmers associations and federations and private consulting companies. These options became known to BASE researchers through a set of semi-structured personal interviews to a representative sample of Alentejo Farmers (i.e. 21 interviews)

At the Tamera community level, the development of potential adaptation options was over the previous decade with the participation of their Tamera residents and several external experts. The main contributor and designer for the adaptation options (i.e. artificial lake system for water retention in the landscape) was an external Permaculture expert and consultant named Sepp Holzer.

At the Amoreiras village level, adaptability is not characterized by a single measure, but by a set of strategies, ways of being and living in the landscape and community projects that over the past 9 years have increased local social and ecological adaptability and resilience in the village. The project demonstrates that it is possible to produce a sustainable village, by mapping its resources and engaging local residents and citizens in a collective action towards a more sustainable future. This process was mainly ignited by a local development project - the Convergence Centre of Amoreiras Village. The Convergence Center, initially designed by member of a Lisbon based NGO (GAIA) was implemented by a group of external consultants and new residents the village. The process was developed over the years with a genuine participation of village citizens and benefiting from consultation and collaboration of several local partner institutions such as: public administration (municipality and district/parish), development and environmental associations (CMAA, ADA, CAC, FEsdime, Taipa, Teatro Três em Pipa, Tamera), local and regional media, other national and international NGOs (AFC, Rota Jovem), local public company of municipal waste (Ambilital).

3. *Decision-making*

At the regional level, there are several implemented adaptation measures that have important impacts at the regional scale, namely the Alqueva Dam (the biggest artificial lake in Europe) and financial support for regional development. Decisions at this level are made by different stakeholders in different sectors but are normally coordinated by the Regional Coordination Commission (CCDR – Alentejo). There still are no regional strategies for climate change adaptation in the agriculture and forestry sector in Portugal.

At the farm level, decisions are made by farmers that are also owners of their real-estate. Their decisions are mostly determined by the economic feasibility and capacity of investment, which means that given the

present economic conjuncture the decision for implementing adaptation options is influenced by public subsidies/ payments/ incentives to the farm.

At the Tamera community level, decision are made by a coordination body. The decision to implement a measure for water retention within the frontiers of the Eco Villa's community, did not take into account regional rules and legislation. This created some legal issues with the local administration, although the process of licensing has been taking place over the last year . However, the community's disregard for local dominant rules and structures ultimately simplified decision-making and the implementation of the innovative adaptation measure.

At the Amoreiras village level, a higher level of adaptability and resilience has been intrinsically linked to the participatory process and collective action taking place over the past nine years. Collective action resulted in a set of requests from the population to the municipality and to the national health services system, namely: the building of a sewage treatment facility, the presence of a doctor in the district/parish, building a children's playground. Other requests from the population were directly implemented by the population, but included the approval of the local district/parish administration. These include the whitewashing of the village by the population, and the improvement of public green spaces. Moreover, the Convergence Centre project has been disseminating and raising awareness on sustainability and climate change issues. Some members of the project have also demonstrated locally the use of techniques to prevent soil erosion and landslides. The introduction of organic farming in the region is also largely due to the residents that have arrived either as active members of the Convergence Centre or as local partners.

4. *Implementation*

Altogether, implementation of adaptations in this region is done mostly by the farmers, private and public companies, and local innovators and entrepreneurs. Measures implemented may be highly disarticulated. There is not yet a concerted regional or national action-plan to implement climate change adaptation in Alentejo.

c) Participation Experience

Strenghts	Weaknesses
Identify local solutions for soil irrigation and regeneration techniques Identify research gaps in climate change scenarios and adaptation for the region Multi-actor and multi-level engagement in joint discussions for climate adaptation Gain the support of national and regional policy makers. Identify new adaptation options not listed in the national adaptation strategy for the agriculture and forest sectors	Difficult to involve all relevant stakeholder groups in an action-research design that encompasses the whole region.
Opportunities	**Threats**
Develop an adaptation action-group for Alentejo Design an adaptation strategy for Alentejo, with the involvement of all relevant stakeholder groups Identify strategies, policies and regulations which may support local adaptation	An adaptation plan may never move to an implementation stage, leading to demotivation of stakeholders

d) Learning through Participation

In order to capture how participation could improve the climate change adaptation process, please report with regards to your case study:

a) Your view whether and how participation influenced the strategies and measures decided in your case?

   Yes, participation has been a key component in the social learning process that was developed throughout the case studies. Participatory events contributed to identify, characterize and assess adaptation actions, as well as to map out particular needs and knowledge gaps in the region.

b) How you think the participatory process in your case could be/have been improved?

There could have been more workshops following the last event to build on the prioritized adaptation measures and commence designing a holistic action-plan for the climate change adaptation in the region.

c) Any novel (use of) participatory methods observed in the case studies

Yes, both the Participatory State of the Art workshop and the Systematization of Experiences of the Convergence Centre resulted from a co-creative process developed by researchers and local practitioners. Also SWAP – Scenario workshop and Adaptation Pathways was used for the first time in the agriculture sector. The method Participatory Cost Benefit Analysis, applied in this case study and also in the Cascais Municipality case study also benefited the cost benefit analysis a novel add-on to cost benefit analysis.

4. Climate Change Adaptation Measures and Strategies

a) Adaptation Measures under analysis in your case study

Option	Strategy	Measure	Description	Reference
Protect Soil quality/Productivity	Increase amount or prevent loss of carbon in the soil		The amount of carbon in the soil is directly related to soil organic matter - this has a direct impact on plant growth and carbon sequestered in the soil can have a mitigation effect on the effects of greenhouse gases. Increasing soil organic carbon (SOC) is a key process in both mitigation and adaptation strategies to climate change. It has a particular relevance in Mediterranean agroecosystems, where soils usually have a low SOC content and are very vulnerable to desertification.	González-Prieto, S.J., Díaz-Raviña, M., Martín, A., López-Fando, C. (2013) Effects of agricultural management on chemical and biochemical properties of a semiarid soil from central Spain. Soil Tillage Research 134, 49-55. Aguilera, E., Lassaletta, L., Gattinger, A., Gimeno, B. S. (2013) Managing soil carbon for climate change mitigation and adaptation in Mediterranean cropping systems: A meta-analysis. Agriculture, Ecosystems and Environment, Vol. 168, pp. 25–36 http://www.upv.es/contenidos/CAMUNISO/info/U0644436.pdf

Protect Soil quality/Productivity	Increase amount or prevent loss of carbon in the soil	Use of compost and manure	Compost, either applied alone or in combination with cover crops, provides very high increases in carbon in the soil. it contributes to the soil C balance with additional biomass produced within the cropping system. It also minimizes soil disturbance and efficiently protects the soil against erosion, which is also an important process in SOC depletion. There exist many kinds of external sources of organic matter, including compost, manures and agro-industrial wastes.	Lal, R., 2003. Soil erosion and the global carbon budget. Environ. Int. 29, 437–450. Lal, R., 2004. Soil carbon sequestration impacts on global climate change and food security. Science 304, 1623–1627. http://www.upv.es/contenidos/CAMUNISO/info/U0644436.pdf
Protect Soil quality/Productivity	Increase amount or prevent loss of carbon in the soil Prevent evapotranspiration	Use of prunings and crop residues on site	The use of materials that are nowadays frequently burned in the field (pruning residues and straw) or constitute an environmental problem (olive mill and other agro-industrial wastes, urban wastes) directly back into the agro-ecosystem.	Sommer, S.G., Olesen, J.E., Petersen, S.O., Weisbjergz, M.R., Valli, L., Rodhe, L., Beline, F., 2009. Region-specific assessment of greenhouse gas mitigation with different manure management strategies in four agroecological zones. Global Change Biol. 15, 2825–2837.

Protect Soil quality/Productivity	Increase amount or prevent loss of carbon in the soil	Superficial soil tillage	Tillage destroys the natural soil structure and soil organic matter as well as the associated soil life and biodiversity, and many of the soil-mediated ecosystem functions that provide, regulate and protect environmental services. Offer higher effective rainfall due to higher infiltration and therefore reduced surface runoff and soil erosion as well as greater soil moisture-holding capacity.	Hernanz, J.L., Sanchez-Giron, V., Navarrete, L., 2009. Soil carbon sequestration and stratification in a cereal/leguminous crop rotation with three tillage systems in semiarid conditions. Agric. Ecosyst. Environ. 133, 114–122 Kassam, A., et al., (2012) Conservation agriculture in the dry Mediterranean climate. Field Crops Res.
Protect Soil quality/Productivity	Erosion Control	Interrange cover crops	inclusion of cover crops (usually winter cereals or natural cover) intercalated between the olive rows in order to reduce water erosion	Rodríguez-Carretero, M.T.,Lorite; I., Ruiz-Ramos, M., Dosio, A. and Gómez, J.A. (2013) Impact of climate change on water balance components in Mediterranean rainfed olive orchards under tillage or cover crop soil management, European Geosciences Union
Protect Soil quality/Productivity	Erosion Control	Construction of terraces	Construction of terraces to reduce slopes; building of small dams to help nutrient sedimentation and prevent the formation of cavities in the riverbeds; protect the soil from direct waterdrop impact with mulch or stones; planting a	

			cover of living plants such as leguminous species;	
Protect Soil quality/Productivity	Erosion Control	Agroforestry plantations	promote agroforestry and bioenergetic plantations - can reduce nutrient leaching and soil erosion, and generate additional environmental services. They can contribute to the recycling of nutrients.	López Fernández, A. El Olivar: entre la dehesa y la erosión, http://helvia.uco.es/xmlui/bitstream/handle/10396/9277/braco160.5.pdf?sequence=1 FDER (2011) Mapa de Impactos del Cambio Climático en Extremadura, Junta de Extremadura
Protect Soil quality/Productivity	Erosion Control	Direct seeding	Soils are subjected to negligible disturbance, usually only narrow slots opened for seed insertion with planters	González-Sánchez, E.J., Ordóñez-Fernández, R., Carbonell-Bojollo, R., Veroz-Gonzalez, O., Gil-Ribes, J.A. (2012) Meta-analysis on atmospheric carbon capture in Spain through the use of conservation agriculture. Soil Till. Res. 122, 52–60. FDER (2011) Mapa de Impactos del Cambio Climático en Extremadura, Junta de Extremadura
Reduce vulnerab	Cultivating a range	Selecting climate-adapted	Fig, carob, almond, pomegranate, apricot, suitable introduced species and annual crops, would allow farmers to be	AGFORWARD WP1 (2014)

ility to draught	of tree species with low irrigation requirements	crops and fruit trees.	less vulnerable to both market fluctuations and drought	
Reduce vulnerability to draught	Increase water use efficiency	Conversion from traditional flood irrigation to drip irrigation technology	improve the water use efficiency of irrigation farmers and could thus be supported to reduce farmers vulnerability and to avoid water scarcity Conversion from traditional flood irrigation to drip irrigation technology could greatly improve the water use efficiency of irrigation farmers and could thus be supported to reduce farmers vulnerability Improved irrigation practices (e.g. generalized drip irrigation and underground irrigation) may, on the other hand, save up to 50% water as compared with traditional or conventional irrigation systems	AGFORWARD WP1 (2014) Le Houérou, H.N. (1996) Climate change, drought and desertification. Journal of Arid Environments (1996) 34: 133–185 http://www7.nau.edu/mpcer/direnet/publications/publications_l/files/LeHouerou_1996.pdf
Protect Soil quality/Productivity	Erosion Control	Tillage in contour line: do not till the soil in areas with steep slope.	Superficial tillage to be done perpendicular to the slope to retain as much water as possible Aligning plant rows and tillage lines at right angles to teh normal flow of runoff. The rate of runoff is slowed down, thus giving the water time to infiltrate the soil	Gabriels, D., Cornelis, W.M. and Schiettecatte, W. (2010) Water Harvesting and Water-Saving Techniques. Land Use, Land Cover and Soil Sciences, Vol. V http://www.eolss.net/sample-chapters/c12/E1-05-06-10.pdf
Reduce vulnerability of farmers	Value and use the wild products of the Mediterranean (PAM, Arbutus, honey,figs, mushrooms, carob)	Support and facilitate promotion and sale of non-timber forest products	Importance of diversifying farmers' income around different forest products (e.g. rural tourism), to provide complementary benefits and working opportunities all year round, while guaranteeing sustainable harvesting	Croitoru, L. (2007) Valuing the non-timber forest products in the Mediterranean region, Ecological Economics, Vol. 63, pp. 7 6 8 – 7 7 5 Strategic framework for forests and climate change. Collaborative Partnership on Forests, 2008

Reduce vulnerability of trees and crops	selection and improvement of species	Diversification through climate-adapted species	Increasing genetic diversity will help the ecosystem adapt faster to changes in the environment The maintenance of high genetic diversity will help ensure a higher forest adaptive capacity. Forest species and populations with higher phenotypic plasticity and genotypic diversity can better tolerate changes in the environment.	FDER (2011) Mapa de Impactos del Cambio Climático en Extremadura, Junta de Extremadura IUCN (2008) Adapting to Global Change: Mediterranean Forests, https://cmsdata.iucn.org/downloads/adapting_to_global_change.pdf
Reduce vulnerability of trees and crops	Change tree species composition	Planting new tree species that are better adapted to the predicted climate conditions	Accelerate migration by planting new tree species that are better adapted to the predicted climate conditions Increase mixed forest stands and tree diversity, especially in ecotonal zones, combining different life strategies (resprouting, fruit trees, etc.) and drought tolerant species.	IUCN (2008) Adapting to Global Change: Mediterranean Forests, https://cmsdata.iucn.org/downloads/adapting_to_global_change.pdf Vennetier, M., Ripert, C., (2009) Forest flora turnover with climate change in the Mediterranean region: A case study in Southeastern France, For. Ecol. Manage
Reduce vulnerability of trees and crops	Change tree species composition	Thinning	Thinning is the cutting down and removal of a proportion of trees in a forest crop. It is carried out primarily to provide more growing space for the remaining trees, which leads to an increase in volume of individual trees. Thinning also provides the farmer with an intermediate source of timber revenue before the final crop is cut down at the end of the rotation. In the context of impending climate change, the issue of stand density influence on soil water availability remains crucial and warrants thorough quantification. Thinning remains the principal silvicultural means through which the forest manager can avoid the severe water stresses and slow growth rates	IUCN (2008) Adapting to Global Change: Mediterranean Forests, https://cmsdata.iucn.org/downloads/adapting_to_global_change.pdf
Protect Wildlife and Biodiversity	Microclimate creation and management	Select trees adapted to climatic conditions that can provide shade	Appreciation of trees for their microclimatic effects in sylvopastoral agroforestry systems has been clear. Tree shade in relation to the daily cycle of livestock activity and movement can reduce direct heat exposure of the animals, and hence their sensitivity to climate variability The evolution over time of forest communities helps create microclimate conditions in the forest understorey, which allow the existence of species which may not withstand the external climatic conditions. Thanks to this feature, the maintenance and restoration of mature old-growth forest	Thornton, P.K., Van de Steeg, J., Notenbaert, A. and Herrero, M. (2009) The impacts of climate change on livestock and livestock systems in developing countries: a review of what we know and what we need to know. Agricultural Systems 101, 113–127 Regato, P. (2008) Adapting to Global Change, IUCN

			stands is extremely valuable for building resilience against future climate change	
Reduce vulnerability to draught	Increase landscape water retention	Build natural dams, pools and lakes	Natural water retention can be improved through techniques like creating wetlands and increasing soil coverage. Additional water storage capacity can be achieved with structures such as off-stream polders. Water retention landscapes are seen as good adaptation solutions because they retain runoff, and promote water infiltration and aquifer recharge. Creation of water retention spaces with dams made of natural materials (no concrete or plastic)	M. Máñez, A. Cerdà (2014): Prioritisation Method for Adaptation Measures to Climate Change in the Water Sector, CSC Report 18, Climate Service Center, http://www.climate-service-center.de/imperia/md/content/csc/csc_report_18.pdf Boinet. E. (2015) The interest of Natural Water Retention Measures for climate change adaptation, EU-NWRM- project http://www.world-water-forum-2015-europa.eu/IMG/pdf/inr.1.3.eu_boinet_edouard_nwrm.pdf
Reduce vulnerability to draught	Water harvesting	Capture runoff with hillside lakes	practices that aim at enhancing soil infiltration at the site, improving rainfed cultivation (in situ rainwater harvesting), or collecting and diverting rainwater to reservoirs harvesting of surface water and the protection of sloping land, constructing water reservoirs (dams, hillside lakes, etc.). Capturing runoff water (runoff harvesting), promoting infiltration, enhancing water holding capacity, and reducing evaporation	Bergaoui, M. and Albergel, J. (2002) The Effects of a Dry Stone Anti-Erosive Management on the Strength and Shape of Floods: Example of the Zioud Wadi Watershed in Central Tunisia, 12th ISCO Conference

Reduce vulnerability to draught	Water harvesting	Water harvesting: micro	Microcatchments are simple structures designed to increase the surface of land (source) that supply runoff water to the planting hole (sink) by shaping small channels at both sides of the hole that direct collect runoff to it Delineation of natural depressions, construction of contour and stone bunds, systems for inter-row water harvesting, terracing, construction of semicircular and triangular bunds, pits, Vallerani-type micro-catchments, meskats, negrim	Vallejo, V., Smanis, A., Chirino, E., Fuentes, D., Vladecantos, A. and Vilagros, A. (2012) Perspectives in dryland restoration: approaches for climate change adaptation, New Forests Vol. 43, pp. 561–579 Gabriels, D., Cornelis, W.M. and Schiettecatte, W. (2010) Water Harvesting and Water-Saving Techniques. Land Use, Land Cover and Soil Sciences, Vol. V http://www.eolss.net/sample-chapters/c12/E1-05-06-10.pdf Yazar, A., Kuzucu, M., Çelik, I., Sezen, S.M and Jacobsen, S.E. (2014) Water Harvesting for Improved Water Productivity in Dry Environments of the Mediterranean Region Case study: Pistachio in Turkey, J Agro Crop Sci, Vol. 200, pp. 361–370 http://onlinelibrary.wiley.com/doi/10.1111/jac.12070/pdf
Reduce vulnerability to draught	Water harvesting	Water harvesting: macro	Hillside conduits, floodwater diversion, underground reservoirs, cisterns; surface tanks, ponds and reservoirs	Gabriels, D., Cornelis, W.M. and Schiettecatte, W. (2010) Water Harvesting and Water-Saving Techniques. Land Use, Land Cover and Soil Sciences, Vol. V http://www.eolss.net/sample-chapters/c12/E1-05-06-10.pdf
Reduce vulnerability to draught	Water harvesting	Water harvesting from fog	Fog may represent an important source of water to ecosystems. When fog meets a natural or artificial obstacle water condensates at the obstacle's surface. It can later be stored for further use in restoration activities during water stress periods.	IUCN (2008) Adapting to Global Change: Mediterranean Forests, https://cmsdata.iucn.org/downloads/adapting_to_global_change.pdf Vallejo, V., Smanis, A., Chirino, E., Fuentes, D., Vladecantos, A. and Vilagros, A. (2012) Perspectives in dryland restoration: approaches for climate change adaptation, New Forests Vol. 43, pp. 561–579
Reduce vulnerability to draught	Water harvesting	Aquifier recharge	Technique used in arid and semi-arid regions to enhance natural ground water supplies using manmade systems such as infiltration basins or injection wells. Excess water can then be used later for water supply or environmental protection. Particularly relevant to address climate change in areas with low natural recharge or surface water quality problems.	M. Máñez, A. Cerdà (2014): Prioritisation Method for Adaptation Measures to Climate Change in the Water Sector, CSC Report 18, Climate Service Center, http://www.climate-service-center.de/imperia/md/content/csc/csc_report_18.pdf NWRM (2013) Atmospheric Precipitation -

BASE report

				Protection and efficient use of Fresh Water, MEDIWAT Project
Reduce vulnerability to draught	Increase water use efficiency	Renewable energy for irrigation systems (solar, wind)	many easy and simple options can be applied without electricity storage, such as direct pumping, using wind turbines, photovoltaic panels, or both, for drip irrigation; this can be coupled with achieving the required constant pressure by water accumulation in an elevated tank in days with no wind or sufficient radiation	Carroquino, J., Dufo-López, R. and Bernal-Agustín, J.L. (2015) Sizing of off-grid renewable energy systems for drip irrigation in Mediterranean crops, Renewable Energy, Volume 76, Pages 566–574 http://www.sciencedirect.com/science/article/pii/S0960148114008003
Reduce vulnerability to draught	Wastewater reuse	Reclaim wastewater	Reclaimed water (or recycled water) is former wastewater (sewage) that, additionally to the common treatment given in a wastewater treatment plant (primary treatment + aerobic/anaerobic treatment), goes through a tertiary treatment in which solids and certain impurities are removed, obtaining a high quality water used in sustainable landscaping irrigation or for recharging groundwater aquifers.	M. Máñez, A. Cerdà (2014): Prioritisation Method for Adaptation Measures to Climate Change in the Water Sector, CSC Report 18, Climate Service Center, http://www.climate-service-center.de/imperia/md/content/csc/csc_report_18.pdf Monteverdi, M.C., Da Canal, S., Del Lungo, A., Masi, S., Larbi, H. and De Angelis, P. (2014) Re-use of wastewater for a sustainable forest production and climate change mitigation under arid environments. Annals of Silvicultural Research, Vol. 38, Issue 1, pp. 22-31
Reduce vulnerability to draught	Wastewater reuse	Constructed Wetlands	Constructed wetlands: ponds placed in sequence, filled with specifically selected plants, shrubs and vegetation for their ability to filter impurities from the water	mediterranean Wastewater Reuse Working Group (2007) Mediterranean Wastewater Reuse Report, EUWI http://ec.europa.eu/environment/water/water-urbanwaste/info/pdf/final_report.pdf
Reduce vulnerability to draught	Landscape water retention	Micro modelling for water retention in the soil	rock fragments in the soil profile may also facilitate the penetration of the wetting front down the soil profile by decreasing the density of fine earth and increasing macropores. A dry well filled with stones (Dry Well), 20–25 cm deep and close to the planted seedling promotes infiltration around the root system before collected water evaporates	Van Wesemael B, Vertraten JM, Sevink J (1995) Pedogenesis by clay dissolution on acid, low grade metamorphic rocks under Mediterranean forests in southern Tuscany (Italy). Catena 24:105–125

Protect Wildlife and Biodiversity	Refrain from Clearing	Preserve hedgegrows	hedgerows potentially function as refuge habitat and/or corridors due to their capacity to provide milder temperature conditions and a higher soil water content refrain from clearing - the bush serves as shade, protection against the cold and food for animals	Sánchez, I.A., Lassaletta, L., McCollin, D. and Bunce, R.G. (2010) The effect of hedgerow loss on microclimate in the Mediterranean region: an investigation in Central Spain. Agroforestry Systems 78, 13–25.
Protect Wildlife and Biodiversity	Choose species for characteristics beyond productivity	selection of species according to projected climate conditions	reforestations are carried out using a larger number of native tree and shrub species, taking into account objectives other than simply productivity, i.e. plant biodiversity and functionality, soil conservation, climate change mitigation, among others.	Vallejo, V., Smanis, A., Chirino, E., Fuentes, D., Valdecantos, A. and Vilagros, A. (2012) Perspectives in dryland restoration: approaches for climate change adaptation, New Forests Vol. 43, pp. 561–579
Protect Soil quality/Productivity	Increase amount or prevent loss of carbon in the soil	placement of sewage sludge to increase the organic matter	Mediterranean soils favor the application of sewage sludge as an organic amendment and nutrient supply to these soils with a relatively small risk of pollution. An increase in soil organic matter and nutrient availability after sewage sludge application has been observed by many researchers. the addition of lime may significantly reduce the solubility and bioavailability of heavy metals from sewage sludge. Thus, an increase in pH may also prevent the risks of soil and plant contamination by heavy metals	Bozkurt, A., Yarilgaç, T. and Yaziçi, A. (2010) The Use of Sewage Sludge as an Organic Matter Source in Apple Trees, Polish J. of Environ. Stud. Vol. 19, No. 2, 267-274 - http://www.pjoes.com/pdf/19.2/267-274.pdf
Protect Soil quality/Productivity	Erosion Control	Conservation tillage	Minimizing soil disturbance, either with no-tillage or with some other conservation tillage practice. No-tillage is the only type of conservation tillage that appears to promote C sequestration. In Mediterranean herbaceous systems, no-tillage practices are usually associated to higher C inputs to the soil, mainly because straw is retained instead of being removed or burned Soil Organic Carbon losses can mainly be reduced: reducing the number of passes, tilling at a shallower depth or avoiding soil inversion.	González-Sánchez, E.J., Ordóñez-Fernández, R., Carbonell-Bojollo, R., Veroz-Gonzalez, O., Gil-Ribes, J.A. (2012) Meta-analysis on atmospheric carbon capture in Spain through the use of conservation agriculture. Soil Till. Res. 122, 52–60. FDER (2011) Mapa de Impactos del Cambio Climático en Extremadura, Junta de Extremadura
Protect Soil quality/Productivity	Create wind barriers	Planting trees in marginal agricultural land	Use of agricultural land in marginal areas or areas not reached by irrigation systems. These plantations could improve the efficiency in irrigation as they act as a wind barrier or reduce horizontal water flow.	AGFORWARD WP2 (2014) Portugal Montado System

b) Adaptation Measures selection and data availability prior to BASE

c) Full description of Adaptation Measures

Process

I. Would, or at which part would, institutions and private stakeholders implement the measure autonomously to adapt to climate change (Adaptive capacity)?

Most measures are being autonomously implemented by local farmers and communities.

II. Does the measure initiate further activities for adaptation to climate change? (Y/N)

  a. If Yes, please name which

  It is not possible to understand yet, of the measures will lead to more activities for CC adaptation

III. Does adaptation aim for flexibility and reflexivity (i.e. the ability to change as CC and other factors develop)? (Y/N) Yes

IV. Is the measure effective under different climate scenarios and different socio-economic scenarios? (Y/N) Yes

V. Is the adaptation measure iterative? (Y/N)

Yes

VI. Does the measure contribute to overall sustainable development, alleviate already existing problems and bring benefits for other social, environmental or economic objectives than adaptation (no regret measures)? (Y/N) Yes

  a. Please describe briefly how

Most adaptation options in Alentejo have this dimension, since they will contribute to higher productivity and quality of living standards.

VII. Can adjustments be made later if conditions change again or if changes are different from those expected today? (Y/N)

Yes

Relevance and effectiveness of adaptation measures

VIII. How important is the climate change threat addressed by the measure? What economic values, ecosystem functions and socio-cultural values are at stake, and to what extent are they affected by climate change impacts? Is there an indication of overriding public interest, e.g. critical infrastructures, public health?

It is central for a sustainable development in the region. Rural exodus and land abandonment are serious problems in the area and climate change poses an additional threat.

IX. What portion of the targeted potential damages can be avoided by implementing the measure? (0-100%)

Efficiency

X. How high are the benefits of the measure relative to the costs? Are the costs justified by the benefits

(Please refer to results of economic evaluation in chapter 5)

XI. What are the costs of the administrative implementation of the measure? Are there potential funding under the umbrella of other European policies (eg. CAP/Cohesion policy?

(fill with your answer)

XII. Does the measure give an incentive for innovation to different actors (e.g. SMEs) / can it deliver a competitive advantage for the local economy? (Y/N)

XIII. Does the measure have effects on employment? (Y/N)

XIV. How long is the time-lag between implementation of the adaptation measure and the effect of the measure? _______

XV. What is the timeframe during which the measure will have an effect? ________________________

XVI. Does the measure create synergies with mitigation (i.e. reduce GHG emissions or enhance GHG sequestration)? (Y/N)

XVII. Does the measure alleviate or exacerbate other environmental pressures? (Explain briefly)

(fill with your answer)

Equity

XVIII. What are the impacts on different social or economic groups, are there expected impacts on

(fill with your answer)

particularly vulnerable groups? (distributional impact)

XIX. Does the measure enhance well-being and quality of life (e.g. in the urban environment)? (Y/N)

5. Impacts, Costs and Benefits of Adaptation measures

e) Step 1 – Preliminary Risk Assessment and identification of adaptation tipping points (max 1500 words)

The projected impacts from climate change for the Mediterranean region are well known and documented. In fact, the Mediterranean drylands have been identified as one of the most prominent regions affected in climate change projections (Schröter et al. 2005, Giorgi 2006). Temperature rise – larger than any other European region -, increase in heat waves, together with a decrease in precipitation envision a future of increased risk of desertification and biodiversity loss for most of southern Portugal, Spain, Italy and Greece (EEA 03/2013). In the Portuguese history drought[4] events occur often with severe consequences (Figure 4), namely in agriculture production. In the last 65 years Portugal witnessed seven extreme drought periods (Figures 5 and 6): 1943/46, 1965, 1976, 1980/81, 1991/92, 1994/95 e 1998/99 e 2004/06. From these, the 2004-06 was by far the one with the biggest territorial cover (100% of the Portuguese national territory) and the most intense in duration and severity (see figure 4) as well as overall cost, estimated in 286.205.800 € (PNUEA Report, 2012). These estimated costs, however, do not englobe all assumed social, economic and environmental costs – for example the rise in CO2 Emissions and consequent economic costs – as droughts can have multi-sectorial and multi-scale impacts (Figure 4). This is particular relevant for the Alentejo region where agriculture productivity has a strong relation with the region's income and droughts can have a significant impact in people migratory dynamics and in the human and environmental desertification[5] of this region. It is also important to to acknowledge that in such regions such as the Alentejo droughts can play an even more crucial role in intensifying the cycle of desertification (Figure 8) as these are already fragile ecosystems with high social and environmental exposure to droughts (PNCAD, 2004).

[4] In this report we consider Drought's to be temporary natural water scarcity conditions derived from climatic conditions. According to Pereira et al (2010), „..drought is defined as a natural but temporary imbalance of uncertain frequency, duration and severity, whose occurrence is difficult to predict".

[5] According to the UNCCD Desertification is „land degradation in arid, semi-arid and dry sub-humid regions resulting from various factors, including climatic variations and human activities."

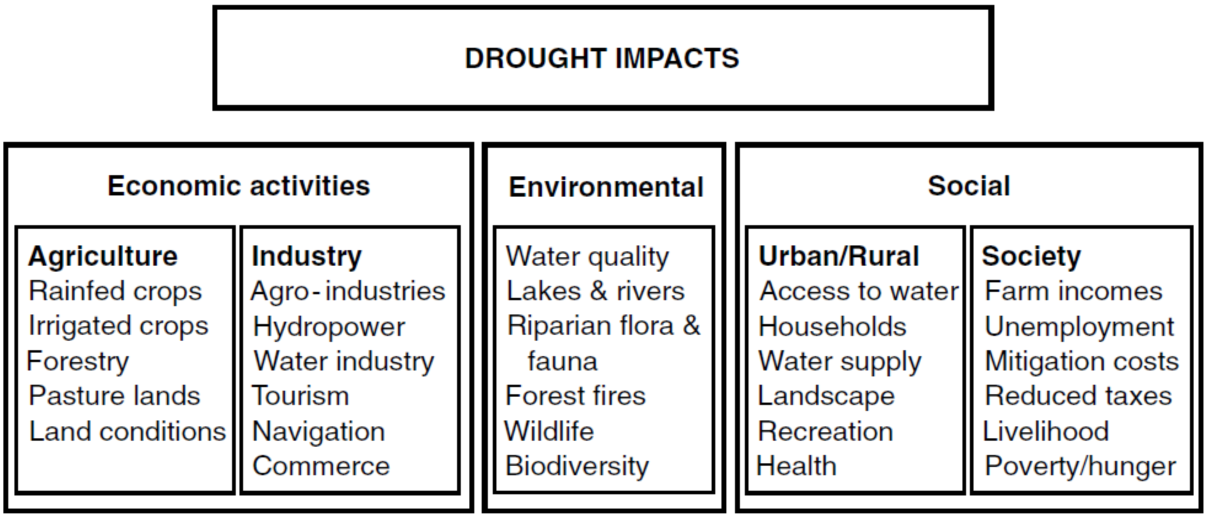


Figure 4 – Drought impacts (Pereira et al 2010)

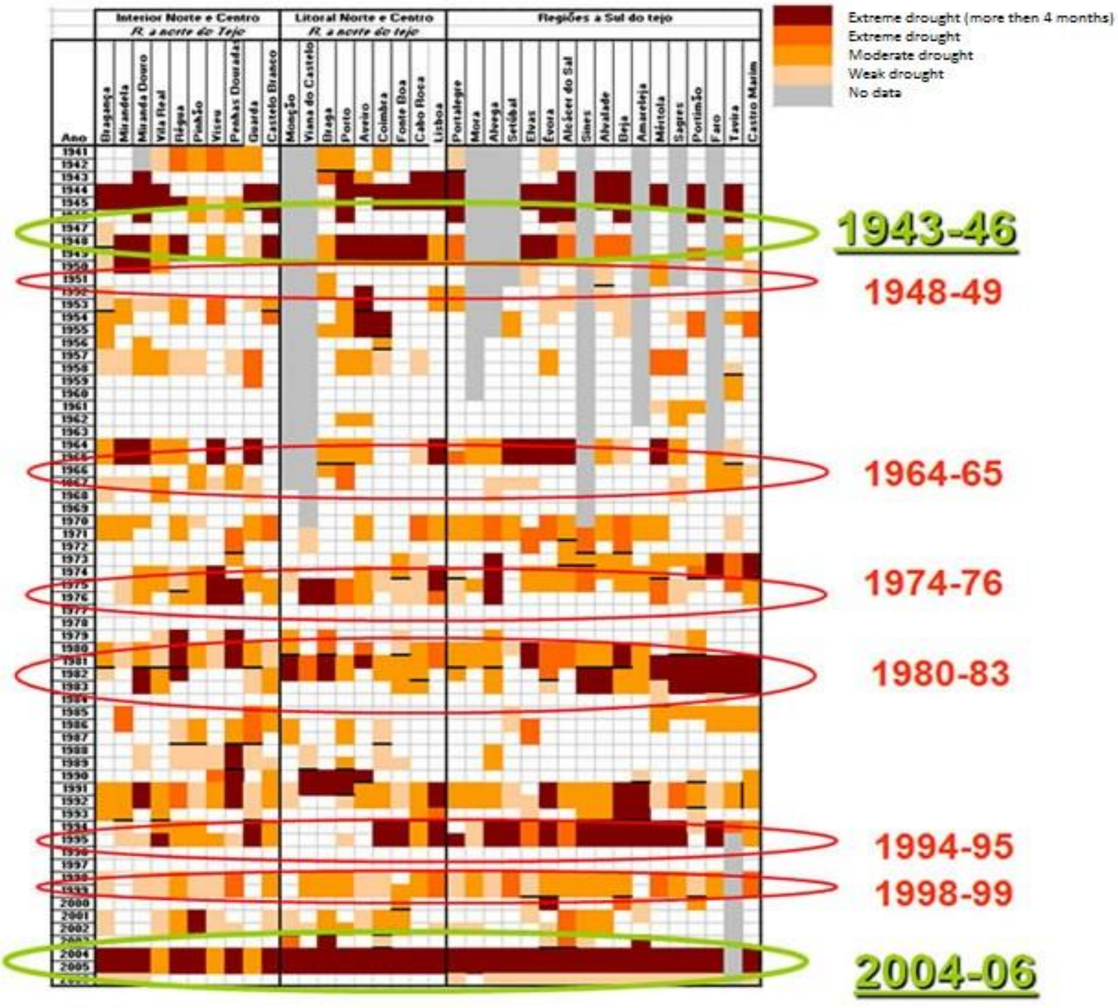


Figure 5 – Territorial cover and severity of droughts in Portugal in the period 1941-2007

Regarding the monitoring and measuring of droughts, the Palmer Drough Severity Index (PDSI)[6] has been calculated from 1900-2014 for Portugal with relevant conclusions, namely the fact that in the last decades we've observed an intensification in the frequency of droughts, particularly in the months from February to April (see figure 7, Pires et al 2010) and in the Alentejo region (see figure 6 below for the city of Elvas). More recently and after the December 2009 Lincoln Declaration on Droughts Indices, signed by consensus by the UNCCD, the Portuguese national meteorological institute is also using the Standard Precipitation Index (SPI)[7] which yields similar results and overall conclusions.

Both of the fore mentioned indices only produce historical data based on observations and modelling and do not offer future predictions for this extreme weather events. However, the European Centre for Medium-Range Weather Forecasts (ECMWF) does provide EU members with a medium-range (30 and 90 days) forecast for the PDSI which can be used to develop better early warning systems.

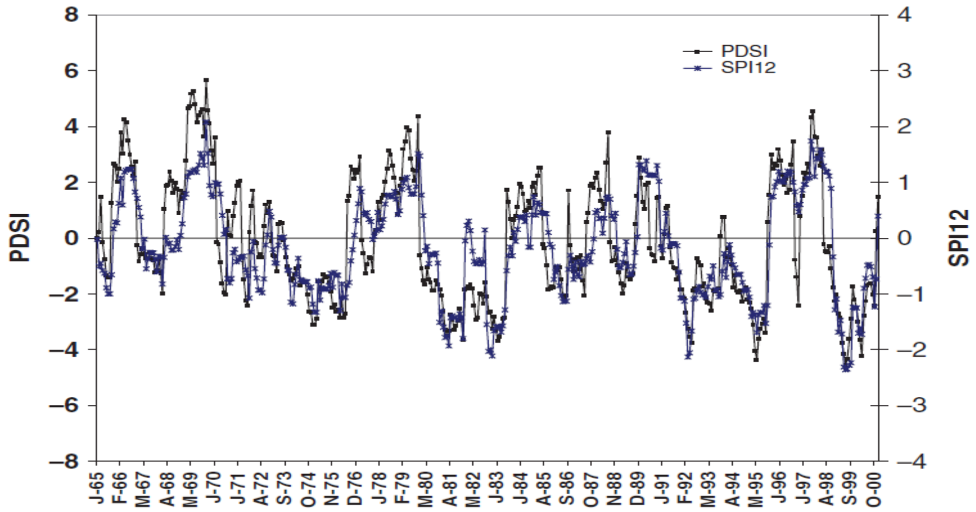


Figure 6 – Comparing the drought indices PDSI and the 12-month SPI[8] 1965-2000 for Elvas, Portugal (Pereira et al 2010)

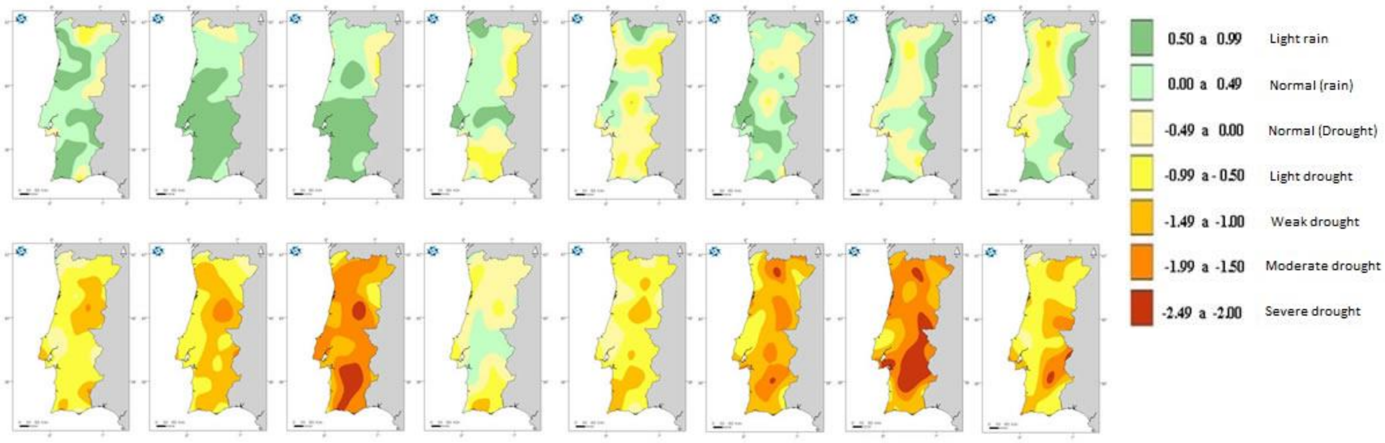
1960-1970

1971-1980

[6] The PDSI is just one of many possible indicators to measure drought (see figure XX in Annex). It is considered as an metereological index. However, some authors also refer to its relevance for agriculture as the main purpose is to measure the departure of the moisture supply in the soil. For more information on the PDSI please see Palmer WC (1965), Metereological drought, Research paper No. 45, US Dept. Of Commerce

[7] For more information and comparison between the two indices please see Guttman, N.B. (1998), Comparing the Palmer Drought Index and Standardized Precipitation Index, Water Resources Association, No. 34, pp: 113-121

[8] SPI: Standard Precipitation Index



1981-1990

1991-2000

Figure 7 – Historic evolution of the PDSI 1961-2000 in Portugal (Trimestral average)

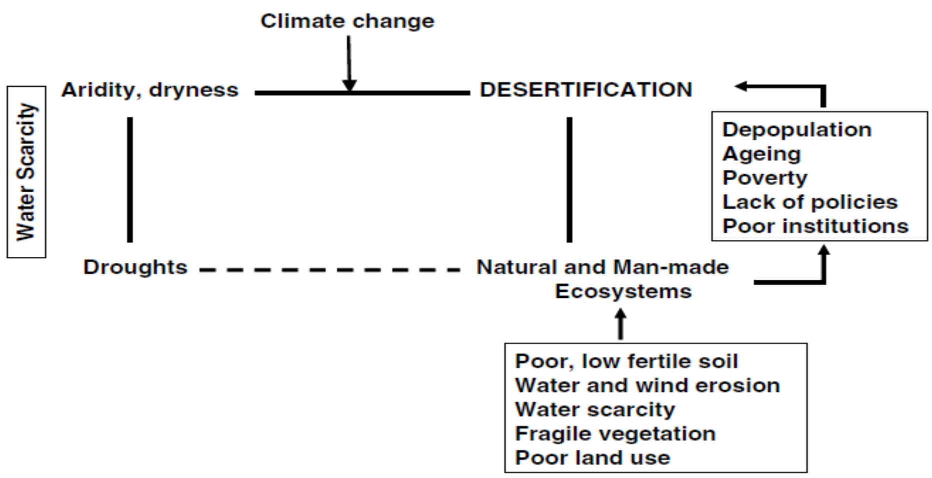


Figure 8 – The circle of the desertification integral process by Pereira et al (2006)

The IPCC WGII AR5 reports that analysing and predicting future trends in droughts occurrence due to climate change is a complex processes with inherent difficulties not only regarding the categories and definitions of drought (meteorological, hydrological, etc.) but also regarding the lack of observational data and the unpredictability of extreme weather events. Nevertheless, the Mediterranean region shows a clear trend towards more severe (Wong et al. 2011), more frequent (Hisdal et al. 2001, Iglesias et al. 2007) and longer droughts (Kim and Byun 2009), with increased water stress due to precipitation decline (Collins et al. 2013; Hesselbjerg et al. 2013; De Luis et al. 2001, De Dios 2007) and decreased groundwater recharge (Boko 2007).

As one can see in figure 9 even taking into consideration multiple models under RCP 4.5 the impacts felt on the Mediterranean are among the most severe worldwide concerning droughts. This is also the case for mega-drought events[9], for which there is a growing risk projected for the Mediterranean region in all RCP scenarios.

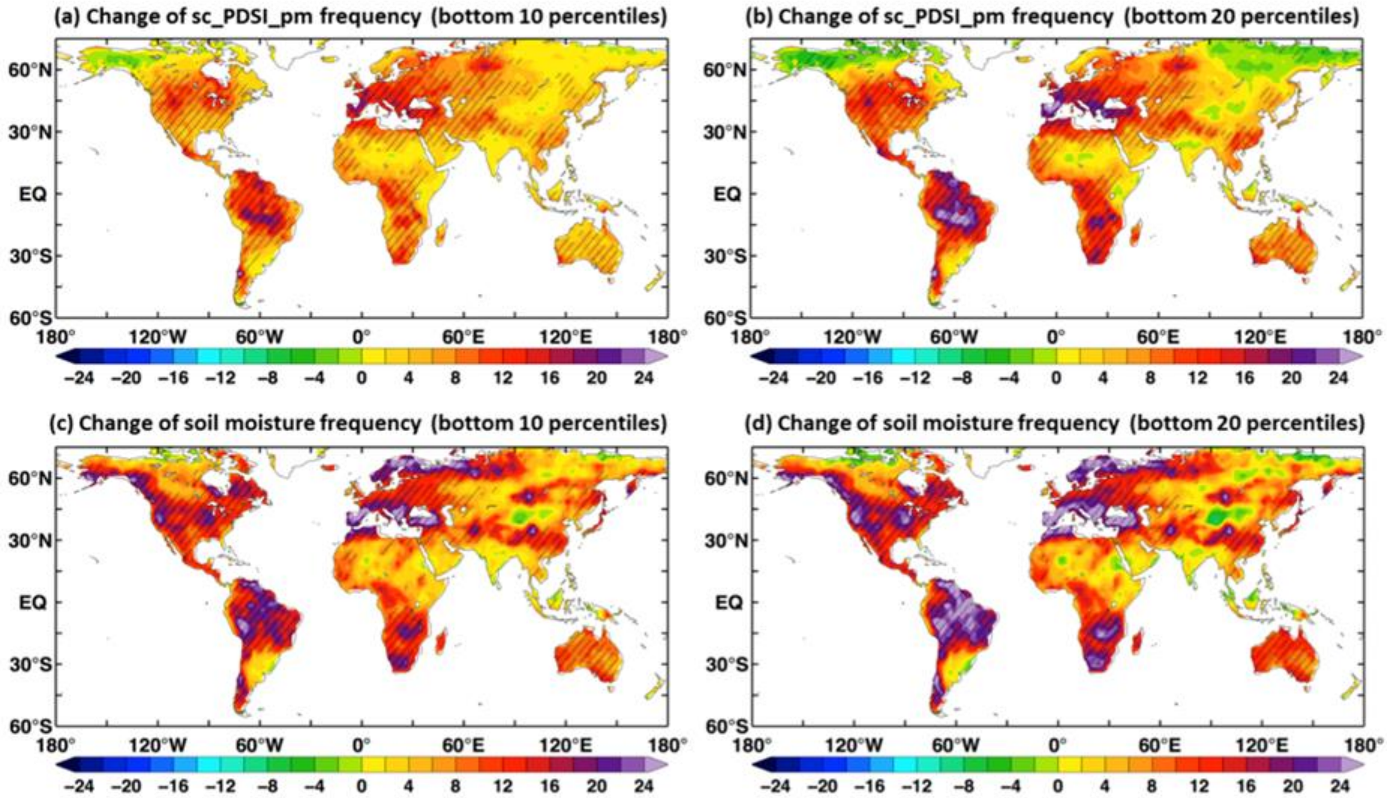


Figure 9 – Multi-model ensemble avreaged changes of drought frequency from 1970-1999 to 2070-2099 under the RCP 4.5 scenario (Zhao and Dai 2014)

Finally it is crucial to highlight that these projected drought events can strongly exacerbate soil erosion, loss of top soil and nutrients flow and availability, which is directly connected with the capability of ecosystems deliver key services, such as water purification (De Groot et al. 2010, Keller et al 2012), and these with agriculture productivity and human habitability of such regions (Rosenzweig and Tubiello 1997). The cycle of desertification identified (figure 7) is also strongly influenced by future projections of increase in water demand (EEA 12/202) and other pressures in ecosystems such as higher urbanization pressures.

[9] Mega-droughts or multi-decadal droughts are decades-long droughts lasting two decades or more (Cook et al. 2011). The term has been used in grey literature also to describe multiyear droughts with strong severity, such as the Dust Bowl drought 1930's.

f) Step 2 – Identification of Adaptation Measures

Within the existing national strategies already mentioned (PNCAD, ENAAC, PNUEA) several mitigation and adaptation measures to face climate change impacts in the Alentejo have been identified, analysed and ranked. During BASE, regional stakeholders - practitioners (Farmers), farmers associations, decision-makers and researchers - were convened in a participatory workshop in order to discuss and vote for Alentejo's most effective and efficient measures to deal with climate change future impacts. In this event (November 2014), 21 adaptation measures to face drought and water scarcity were considered and voted regarding Droughts and Water Scarcity. Among mulching and other soil coverage techniques, crop diversification, holistic management together with new irrigation systems, there is a group of measures that concerns rainwater harvest and retention but that differ significantly in terms of scale and uses. From the construction of big dams used to irrigate vast areas to the management of small scale seasonal ponds, different options with different impacts were considered. Among them, the Water Retention Landscape (WRL) of Tamera (see figure 10 and 11) stands out as a unique case study not only due to its Permaculture[10] holistic design but also due to the larger vision it represents: A Vision for a 1000 lakes in the Alentejo.

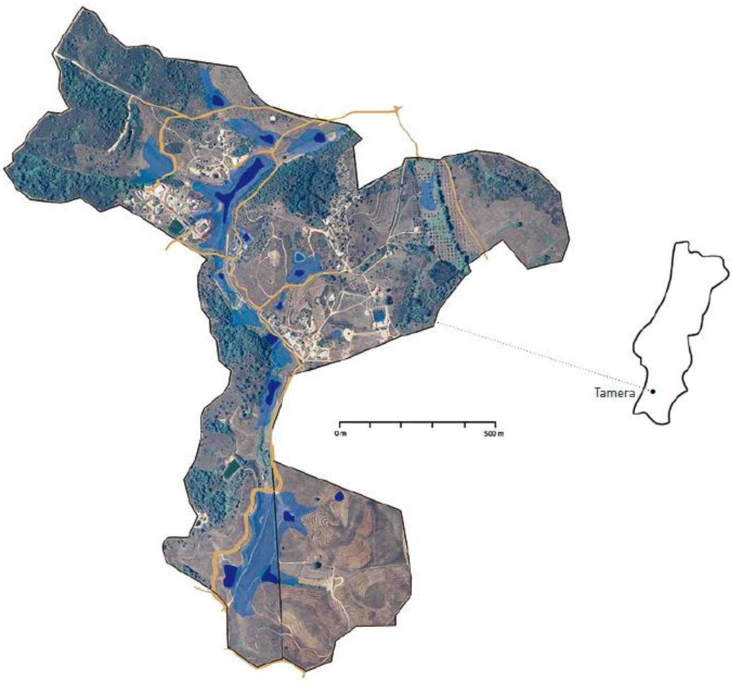


Figure 10 - Water Retention Landscape of Tamera in 2013

[10] Permaculture is and holistic design system based on ethics and principles derived from the observation of nature's patterns and which can be applied to the development of environmental, economic and social systems that support sustainable livelyhoods (Homgren 2004).

According to CIRCLE-2 publication "Adaptation Inspiration Book" (2013)[11], water retention landscapes (WRL): "*are permanent artificial lakes that serve to manage storm water runoff, prevent flooding and erosion, improve the water quality and support the restoration of the water cycle by retaining the water in the areas where it falls as rain. In addition, they improve the quality of their environment and allow for groundwater recharge. Water retention basins are sometimes also referred to as wet ponds. A water retention landscape consists of a series of interconnected retention spaces, from pond-sized up to lake-sized, in which the rainwater can collect behind a dam constructed from natural material. The retention spaces themselves are not sealed with concrete or any artificial layer, so the water can slowly but steadily diffuse into the earth-body*." It is important to highlight that rainwater harvesting has been neglected in recent agricultural water supply developments, even though there is a long history in traditional water supply for agricultural purposes (Wisser et al 2010; Frolking et al. 2010). Especially the significance of rainwater harvesting in small reservoirs has been underlined by several studies in semi-arid zones (Smith et al. 2002; Van de Giesen et al. 2005). Water storage in soils of the Alentejo region seems to be rather low, as soils of the region, derived from schist or granite, are mainly characterized by scarcity in organic matter, thinness and low water storage capacity (Correia 1993). Additionally, soil erosion as a result of deforestation, agricultural mechanization and often very strong rainfall events, contribute to low water absorption by soils of the region.

[11] Available for download here: http://www.circle-era.eu/np4/552.html

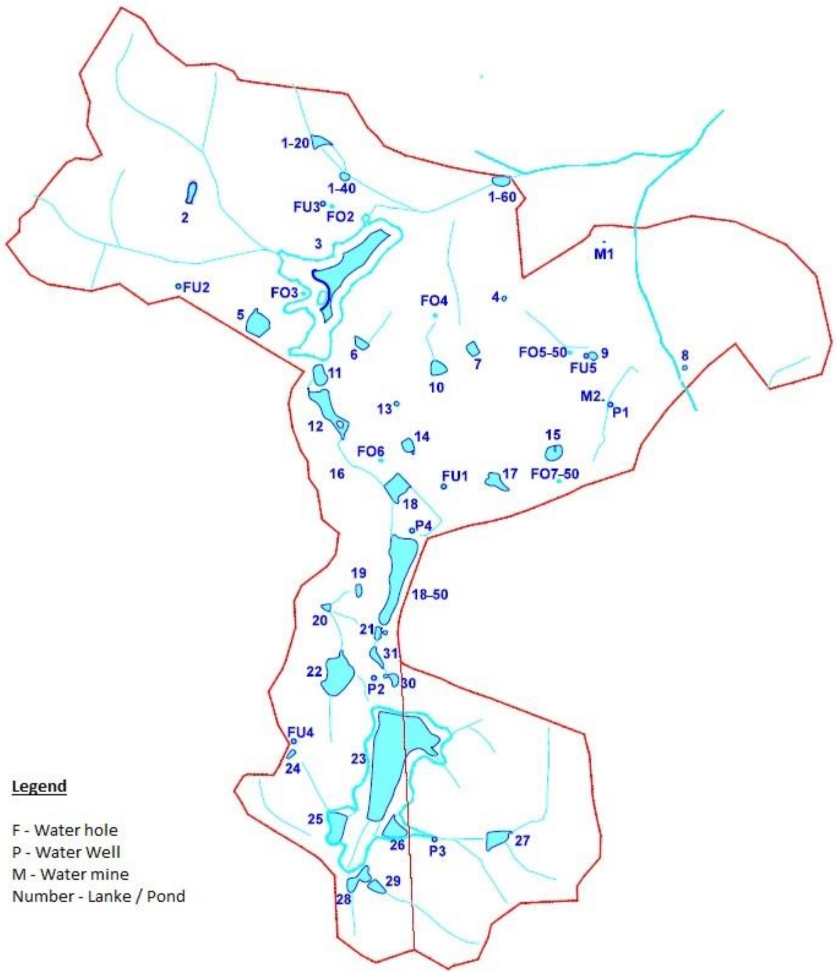


Figure 11 - Tamera's water sources 2015

The WRL of the Tamera ecovillage, designed in collaboration with Permaculture expert Sepp Holzer, has been in construction since 2005 following more than 20 years of community living in a 155ha property near Colos, Odemira. Tamera's has had and still has multiple water sources – Water mines, holes, well's, ponds and lakes – in order to support the livelihood of the resident community (Figure 11 and annex X). These are crucial elements in the shaping of the landscape as well as in the shaping of the community itself and the activities developed, namely agriculture. The land cover in 2006 and in 2014 is shown in Figure 12. The changes observed reflect the construction of several artificial lakes, making the area of water bodies to increase from 0,62ha in 2006 to 8,32ha in 2014 (Figure 11 and 12). The lake construction and the increase of water availability allowed the development of arable land. Transitional woodlands increased from 9,34ha to 19,50ha mainly in the southern area. Natural grasslands is the only land use and land cover category which decreased between 2006 and 2014, from 62,89ha to 35,84ha, since the construction of the artificial lakes and the associated expansion of arable land, as well as the development of transitional woodlands took place

mainly in areas previously occupied by natural grasslands. The area occupied by broad leaf forest remained approximately the same (63,89ha in 2006 to 64,29ha in 2014), and no changes were observed regarding the areas of discontinuous urban fabric and olive groves between the analysed time-span.

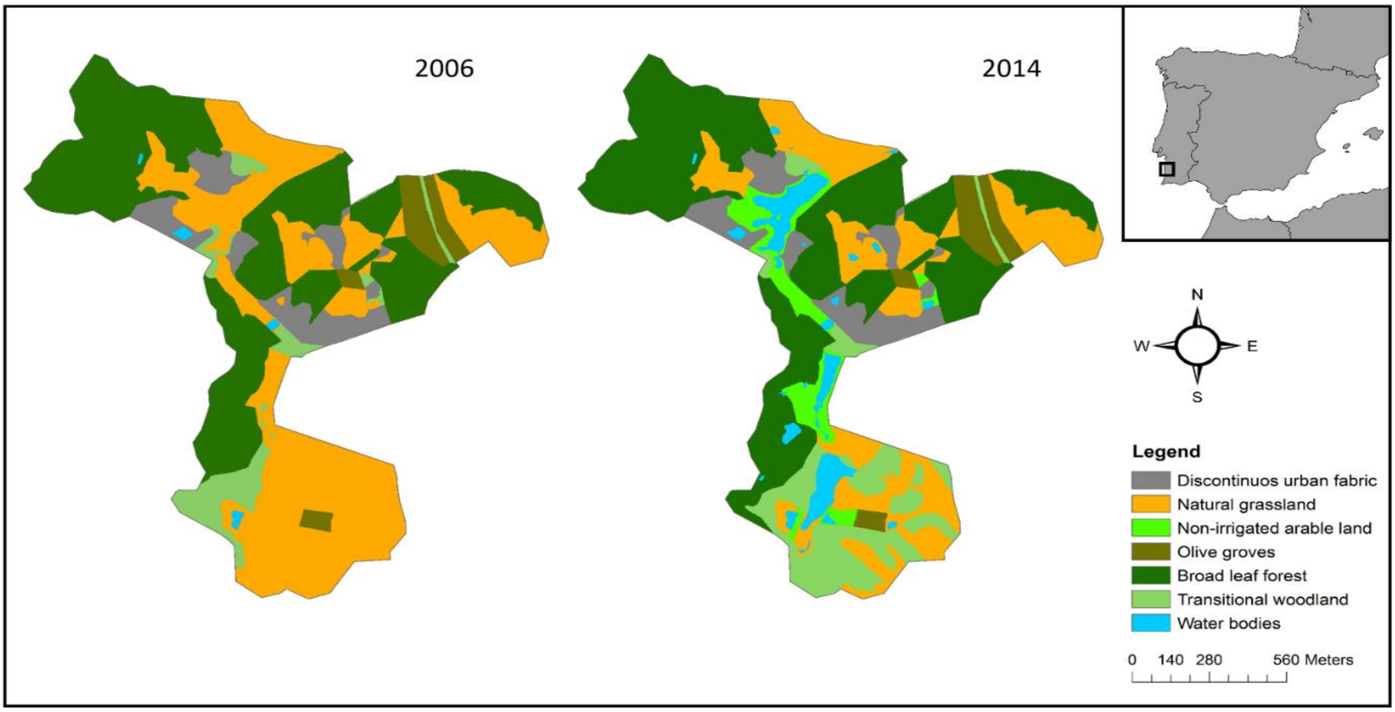


Figure 12 - Past (2006) and current (2014) land cover for the study area and its location in the south of Portugal (Santos et al 2015)

g) Step 3 - Evaluation Criteria and Method

Due to the intrinsic complexity of such an investment as well as due to the holistic dimension of the WRL in the specific case of Tamera the choice of the evaluation criteria, it's proxy's and appropriate weighting were identified in close partnership between scientific experts and members of the community of Tamera in two separate moments. In an initial research moment, scientific experts convened with Tamera's representatives Christopher Ulbig and Fátima Teixeira to co-identify and validate indicators and criteria's for the economic assessment; in a second moment a participatory benefit-cost analysis was performed with 30 community members, who reached consensus decision regarding the key positive and negative impacts to be valued and accounted for in any economic analysis.

The key benefits initially identified were:

	Benefits	*Indicador / Economic Proxy*
Economic	**Increase in property value**	Property value evolution (€/m2)
	Access to new financing opportunities	Approved funds and access to new financing lines due to expanding activities and water-related investments;
	Increase in number of visitors	Number of visitors / Number of stay-overs;
	Attracting qualified Human Resources	Number of research/grey publications having the WRL as a case study;
	Increased agriculture production	Kg/m2; Farming irrigated area expansion

	Consulting services	Revenue from external consulting
Social	**Increase in well-being**	Social questionnaire
	Increase community unity and feeling of belonging and rooting in the landscape	Social questionnaire
Environemntal	**Carbon Storage**	InvEST Modelling
	Water purification	InvEST Modelling
	Sediment retention	InvEST Modelling
	Increased biodiversity	
	Decreased water use and water pressure	

Table 1 - Main beenfits identified by BASE Team together with Tamera representatives

The key costs initially identified:

	Costs	*Indicador / Economic Proxy*
Economic	**Construction costs**	Direct costs + Project costs + Indirect Tamera Costs
	Licenses, Fees, Taxes	ARH Taxes; Licensing fees;
	Insurance	
	Maintenance of the system	Sediment removal; Pumps Maintenance;
	Loss of farming area	Square meters
Social	**Well-being decrease during construction**	Social questionnaire
	Disunity within the community	Social questionnaire
	Loss of well-being due to externalities (mosquitos, etc.)	Social questionnaire
Env.	**Pollution during construction**	CO_2 Emissions
	Habitat destructions	Loss of original grassland / Montado

Table 2 - Main costs identified by the BASE Team together with Tamera representatives

Regarding the costs and benefits identified by the community members during the PBCA workshop:

	Benefits	*Costs*
Econ.	Food sovereignty	Construction costs (including re-rooting existing roads)
	Affordable lifestyle	Increased taxes and license fees
	Increasing guests/visitors	Labour intensity
Social	Global healing	Displacement
	Improved life quality	Finding consensus/decision making
	More working opportunities	Bureaucratic restrictions
	Water secutiry	Cultural adaptation
Env.	Increased biodiversity	CO2 Emissions
	Re-activating ecosystem potential	Loss of existing vegetation
	Water availability	Change of niche habits/ Disruption with existing habitats

Table 3 - Benefits and costs identified by Tamera community members in the PBCA workshop

Regarding the methodological choices for this economic assessment of costs and benefits of the WRL of Tamera and as mentioned before we've used a combination between participatory methodologies which yields qualitative non-expert values, modelling tools for the environmental assessment – InVEST- and literature review for the economic indicators. The Integrated Valuation of Ecosystems Services and Tradeoff's (InVEST[12]) is a free, open-source software developed under the Natural Capital project (NatCap) in order to better integrate the biophysical, socio-economic and other dimensions and values of nature into decision-making processes. The underlying reasoning states that ecosystems, if properly managed, yield a flow of services that are vital to humanity, including the production of goods (e.g., food), life support

[12] http://www.naturalcapitalproject.org/InVEST.html

processes (e.g., water purification), and life fulfilling conditions (e.g., beauty, recreation opportunities), and the conservation of options (e.g., genetic diversity for future use). Despite its importance, this natural capital is poorly understood, scarcely monitored, and—in many cases—undergoing rapid degradation and depletion. To better align ecosystem conservation with economic forces, the NatCap developed InVEST which quantifies and maps the values of ecosystem services. The modelling suite is best suited for analyses of multiple services and multiple objectives. The current models, which require relatively little data input, can identify areas where investment may enhance human well-being and nature.

The **Participatory Benefit-Cost Analysis** (PBCA) is an economic appraisal tool which has been developed and tested by the Climate Change Impact, Adaptation and Modelling (CCIAM) research group, from the cE3c research Center at the Faculty of Sciences, University of Lisbon, under FP7 Project BASE – *Bottom-up Adaptation Strategies for a Sustainable Europe* - in order to assess through participatory methodologies the costs and benefits of different adaptation measures of the Strategic Plan for Climate Change of Cascais (PECAC). It aims to combine the advantages and strengths of multi-criteria analysis with the rationality of Cost-Benefit Analysis (CBA), thereby evolving from the simplicity of the Simplified Participatory Cost-Benefit Analysis (SPCBA) as proposed by the Climate Resilience Framework[13] . PBCA is a hybrid methodology of economic project appraisal, combining interpersonal deliberation and quantitative methodologies.

[13] http://training.i-s-e-t.org/module-series-3/

h) Step 4 - Data collection

Construction costs:

Name of the lake	External costs[14]	Overall construction costs
Lake/Dam 1	250.000 €	312.500 €
Lake "Espaço dos Jovens"	154.000 €	192.500 €
Pond/Dam "Office"	60.000 €	75.000 €
Lake "Grace Village"	20.000 €	25.000 €
Pond/Dam "Aldeia da Luz"	25.000 €	31.250 €
TOTAL	**509.000 €**	**636.250 €**

Table 4 - Construction costs of the Tamera WRL

Although within the WRL we've identified and mapped 29 lakes or small ponds in the research we could only trace back reliable financial data for the biggest lakes having in mind that some lakes/ponds were already existing prior to 2005, other were accounted for in the big lakes costs and for many other small lakes there is no data available. For the CBA we've considered that the total amount invested in the lakes construction in Tamera in the period 2005-2014 was 636.250 €.

Licensing, Fees and Taxes Costs

The EU Directive No. 2000/60/CE, transposed to national legislation by the Law No. 58/2005 (Water Law) and later updated to national law-decree 226-A/2007 on the 31st May and whose later version comes from 2012 – Law No. 44/2012 from 29th August - considers that all uses of water are obliged not only to map, identify and name their water sources and uses but also pay a tax on the use of water resources (TRH). The

[14] External costs refer to all sub-contracted services not accouting for Tamera's own resources input.

TRH has five key components (A|E|I|O|U) with a cumulative calculation formula (annex X). Tamera's calculus amounts to 38,037 € per year. However, it only takes into account component A and U as the WRL is not yet fully legalized/authorized by the ARH-Alentejo (Hydric Resources Agency Alentejo). According to the mentioned legal framework the fee for not having the proper authorization/license for the use of its water resources, Tamera can be forced to pay between 60.0000 € and 2.5 Million € (Law No. 44/2012).

Ecosystem services and Environmental indicators: Invest data collection

As previously referred, InVEST v.3.0.1 was the tool chosen to model and map in a spatial explicit way the selected ecosystem services in the study area and it contains different sub models, one for each ecosystem service. This modelling tool has been widely used in a variety of studies (e.g. see: Bangash et al., 2013; Leha et al., 2013, Harmáckováa et al., 2014) and has been applied to understand how land cover changes affect different ecosystem services (e.g. Tallis et al 2011; Tallis and Polasky, 2011). In the present study carbon storage, nutrient retention: water purification and sediment retention were the selected ecosystem services to evaluate the land use changes due to artificial lake construction (Zedler and Kercher 2005).

The carbon storage InVEST sub-model is based on four carbon pools - above ground biomass, below ground biomass, soil, dead organic matter (Tallis et al., 2011) and employs a simplified carbon cycle that maps and quantifies the amount of carbon stored and sequestered (e.g. Leha et al., 2013) for the past and current land cover. Therefore, for this ecosystem service to be assessed it was required information regarding current land use and land cover (Base Landscape), past land use and land cover and values of carbon pools (aboveground, belowground, soil, dead organic matter) for the study area climate and taking in consideration the different land cover types (Table 2). Water purification: the assessment of this ecosystem service with InVEST can be done calculating nutrients retention, using nitrogen (Tallis et al., 2011). Therefore, the nitrogen leaching was interpreted as the ecosystem service of water purification and was calculated based on the amount of nitrogen loadings (inputs) and landscape capacity to retain nitrogen (Tallis et al., 2011). InVEST sediment retention sub model is a three-step approach to evaluate this ecosystem service. First, the potential soil lost (eroded soil) is estimated from each cell using the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978). Secondly, it calculates the service of erosion control, which is the capacity of the landscape to retain sediment, taking in consideration the different land-cover types. Finally, sediment discharge will be the difference from received (from upstream cells) and exported sediment

year	carbon	water purification			sediment retention		
	Carbon storage (Mg ha^{-1})	Nitrogen input (Kg ha^{-1} year^{-1})	Nitrogen retained Kg ha^{-1} year^{-1})	Nitrogen leaching (Kg ha^{-1} year^{-1})	sediments loss (ton ha^{-1} year^{-1})	sediments retained (ton ha^{-1}year^{-1})	sediments discharge (ton ha^{-1} year^{-1})
2006	75.22	4.85	4.62	0.23	1.12	1.08	0.034
2014	82.27	5.07	4.84	0.23	1.73	1.64	0.080
Δ 2006-	7.05	0.22	0.22	0.001	0.61	0.56	0.046

Table 5 - Trade-offs between non-targeted ecosystems services caused by the construction of artificial lakes

Our results confirm the role of artificial lakes in the sequestration as a contributing to the mitigation and adaptation to climate changes (Travik et al. 2009, Williamson et al. 2009). In fact, the land cover between 2006 and 2014 showed an overall increase in carbon (year) (9.4%), causing a positive carbon storage. This overall result was mainly due to the replacement of grasslands for lakes. Indeed, when land change occurred from broad-leaf forest to water body the difference in carbon storage was negative. Thus carbon storage is positive depending of the land use and land changes that is replaced. Here we show that, only looking to carbon storage, reforestation by natural broad-leaf forest (*Montado*) might be a better strategy regarding the improvement in this ecosystem service for climate change adaptation (Cañellas et al. 2008).

Our results show an increase in the total nitrogen leaching to the landscape. Since it is known that lakes are not significant nitrogen sources, the artificial lakes *per se* are not responsible for the nitrogen increase in a system. However, one of the objectives of the construction of artificial lakes in the study area was to allow the development of agriculture, a major nitrogen source. This may explain the differences found in nitrogen leaching, although the extra nitrogen added did not exceeded the critical loads for broadleaved deciduous and Mediterranean evergreen *Quercus* woodlands: 10-20 kg nitrogen year^{-1} (Bobbink and Hettelingh, 2011).

Value of C (US$/Ton)	117,44
Market discount in price of C	3,5%
Annual rate of change in C price	2,23%

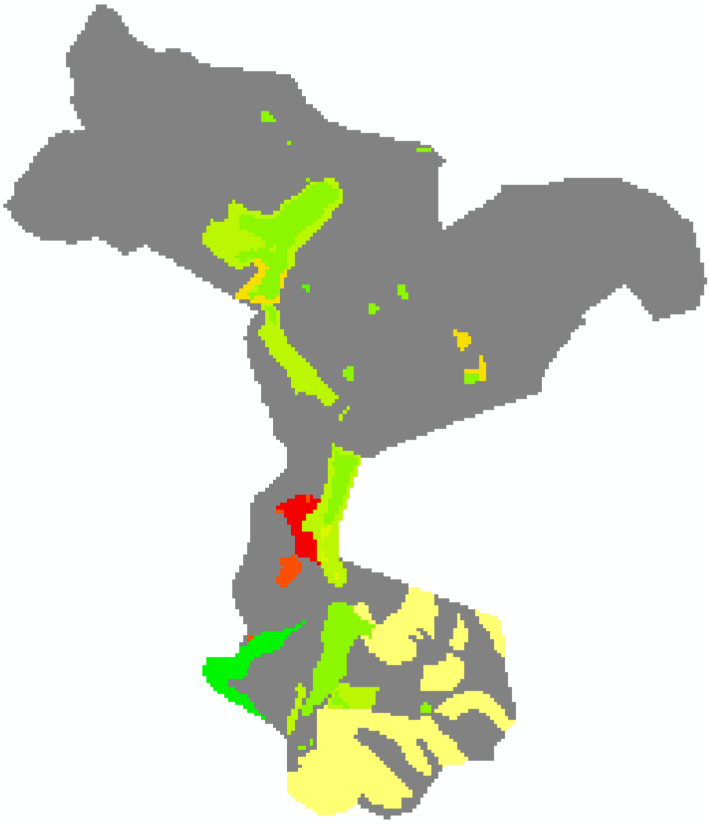


Figure 13 - Economic value of C sequestered between 2006 and 2050 (US$ per grid cell 10m*10m)

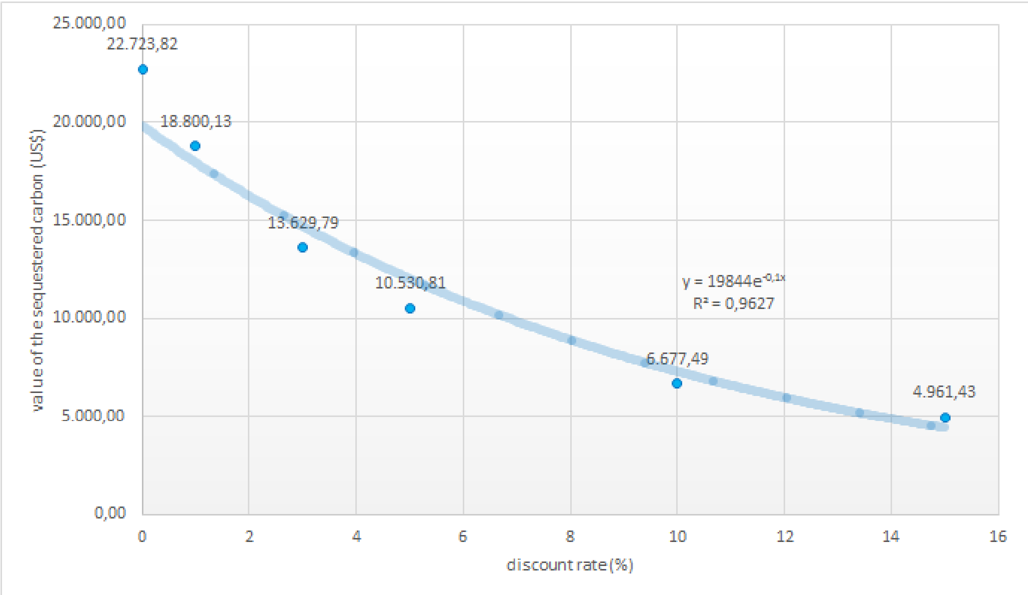


Figure 14 – Value of total sequestered carbon (US$) with different discount rates (Branquinho et al 2015)

Benefits from increased number of visitors/water-related events

The WRL is an iconic investment and since the beginning of its construction it has attracted many people not only due to the holistic design but also due to the impact it has in the community life of Tamera. We've taken

into account the increase number of visitors and water-related events since 2008, namely the average number of participants in the Water Symposium since 2011, the visitors during the Open Days with Permaculture Designer Sept Holtzer since 2008 as well as the Permaculture Seminars with Sept Holtzer also since 2008. Having into account an average spent of 50 € per day in Tamera and the average fees for the trainings, the overall economic benefit can be accounted for:

Event	Average number of participants per year (last 7 years or 5 in the case of the Water Symposium)	Estimated net income for 2014-2050
Water Symposium	100	500.000 €
Permaculture Sept Holtzer Open Days	100	100.000 €
Permaculture Sept Holtzer Seminars	35	35.000 €
Water retention Landscape Training	25	175.000 €
TOTAL		**810.000 €**
TOTAL DISCOUNTED (3%)		**243.000 €**

Social and agriculture benefits of the WRL

Both the scientific experts and the members of the community highlighted the role of water in the landscape as a crucial element for social and environmental well-being and a thriving society, especially in semi-arid regions. In our research process a questionnaire was foreseen in order to scientifically measure and quantify that perceived benefit and social impact of the WRL. Due to time and resources limitations this was not possible to implement during BASE research process. Nevertheless, this important benefit was internalized when we take into account that the market valuation of land which has water availability and storage has a premium value which is scientifically proven to be between 15% to 40% in semi-arid regions.

i) Step 5 – NPV Calculation and discussion of results

The criteria used to assess the overall social welfare impact of the WRL in Tamera is the Net Present Value, which accounts for the sum of all discounted benefits for the period minus the sum of all discounted costs in a single monetary common unit (€). We've used the time period of 2005 to 2050 and a discount rate of 3%.

NPV (net present value) = ∑ Bt (1+i)-t - ∑Ct (1+i)-t

$\sum Bt$ = Land value increase + Increased number of visitors and Water-related events + Ecosystems services

$\sum Bt$ =

$\sum Ct$ = Construction costs + Licenses/Fees/taxes + CO_2 Emissions

$\sum Ct$ =

NPV = net present value

6. Implementation Analysis – Understanding, Leadership and Governance of the implementation of adaptation measures

Checklist

Alentejo - Tamera

Key factors:	Rank from 1 – 5
i. **Knowledge and information about climate adaptation**	5
ii. **Actors** (e.g. leadership, perceptions, understanding of climate adaptation, participation, decision making, stakes, conflicts/synergies)	3
iii. **Framing of climate adaptation** (e.g. as sustainability concern, (urban) planning or environmental issue, disaster risk mitigation topic)	3
iv. **Local and regional context** (e.g. culture, history, geography, environment, economy)	3
v. **European, national, regional and local regulatory framework** (e.g. be specific about laws, strategies, policies)	1
vi. **Institutional context** (e.g. integration of adaptation into existing structures/activities/strategies, decision making, conflicts/synergies, governance arrangements, incentives for engagement)	3
vii. **Resources** (e.g. financial, human)	3
viii. **Nature of adaptation measures** (e.g. no regret, flexibility, important co-benefits, side-effects)	3
ix. **Other: Consultants' (Permaculture Designer Sepp Holzer) opinion and design.**	5

Summary Information (based on your answers to the questions below)

The checklist above and the answer bellow are made regarding one of the "farms" studied in the Alentejo case study, the ecovillage of Tamera, where the adaptation measure of Water Retention Landscapes (WRL) was implemented in 2006. The Alentejo case study looks at different aspects of adaptation in agriculture and

forestry in the region of Alentejo. One is looking at farmers and their adaptation measures. Another is looking in detail at the Tamera ecovillage, namely on the quantitative economic analysis (Cost Benefit Analysis). The Water Retention Landscape (WRL) is a series of interconnected lakes that create a fertile and irrigated landscape in a region affected by water scarcity, drought and climate scenarios of increased water scarcity, drought, maximum temperatures and heat waves. The WRL is used in this ecovillage to support agriculture but also biodiversity, tourism and education. Regarding the agriculture this ecovillage practices organic farming aimed at their own internal consumption and not for the market.

a) Specify sectors covered (e.g. coast, city, agriculture): Agriculture, Tourism, education. The WRL is used in this ecovillage to support agriculture but also biodiversity, tourism and education. Regarding the agriculture this ecovillage practices organic farming aimed at their own internal consumption and not for the market.

b) Specify adaptation measures covered (e.g. altering cultivation practices, building defences; explain why they were chosen): Creation of a Water Retention Landscape in the ecovillage of Tamera which consists of a series of interconnected lakes and some changes in land-use and land use management connected to agriculture and forestry namely the use of the margins of the lakes for fruit trees production and the practice of keyline and contour line agriculture on the slopes and diverse forestry plantation to prevent soil loss and promote soil regeneration.

c) Specify climate change impacts covered (e.g. flooding, heat stress, sea level rise): drought, water scarcity and reduction in precipitation.

d) Specify main results of activities (e.g. changes, outputs): The ecovilllage has about 15 lakes and increased tourism and education courses relating to Permaculture, water management in drylands, ecology and visitors in general. Additionally, the ecovillage has plenty of water for irrigation and uses it for horticulture and irrigation of orchards. Finally, the recreation value of the lakes is high and the quality of life has increased in the ecovillage. The lakes also support neighbours and fireman in times of drought or fire.

Questions

Answer these six questions giving specific evidence and examples where possible. In principle all implementation activities should be included, i.e. adaptation activities supported by BASE partners as well as those by other actors. If it is possible to inform about the implementation of those adaptation measures assessed for task 5.2, it is very important to do so in order to comply with the DoW. The measures covered can be extensive and/or particular to a

case study. They can include for example, the development of plans and strategies, vulnerability/risk assessments, economic assessments such as CBA, MCA, the development of participatory processes/public dialogue, through to the implementation of actual measures including physical measures such as engineering developments and land use change, incentives/subsidies for behavioural change, etc. This list is not all-inclusive and is merely a guide. Your own case study may have very different measures. However, **you must be clear what measures you are referring to when answering these questions.**

Alentejo - Tamera

1. How have climate change adaptation measures and strategies been advanced in the case study? Describe the process! *Note:* Retrospective case studies will not answer this question, but have to update their answer to question 1 E of this document on the history of adaptation at their case study. (Approximately 500 words)

The Ecovillage of Tamera, inside the region and case study of Alentejo is an alternative project that does not follow the patterns identified for farmers, namely through the surveys and interviews applied to 21 farmers in the Alentejo region and also part of the Alentejo case study.

The Alentejo - Tamera sub-case study is a retrospective analysis regarding the implementation of the water retention landscapes in an ecovillage.

TheAlentejo – Amoreiras sub-case study is also a retrospective and participatory analysis to a rural development project that promoted adaptive capacity in a village.

The Alentejo – Farms sub-case study consists of analysis of farmers' knowledge and perception on adaptation measures that have also been implemented in some farms. This analysis is based on interviews and surveys.

The Alentejo – Region study consisted in a participatory state of the art and review of the climate adaptation impacts and adaptation measures in the region with several stakeholders, including governmental and academic. Furthermore it consisted in a participatory multi-criteria analysis of the agriculture adaptation measures based on the experience of a different group stakeholders, also governmental and academic but mostly composed of farmers and associations. At the regional level there is not strategy of adaptation or institution responsible for it. There is only a national strategy on the different sectors and an institution responsible for it, the national agency for environment (APA). At the case study participatory processes promoted by BASE FFCUL researchers, this national strategy was discussed and as well as the potential collaborations between researchers in their work regarding adaptation and agriculture and forestry in the Alentejo region. APA was present. A second workshop of participatory MCA to 15 adaptation measures also had APA present. The results are disseminated to the stakeholders. No further action was proposed by BASE in the WP5 context. The regional and national stakeholder promote and develop different seminars and reflections on similar and related themes such as combat to desertification for example. Furthermore there is a national concern regarding this theme since some European, regional development and EEA grants funds for example, promote adaptation. Presently there are several municipalities in the regional and in the country developing adaptation strategies and the public

company responsible for the Alqueva Dam (the biggest artificial lake in Europe, located in the region of Alentejo) is mobilizing efforts to create an adaptation strategy and plan.

The retrospective sub-case studies consist of autonomous adaptation are sicne they have already made some efforts in the past they keep on monitoring and evaluating possible future actions of adaptation.

2. What and who drives (or enables) the adoption and implementation of adaptation measures and strategies/policies? Please explicitly refer to the factors mentioned in the checklist, highlighting the factor in bold, and be specific about any relevant policies! (Approximately 500 – 1000 words)

The checklist responded to the Alentejo-Tamera sub-case study, meaning the implementation of the Water Retention Landscapes in the ecovillage of Tamera. In this particular case, **European, national, Regional and Local policy and regulatory framework** had no role in the adoption of the adaptation measures. In fact the ecovillage of Tamera is presently in the process of attempting to legalize their infractructural work on the landscape, namely the building of lakes, changing paths of roads and land use changes. The reason why this framework did not condition the adoption of adaptation measures is subjective and relates to the perception that the decision makers of the ecovillage have about their role in the world, the inspirational and innovation impact of their actions and the perception of how the laws and regulations are applied in the region and to them and finally a perception of their power and their capacity to deal with the regulatory framework.

The ecovillage of Tamera is a collective of about 150 permanent residents with a steering coordination group and a few legal entities composed of associations and companies. The population of this ecovillage is mostly international, namely German and interestingly the Portuguese permanent members are a very small percentage of the population of about 3%. This may be or not a justification for the contrast that is shown between the ecovillage relation to the regulatory framework and the farmers response to the same aspect in the surveys and interviews. Traditional farmers consider regulatory framework (CAP – Common Agricultural Policy) a big condition for climate adaptation. Some farmers consider that the legal framework can be a big obstacle while other consider the public payments to farmers a very important incentive and support to farmers adaptation, namely when it relates to their impact in the regional ecosystem services, fire protection, etc.

Regarding the **Knowledge and information about climate adaptation**, this factor is considered critical since it was, together with the **other factor** of the Consultants opinion and knowledge, the main two factor that enabled the adoption of the Water Retention Landscapes. The reason is that the knowledge of the consultant about creating landscapes adapted to the climate (inspired also by Permaculture Design) and its capacity to convince and mobilize the ecovillage of Tamera to take on this multifunctional investment were determinant for the adoption of the adaptation action.

Finally, all other factors and aspects were considered important but it is somehow difficult to rate since they all had relative importance in the adoption and design of the adaptation measure.

3. What obstacles were encountered during the adoption or implementation of adaptation measures and strategies/policies? Please explicitly refer to the factors mentioned in the checklist, highlighting the factor in bold, and be specific about any relevant policies! (Approximately 500 – 1000 words)

One of the main obstacle is the financial investment needed to build the Water Retention Landscapes, since this investment is about half a million euros. The other main obstacle are the legal and regulatory framework. In Portugal it is forbidden to cut cork trees for example, even if you build a lake and plant more cork trees in another place. Furthermore any private or public initiative can take months or years to receive permissions for land use changes or never receive these permissions.

4. If any obstacles were overcome, how was this achieved? (Approximately 500 words)

The ecovillage of Tamera chose to illegally implement the innovative adaptation measure and ask for permissions afterwards. They are presently in the process of resolving all the legal permissions, namely by making a special rural spatial plan, an instrument of spatial planning that allows for the creation of special spatial management for specific territories.

Regarding the obstacle of financial resources, the ecovillage of Tamera used its communication and publicity capacity to raise private funding and donors to sponsor their dream. They believe that money and resources can be found when the vision is clear and manifested out into the world. The direct financial benefits of the water retention landscapes did not compensate for the direct costs.

5. What are the future prospects of the climate change adaptation activities in the case study? (Approximately 200 – 500 words)

Regarding the Tamera Ecovillage, the future prospects of the climate change adaptation consists on monitoring the water management of the water retention landscapes, increasing the amount soils conservation and regeneration earth works like swales and keyline design and forestation and using animals in holistic management to promote soil regeneration. Furthermore they intend to strengthen the applied research to actions they implement on site and use the knowledge acquired in education and tourism.

Regarding the Farmers in the Alentejo region, the situation is very specific to each farm. Typically farmers continue to monitor the climate and its impacts in their farm and continue to experiment with their farm elements and cheap and feasible solutions while at the same time trying to acquire more knowledge and funding for climate adaptation.

6. What is the key message from this case study (and which could work in other cases as well)? Don't forget to consider any specific policy recommendations that arise in your case study! (Approximately 200 – 500 words)

During the interviews and surveys to farmers and the participatory workshops several questions were asked and answers documented to understand the recommendation from stakeholders to the European Union, the “government” and the universities. The following messages constitute a summary of these expressions and reflections.

Innovation: Implementing for the first time innovative solutions of climate change adaptation normally faces the obstacles of regulatory framework that does not incorporate the need to act differently than standards. Despite the need to regulate and protect public space and the landscape private funded innovation constitute an opportunity for learning and evaluation of climate adaptation efforts. Innovation should therefore not be penalised when it added value for research or local development is recognized as important.

Furthermore, farmers mention that innovations that proved to work should be divulgated and publicized to farmers and not only made available through companies the eventually sell them to farmers with products.

Finally, innovation in adaptation should be rewarded/funded.

Funding: farmers that do not operate with tourism and education like the ecovillage of Tamera do not have the opportunity to obtain private funding and donors to finance their adaptation measures and innovation. Recognized solutions should be supported by public funding but also innovation is required in farming adaptation meaning that some degree of support for innovative farming solutions must dedicated from public funding.

Prices: When prices are driven by supermarket chains and they are bought in a European or global market, the adaptation is not promoted since farmers cannot include in the price their full costs of adapting in a certain region. This increases the need of public compensation to farmers and loss of public state income increasing the complexity of managing adaptation in the agriculture sector.

Regulatory Framework: Some farmers complaint about impacts that they suffer from some forestry and agricultural practices that deploy the water and soil resources diminishing their adaptive capacity and are legal. They recommend that these practices in large scale need environmental impact assessments and are made illegal. One example is large regions of many Km2 of monocultures of eucalyptus that take the water from underground.

On the other hand, to accompany the innovation and adaptation needs the regulatory framework should create mechanisms for regular update on environmental and societal needs and change.

Applied research: Farmers recommend that research must become more practical and applied in order to give support to farmers and adaptation in agriculture. They complaint that universities develop very theoretical studies and also that plenty of knowledge is already existing but it is not integrated and combined into innovation partnerships and on the ground applied action-research.

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Annex

Designação	Classificação	Situação dos POAAP	Elementos	Reg. Hidrográfica
Abrilongo	Protegida			Guadiana
Açude do Ardila	Protegida			Guadiana
Açude do Bufo	Protegida			Guadiana
Alcoutim	Protegida			Guadiana
Alqueva	Protegida	Aprovado e publicado. RCM n.º 94/2006, de 4 de agosto	(1)Documentos	Guadiana
Alvito	Protegida	Aprovado e publicado. RCM n.º 151/98, de 26 de dezembro		Sado e Mira
Beliche (*)	Protegida	Determinada a revisão. RCM n.º 106/2005, de 28 de junho		Guadiana
Boavista	Protegida			Guadiana
Caia	Protegida	Aprovado e publicado. Despacho Conjunto de 13 de julho de 1993	Documentos	Guadiana
Campilhas	Utilização Livre	Aprovado e publicado. RCM n.º 17/2007, de 5 de fevereiro	Documentos	Sado e Mira
Corte Brique	Utilização Livre			Sado e Mira
Enxoé	Protegida	Aprovado e publicado. RCM n.º 167/2006, de 15 de dezembro	Documentos	Guadiana
Fonte Serne	Utilização Livre	Aprovado e publicado. RCM n.º 15/2007, de 31 de janeiro	Documentos	Sado e Mira
Grous	Utilização Livre			Guadiana
Lucefecit	Utilização Livre			Guadiana
Monte Clérigo	Protegida			Guadiana
Monte da Rocha	Protegida	Aprovado e publicado. RCM n.º 154/2003, de 29 de setembro	Documentos	Sado e Mira

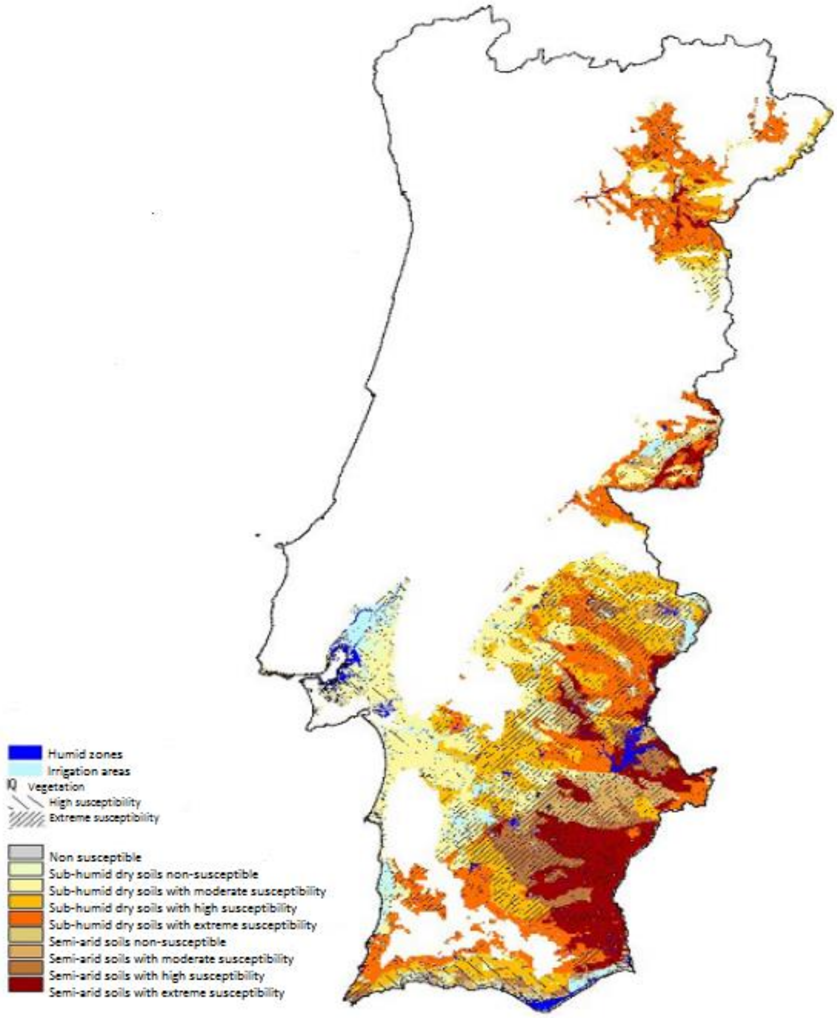
Designação	Classificação	Situação dos POAAP	Elementos	Reg. Hidrográfica
Monte Gato	Utilização Livre			Sado e Mira
Monte Miguéis	Utilização Livre			Sado e Mira
Monte Novo	Protegida	Aprovado e publicado. RCM n.º 120/2003, de 14 de agosto	Documentos	Guadiana
Morgavel	Protegida			Sado e Mira
Odeleite (*)	Protegida	Aprovado e publicado. RCM n.º 54/2014, de 4 de setembro	Documentos	Guadiana
Odivelas	Utilização Livre	Aprovado e publicado. RCM n.º 184/2007, de 21 de dezembro	Documentos	Sado e Mira
Pedrogão	Protegida	Aprovado e publicado. (1) RCM nº 94/2006, de 4 de agosto	Documentos	Guadiana
Pêgo do Altar	Utilização Livre	Aprovado e publicado. RCM n.º 35/2005, de 24 de fevereiro	Documentos	Sado e Mira
Pereiro	Protegida			Guadiana
Roxo	Protegida	Aprovado e publicado. RCM n.º 36/2009, de 11 de maio	Documentos	Sado e Mira
Santa Clara	Protegida	Aprovado e publicado. RCM n.º 185/2007, de 21 de dezembro	Documentos	Sado e Mira
Tapada Grande	Protegida	Aprovado e publicado. RCM n.º 114/2005, de 4 de julho	Documentos	Guadiana
Tapada Pequena	Utilização Livre	Aprovado e publicado. RCM n.º 171/2008, de 21 de novembro	Documentos	Guadiana
Vale de Gaio	Utilização Livre	Aprovado e publicado. RCM n.º 173/2008, de 21 de novembro	Documentos	Sado e Mira
Vigia	Protegida	Aprovado e publicado. RCM n.º 50/1998, de 20 de abril		Guadiana

Designação da lagoa ou lago	Tipologia	Bacia Hidrográfica
Lagoa do Peneireiro	Não costeira	Sado
Lagoa dos Patos	Não costeira	Sado
Lagoa de Melides	Costeira	Sado

Designação da lagoa ou lago	Tipologia	Bacia Hidrográfica
Lagoa de Santo André	Costeira	Sado
Lagoa da Sancha	Costeira	Sado

Type	Index Name	Calculation	Drought Classification	Strength	Weakness	References and Applied Area
Meteorological drought	Palmer Drought Severity Index (PDSI)	Based on a 2-layer bucket-type water balance model, the PDSI measures the departure of moisture balance from a normal condition	−4.0 or less: extreme drought; −3.0 to −3.99: severe drought; −2.0 to −2.99: moderate drought; −1.0 to −1.99: mild drought; −0.5 to −0.99: incipient dry spell; 0.49 to −0.49: near normal	Considers both water supply (precipitation) and demand (potential evapotranspiration)	Does not work well over mountainous and snow covered areas; may require re-normalization	Refs 22–24; mostly the United States, but also globe
	Standardized Precipitation Index (SPI)	Fitting and transforming a long-term precipitation record into a normal distribution with respect to the SPI, which has zero mean and unit SD.	−2 or less: extremely dry; −1.5 to −1.99: severely dry; −1.0 to −1.49: moderately dry; −0.99 to 0.99: near normal	Can be computed for different time scales; symmetric for both dry and wet spells; relates to probability	Requires long-term precipitation data; no consideration of evaporation	Refs 25, 26; any area by drought planners
	Rainfall Deciles (RD)	Ranking rainfall in the past 3 months against the climatological record of 3-month rainfall, which is divided into 10 quantiles or deciles	deciles 1–2 (lowest 20%): much below normal; deciles 3–4: below normal; deciles 5–6: near normal	Provides a statistical measure of precipitation; performed well in limited tests	Requires long-term precipitation data; no consideration of evaporation	Ref 27; Australia
Agricultural Drought	Computed Soil Moisture (CSM)	Soil moisture content is computed by a land surface model forced with observed precipitation, temperature and other atmospheric forcing	Drought may be defined based on the percentiles of the CSM, e.g., ≤20th percentile: very dry; 20–40%: dry; 40–60%: near normal	Considers antecedent conditions	Requires atmospheric forcing data and a land surface model	Refs 28–30; the United States, globe
	Palmer Moisture Anomaly Index (*Z*-index)	The *Z*-index is the moisture anomaly for the current month in the Palmer model	Percentiles of the *Z*-index may be used to define drought	Rapid response to current precipitation deficit	Does not consider antecedent conditions	Refs 22, 24; the United States
Hydrological Drought	Total water deficit (S)	$S = D \times M$, where D is the duration during which the streamflow is below the normal level and M is the average departure of streamflow from the long-term mean during period D	S may need normalization in defining drought	Simple calculation	No sub-basin information, no standard drought classification	Ref 31; the United States
	Palmer Hydrological Drought Index (PHDI)	Computed using the same Palmer model as for the PDSI, but with a more stringent criterion for the termination of the drought or wet spell	Values similar to PDSI, but with smoother variations	Use of a water balance model to account for the effect of both precipitation and temperature	Does not work well over mountainous and snow covered areas; may require re-normalization	Ref 22; mostly the United States
	Surface Water Supply Index (SWSI)	Calculated by river basin based on snowpack, streamflow, precipitation, and reservoir storage	Normalized values similar to PDSI	Considers snowpack and water storage	Basin-dependent formulations	Refs 32, 33; the western United States
Regional Drought	Drought Area Index (DAI)	Percentage of a given region under drought condition based on a drought intensity index	Drought is defined based on a separate index	Quantifies drought areal extent	Does not provide the mean intensity of drought over the region	Ref 34; anywhere
	Drought Severity Index (DSI)	Area-weighted mean of a drought intensity index over the drought area in a given region	Drought is defined based on a separate index	Quantifies drought severity over a region	Does not provide drought areal extent	Ref 35; anywhere

Figure 15 - Comparison of commonly-used Drought Indices (Dai 2011)


Humid zones
Irrigation areas
Vegetation
High susceptibility
Extreme susceptibility
Non susceptible
Sub-humid dry soils non-susceptible
Sub-humid dry soils with moderate susceptibility
Sub-humid dry soils with high susceptibility
Sub-humid dry soils with extreme susceptibility
Semi-arid soils non-susceptible
Semi-arid soils with moderate susceptibility
Semi-arid soils with high susceptibility
Semi-arid soils with extreme susceptibility

REF	MEDIDA de ADAPTAÇÃO	DESCRIÇÃO
SOLO	**Mobilização na zona**	Combinar a sementeira directa com a mobilização superficial do solo na zona entre linhas de sementeira em culturas como o milho. Previne a erosão, aumenta a matéria orgânica do solo, diminui a evaporação.
SOLO	**Sementeira directa**	Operação de sementeira de culturas em solos não mobilizados mecanicamente e nos quais a única preparação mecânica é a abertura de um sulco que apenas possui a secção e profundidade suficientes para garantir uma boa cobertura da semente. Previne a erosão e diminui a evaporação. Aumenta a capacidade de retenção de humidade do solo. Diminui o trabalho na preparação do solo e os gastos de combustível associados.
SOLO	**Mobilização em curva de nível. Não mobilizar em zonas com elevado declive.**	Mobilizar o solo segundo a curva de nível , ou seja , perpendicular ao declive. Diminui a erosão, aumenta a capacidade de infiltração e absorção de água no solo.
SOLO	**Planeamento e mobilização em keyline**	Mobilizar o solo com o arado yeomans, semelhante a um subsolador, de forma semelhante à curva de nível mas com um declive de 2% a descer das linhas de vale para as linhas de cumeada. O planeamento com keyline consiste em plantar e colocar vias de acesso de acordo com a mesma inclinação e captar a água na paisagem de todas as formas possíveis, dando prioridade ao solo. Permite diminuir a erosão, espalhar a água no solo, aumentar a capacidade de armazenamento de água do solo, regenerar solo.
SOLO	**Micro-modelação para**	Criar micro-modelações no terreno a fim de promover a absorção das águas da chuva no solo. Permite prolongar a época em que a água está disponível na exploração. Minimiza a evaporação superficial e canaliza a água para onde ela é necessária, perto das

	retenção de água no solo	raízes das plantas. Aumenta a capacidade de absorção de água no solo e durante mais tempo, reduzindo a vulnerabilidade à escassez de água.
GADO	**Aumentar os stocks de alimentos (em anos bons)**	É uma medida de boas práticas tradicionais que significa aumentar os stocks de alimento para o gado (cereal, palha, feno, etc.) em anos bons para em anos de seca poder recorrer a esse recurso. Implica a capacidade de armazenar esse stock. Pode permitir aguentar um a dois anos de seca.
D IVE	**Cobertura vegetal**	Manter o solo coberto com plantas que podem ser culturas de Verão ou de Inverno. Estas culturas em vez de competirem por água fazem sombra e protegem o solo do vento e da erosão, diminuindo a evaporação, melhorando a disponibilidade de água para as árvores.
D IVE	**Valorizar e usar os produtos silvestres do mediterrâneo**	(PAM, Medronho, Mel, Figo da India, Cogumelos, alfarroba) Os produtos silvestres do mediterrâneo estão adaptados ao clima mediterrâneo ao invés de culturas de regadio. Valorizar e explorar estes recursos significa estar mais adaptado ao clima. Estes produtos têm sido pouco valorizados e explorados, tendo sido preferidos produtos menos adaptados. Reduz vulnerabilidade a secas.
D IVE	**Manter ou criar sistema agro-silvo-pastoril**	A conservação e investimento económico no montado como sistema multifuncional aumenta a resiliência ao invés de manter o sistema como apenas cerealífero, ou apenas floresta para cortiça ou apenas gado. Reduz vulnerabilidade a secas, a outros extremos climáticos e a flutuações nos preços dos produtos.

DIVE	**Selecção e melhoramento de espécies**	A selecção e melhoramento de espécies permite ir adaptando o gene das culturas usadas ao clima da região. Este trabalho sempre existiu, sendo realizado pelos agricultores ou entidades publicas. Hoje em dia é confiado em parte a empresas multinacionais que não podem assegurar esta tarefa por conflito de interesses. Reduz vulnerabilidade a secas, a outros extremos climáticos.
DIVE	**Selecção de espécies em função de condições climáticas previstas**	Cultivar espécies que sejam adequadas ao clima previsto. Reduz a vulnerabilidade às alterações para novos padrões climáticos.
DIVE	**Criação e gestão de microclimas**	Criar barreiras contra o vento com árvores e arbustos; plantar diferentes espécies em zonas umbrias e solarengas; criar e alargar zonas húmidas; plantar na sombra de árvores; criar corredores de vento; etc. Permite reduzir a vulnerabilidade aos extremos climáticos e diminuir os impactes como erosão do solo, escassez de água e ondas de calor pois são criados vários climas na propriedade e aproveitados com espécies adaptadas às diferentes condições. Ex plantar azinheiras apenas nas zonas viradas a norte.
AGUA	**Retenção de Água à Superfície (Charcas temporárias)**	Escavação no terreno com funções de reservatório/captação de água. Permite guardar água à superfície durante quase todo o ano mas tipicamente seca em anos de seca pronunciada. Quando usada para rega fica seca ao final de pouco tempo. Reduz a vulnerabilidade a secas e ondas de calor para o gado.
AGUA	**Retenção de Água à Superfície (Charcas**	Compreende a estrutura hidráulica formada pela estrutura de retenção, a sua fundação, zona vizinha a jusante, órgãos de segurança e exploração e albufeira. Diferencia-se de uma charca por utilizar a estrutura de retenção para captar água da bacia

	permanentes, Pequenas Barragens ou Lagos)	hidrográfica a montante. Permite guardar água à superfície para uso durante todo o ano. . Reduz a vulnerabilidade a secas e ondas de calor e pode permitir rega com proporções limitadas.
A GUA	**Paisagens Aquáticas**	Captação do máximo possível de água da chuva na paisagem, localmente, guardando-a em pequenas barragens, charcas, lagos que estão ligados entre si criando uma grande resiliência à seca. As margens e zonas húmidas são usadas para aumentar produção de forma integrada, valorizando os microclimas. Com esta estratégia é possível aumentar a água no solo alargando a época de culturas, criar microclimas, dar água ao gado e criar reservatórios para regadio e combate aos incêndios.
A GUA	**Regadio a partir de Barragens e infraestruturas de grandes dimensões**	Investir em novos sistemas integrados que abrangem milhares de hectares e que são constituídos por um conjunto de várias barragens de grandes dimensões, reservatórios e açudes, vários quilómetros de redes primárias e de redes secundárias, estações elevatórias, centrais de energia renovável. Permite expandir bastante a área de regadio e canalizar água para zonas secas aumentando o potencial produtivo dessas áreas.
A GUA	**Alimentação dos freáticos**	Promover a absorção da água das chuvas para o subsolo para alimentar os lençóis freáticos. Estando desta forma mais água disponível através de possíveis nascentes ou furos.
A GUA	**Reutilização de águas residuais**	Reutilização de águas usadas mas que ainda apresentam condições benéficas para a rega. Permite minimizar o uso de águas limpas, e maximizar os usos destas águas que, de outra forma, seriam descartadas com possíveis impactos ambientais localizados. Reduz a vulnerabilidade à escassez de água.

ÁGUA	**Rega gota-a-gota**	É um método de irrigação que conserva água e fertilizante por permitir o gotejamento lento da água directamente na zona das raízes das plantas, através de uma rede de válvulas, tubos, mangueiras e gotejadores. Este sistema pode estar colocado à superfície do solo ou enterrado. Permite maximizar a água utilizada, regando apenas nas zonas desejáveis. Reduz a vulnerabilidade à escassez de água.
ÁGUA	**Monotorização da rega (Sondas)**	Utilização de sondas para monitorizar a humidade no solo. Ajuda na utilização eficiente e consciente dos recursos hídricos e da rega. Permite regar de acordo com as necessidades reais das culturas. Reduz a vulnerabilidade a secas.
ÁGUA	**Controle e correcção da qualidade da água de rega**	A qualidade da água de rega é uma condicionante para o desenvolvimento saudável da vida no solo bem como da saúde das plantas. O controle regular da qualidade da água permite ajustar níveis de PH, salinidade, fertilizantes, possíveis contaminantes entre outros fatores. Desta forma aumenta-se a eficiência na utilização da água para rega e minimiza-se impactos indesejáveis nas condições das explorações.

Nº Identificação do Recurso	Nome Identificação do Recurso	Tipo de Captação	Estado Administrativo do Processo (1)	Utilização da Água	Caudal de Exploração Médio (m3 / hora)	Volume Médio Anual Extraído (m3)	Volume Máximo Mensal Extraído (m3)	Nº de Horas Médio em Extração	Área dos Lagos (m2)	Ano de Construção
1 20	Charca "Vale Yin de Cima"	Charca **	Reg. 14.12.2010 ***	ocupação de terreno	-/-	-/-	-/-	-/-	1075	2012
1 40	Charca "Vale Yin de Baixo"	Charca *	Reg. 14.12.2010 ***	ocupação de terreno	-/-	-/-	-/-	-/-	1100	2009
1 60	Charca "Dos Cavalos"	Charca *	Reg. 14.02.2010 ***	Rega	1,5	225	40	150	450	2006 modificado 2008
2 00	**Charca "das Rochas"**	Charca*	Reg. 14.02.2010 ***	Ocupa. Terreno	-------------	-----------	-----------	-----------	600	antes 1994

3 00	**Charca/Barrag "Lago1"**	Charca **	Reg. 14.02.2010 ***	Rega	2	600	100	300	6400	2007
4 00	**Albufeira "Torre"**	Charca *	Reg. 14.02.2010 ***	Reservatório p/ Nº 8	------------	-----------	-----------	-----------	180	2005
5 00	**Charca "Lago Cinzento"**	Charca **	1451_2004 DALBA	Rega	1,5	225	40	150	1400	antes 1994
6 00	**Lago "Espaço dos Jovens"**	Charca *	Reg. 14.02.2010 ***	Ocupa. Terreno	------------	-----------	-----------	-----------	900	antes 1994 modificado 2007
7 00	**Charca "Escritório"**	Charca **	Reg. 14.02.2010 ***	Ocupa. Terreno	------------	-----------	-----------	-----------	625	antes 1994 modificado 1999
8 00	**Lago "Olival"**	Charca *	1639_2005 DALBA	Rega	0,3	270	50	900	50	2005
9 00	**Charca "Casa das Crianças"**	Charca *	Reg. 14.02.2010 ***	Ocupa. Terreno	------------	-----------	-----------	-----------	250	antes 1994
10 00	**Charca "Casa de Campo"**	Charca **	1638_2005 DALBA	Ocupa. Terreno	------------	-----------	-----------	-----------	1470	2004
11 00	**Lago "Lírio de Água"**	Charca *	Reg. 14.02.2010 ***	Ocupa. Terreno	------------	-----------	-----------	-----------	200	2007
12 00	**Lago "Horta do Vale"**	Charca **	Reg. 14.02.2010 ***	Ocupa. Terreno	------------	-----------	-----------	-----------	2450	2008

13 00	**Albufeira p/ "Horta do Vale"**	Charca *	Reg. 14.02.2010 ***	Reservatório p/ Nº 3	-------------	-----------	-----------	-----------	150	2005
14 00	**Lago "Aldeia do Vale"**	Charca *	Reg. 14.02.2010 ***	Ocupa. Terreno	-------------	-----------	-----------	-----------	860	2008
15 00	**Lago "Aldeia Grace"**	Charca **	Reg. 14.02.2010 ***	Ocupa. Terreno	-------------	-----------	-----------	-----------	1125	2009
16 00	**Lago "das Silvas"**	Charca *	Reg. 14.02.2010 ***	Ocupa. Terreno	-------------	-----------	-----------	-----------	500	antes 1994
17 00	**Charca "Aldeia da Luz"**	Charca **	Reg. 14.02.2010 ***	Ocupa. Terreno	-------------	-----------	-----------	-----------	800	2007 modificado 2011
18 00	**Charca "Lago Castanho"**	Charca **	1452_2004 DALBA	Rega	1,5	225	40	180	1575	antes 1994
18 50	**Charca "Lago Sul"**	Charca **	Reg. 14.12.2010 ***	Ocupa. Terreno	-/-	-/-	-/-	-/-	3550	2010
19 00	**Lago "Espaço Yin Pequena"**	Charca *	Reg. 14.02.2010 ***	Ocupa. Terreno	-------------	-----------	-----------	-----------	225	antes 1994
20 00	**Charca/Barrag "Triângulo"**	Charca **	Reg. 14.02.2010 ***	Ocupa. Terreno	-------------	-----------	-----------	-----------	400	antes 1994
21 00	**Charca "Horta do Pastor Baixa"**	Charca *	Reg. 14.02.2010 ***	Rega	1,2	216	40	180	100	2009 modificado 2011

22 00	**Charca/Barrag. "Santuário"**	Charca **	Reg. 14.02.2010 ***	Ocupa. Terreno	-------------	-----------	-----------	-----------	2100	antes 1994
23 00	**Lagoa "Vale Mua 2" (=Sul 2)**	Charca **	Reg. 14.02.2010 ***	Ocupa. Terreno	-------------	-----------	-----------	-----------	750/>8000	2007 modificado 2011
24 00	**Charca p/ F4 Monte cabana**	Charca *	Reg. 14.02.2010 ***	Reservatório p/ Nº F4	-------------	-----------	-----------	-----------	300	2006
25 00	**Charca/Barragem "Pueblo"**	Charca **	1453_2004 DALBA	Ocupa. Terreno	-------------	-----------	-----------	-----------	2000	1997
26 00	**Charca/Barragem "Aurélio"**	Charca **	Reg. 14.02.2010 ***	Ocupa. Terreno	-------------	-----------	-----------	-----------	1200	antes 1994
27 00	**Charca/Barra."Casa Vale Mua"**	Charca **	Reg. 14.02.2010 ***	Ocupa. Terreno	-------------	-----------	-----------	-----------	1350	2006
28 00	**Charca "Vale do Sul"**	Charca *	Reg. 14.02.2010 ***	Ocupa. Terreno	-------------	-----------	-----------	-----------	600	antes 1994
29 00	**Charca "Tamir"**	Charca **		Ocupa. Terreno	-------------	-----------	-----------	-----------	700	2011
30 00	**Charca "Rico"**	Charca *		Ocupa. Terreno	-------------	-----------	-----------	-----------	400	2011

31 00	**Charca "Amarelo"**	Charca *		Ocupa. Terreno	-------------	-----------	-----------	-----------	500	2011
F 1	**Furo "Oficina"**	Furo Vertical	1447_2007_ SB	Rega ****	1,8	300	25	167	-----------	1998
F 2	**Furo "Campus"**	Furo Vertical	1448_2007_ SB	Rega ****	1,8	300	25	167	-----------	2004
F 3	**Furo "Children Place"**	Furo Vertical	1710/CSB/SD/2008 2468-2009-DRHI	Rega ****	1,8	3900	400	2167	-----------	1998
F 4	**Furo "Monte Cabana"**	Furo Vertical	1711/CSB/SD/2008 2468-2009-DRHI	Rega	0,9	1950	200	2167	-----------	1998
F 5	**Furo "Casa das Crianças"**	Furo Vertical	Reg. 14.02.2010 ***	Rega ****	0,7	70	20	100	-----------	1998
P 1	**Poço "Vale da Fonte"**	Poço	Reg. 14.02.2010 ***	Sem uso	-------------	-----------	-----------	-----------	-----------	antes 1994
P 2	**Poço "Horta de Pastor"**	Poço	Reg. 14.02.2010 ***	Rega	1,2	216	40	180	-----------	antes 1994
P 3	**Poço "Vale da Mua"**	Poço	Reg. 14.02.2010 ***	Sem uso	-------------	-----------	-----------	-----------	-----------	antes 1994
P 4	**Poço "Lago Sul"**	Poço		Rega						2012
M 1	**Mina / Fonte "Oráculo"**	Mina / Fonte	Reg. 14.02.2010 ***	Rega	0,02	170	15	8600	-----------	antes 1994
M 2	**Mina / Fonte "Vale da Fonte"**	Mina / Fonte	Reg. 14.02.2010 ***	-------------	-------------	-----------	-----------	-----------	-----------	antes 1994
02 00	**Espace de Chriancas**	Fossa	Reg. 14.12.2010	-------------	-------------	-----------	-----------	-----------	-----------	2010

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03 00	**Campus & Aula**	Fossa	Reg. 14.12.2010	-------------	-------------	-----------	-----------	-----------	-----------	2002
04 00	**Casa de Campo**	Fossa	Reg. 14.12.2010	-------------	-------------	-----------	-----------	-----------	-----------	2010
05 50 peq	**Casa de Criancas**	Fossa pequena	sem	-------------	-------------	-----------	-----------	-----------	-----------	2010
06 00	**Aldeia Solar & Aldeia Luz**	Fossa	Reg. 14.12.2010	-------------	-------------	-----------	-----------	-----------	-----------	2009
07 50 peq	**Aldeia Grace**	Fossa pequena	sem	-------------	-------------	-----------	-----------	-----------	-----------	2006