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Adapting the Mediterranean to climate change

LAYMAN'S REPORT

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IPE Instituto Pirenaico de Ecología CSIC

CONTENTS

LIFE MEDACC "Demonstration and validation of innovative methodology for regional climate change adaptation in the Mediterranean area" LIFE12 ENV/ES/000536

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Photograhy: LIFE MEDACC partners, Jordi Baucells, City of Tiurana, Catalan Rangers.

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Photograph of the Sau reservoir (Spring 2008) by Jordi Baucells

THE CHALLENGES OF ADAPTATION IN THE MEDITERRANEAN

The Mediterranean is and will continue to be one of the world regions most affected by climate change. Observations over the past few decades show a trend towards warmer conditions and changes in the seasonal distribution of precipitation, with alarming reductions during the summer period. In this sense, recent predictions show that climatic conditions will be warmer later on in the 21st century. Overall reductions in annual precipitation are also foreseen, especially during the summer, as well as greater irregularity in rainfall and longer periods without any precipitation.

On the other hand, the processes of land use change in recent decades on the northern shore of the Mediterranean basin have led to **increases in the areas of forests and irrigated crops**, causing an increase in water demand. These processes have led to reduced water availability in rivers and aquifers, an effect which is expected to increase over the next few decades, with associated impacts on different ecological processes and human activities.

The high vulnerability of **water resources, agriculture, and Mediterranean forests** to climatic variability make them highly sensitive to the expected regional (Catalonia) and global consequences of climate change. For this reason, a **multidisciplinary approach** is necessary in order to identify vulnerabilities, quantify impacts, and design and implement adaptation measures.

The integrated management of water and its use by major consumers such as agriculture and forestry will play a central role in climate change adaptation in the Mediterranean. What will be needed is **integrated regional water management** which guarantees good ecosystem health and responsible use of water resources.

THE LIFE MEDACC PROJECT

The **objective** of the LIFE MEDACC project is to develop innovative solutions which will assist in adapting Mediterranean agroforestry and urban systems to the impacts of climate change. The project was carried out in three hydrographic basins representative of Catalonia (**the Muga, the Segre and the Ter**), though the methodological approach can be extended to other Mediterranean basins.

The **main activities** of the project have been:

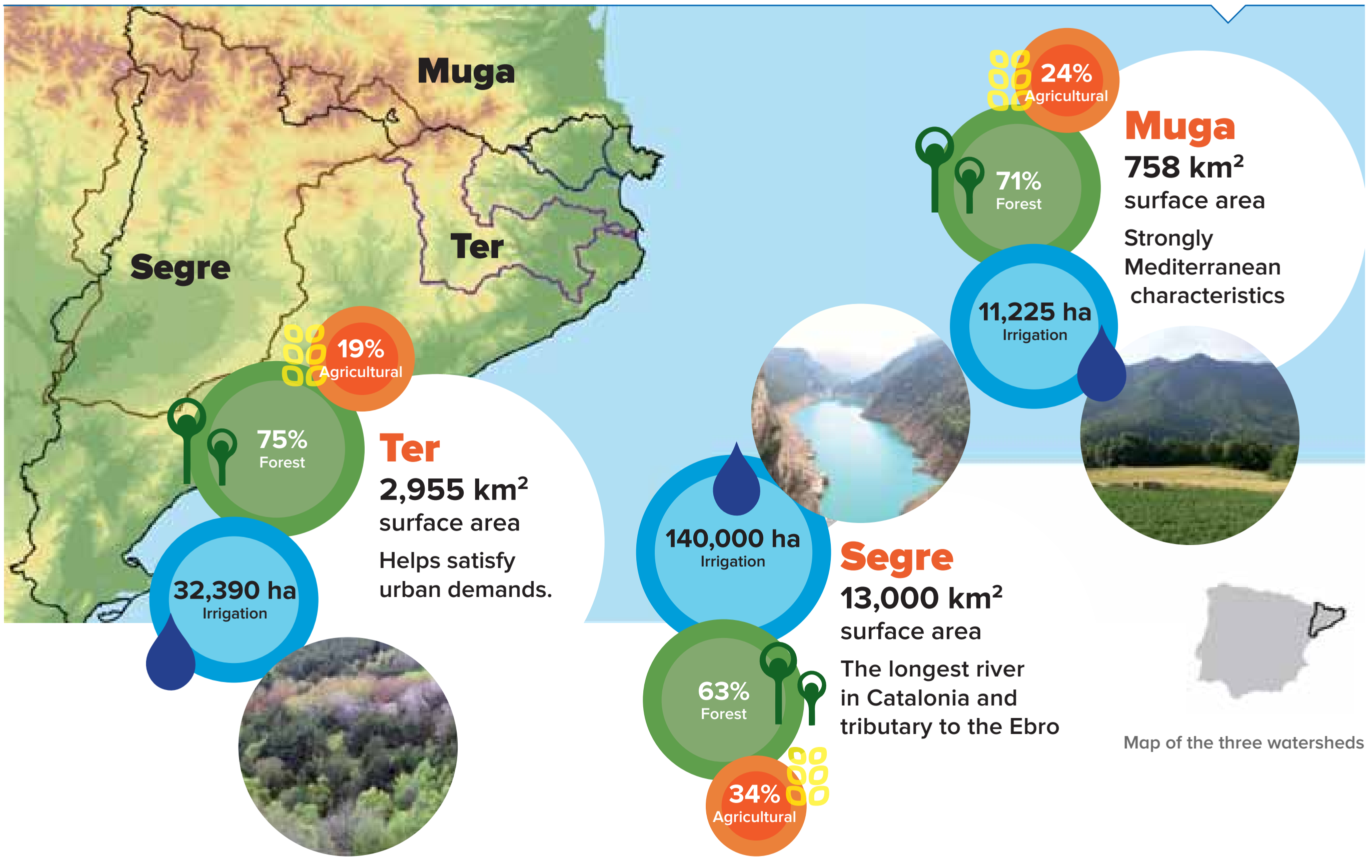
1. Diagnosis of trends in climate, land use, forests and water availability in the three basins over the past few decades.
2. Estimation of the future impacts of climate change and global change on hydrological and agroforestry systems in the three basins through the year 2050.
3. Development of a methodology based on indicators to assess the degree of adaptation of the three basins to the impacts of climate change.
4. Implementation of pilot tests on the efficiency of different adaptation measures in the agriculture, forestry and water management sectors, designed jointly with local actors.
5. Action plan for climate change adaptation of the three basins, including an evaluation of previous adaptation measures and a proposal and evaluation of new measures.
6. Creation and consolidation of a network of local actors (monitoring and management committee) which provided its knowledge and experience during project execution.
7. Dissemination and communication activities oriented towards informing and training actors at the local, county, and national levels.

The LIFE MEDACC project uses the hydrographic basin as the reference unit for analysis and activity execution. The chosen basins represent the diversity of the Mediterranean at a local level, incorporating a wide range of topographic, climatic, environmental, and land use conditions. The three basins have quite different water consumption levels but have common difficulties such as meeting demand and maintenance of environmental flows.

The Segre at Bellver

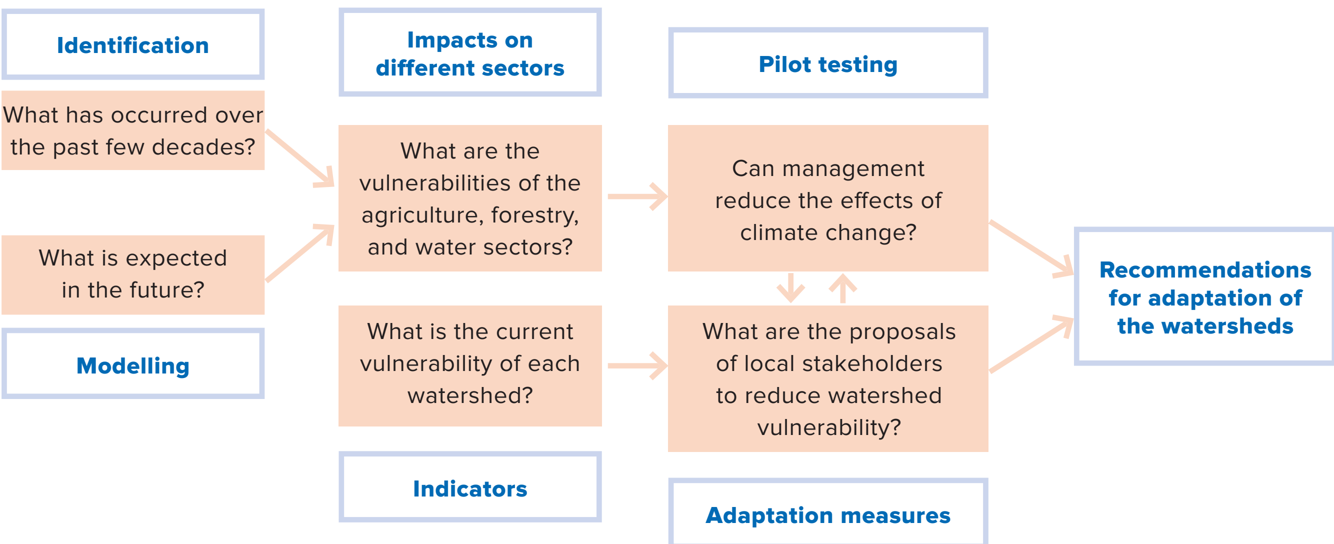
The Ter at the Susqueda reservoir

The Muga at Pont de Molins



The **results** of the project have led to the quantification of how adaptation can reduce the vulnerability of natural systems and socioeconomic activities to the impacts of climate change, as well as the economic and environmental costs associated with the application (or not) of a series of adaptation measures. This way, LIFE MEDACC contributes to the design and establishment of adaptation strategies and policies at the regional and national level in the Euro-Mediterranean context. In Catalonia, the project has contributed to the execution of the Catalan Strategy for Adapting to Climate Change (ESCACC 2013-2020).

Project map



WATER

PAST AND PRESENT

The main changes in the climate of the basins over the past few decades include **overall reductions in precipitation** -most notably during the summer- **more frequent and severe droughts,** and an increase in the atmospheric evaporative demand.

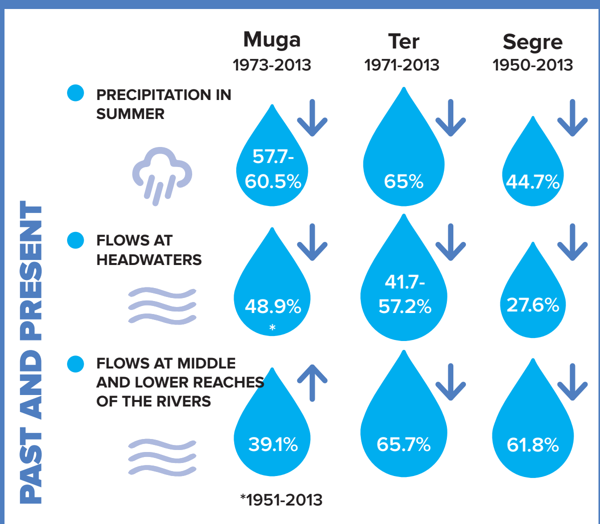
Regarding the water cycle of the watersheds, **overall reductions in flows** have been observed. These flow reductions vary depending on the section of the river and part of the basin considered. At headwaters, the observed reductions in flow are too severe to be only attributable to climatic factors. Therefore, it must be that changes in land use such forestland expansion have played a relevant role (in the Muga and Ter). In the lower river reaches, flow rates are strongly conditioned by the management regimes of the reservoirs.

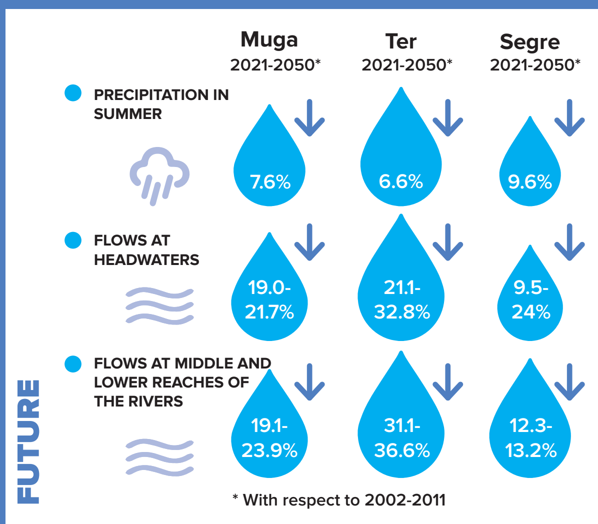
FUTURE

- Climatic projections through 2050 predict overall warming in Catalonia, affecting all climatic zones (Pyrenees, inland, and coastal areas) and in all temporal periods. At the same time, drought episodes are expected to be more frequent and severe, especially during the period from 2021-2050.
- It is expected that annual precipitation in Catalonia will be reduced by about 9% between 2012 and 2050 as compared with the period of 2002-2012. The greatest reductions in precipitation (-11.6 to -15.1%) are foreseen for the autumn season.
- The average temperature may increase by about 0.38 ˚C per decade from 2012 to 2050 with respect to the 2002-2012 period. The maximum and minimum temperatures show a clear increasing trend for both the Pyrenees and the interior (+1.12 ˚C), which will be greater than in coastal areas (+0.94 ° C).

The evaluation of the impacts of climate change on the water cycle shows **overall reductions in flows for the three watersheds during the first half of the 21st century.** In 2050, reductions in flows of between 9.5 and 32.0% are expected at the headwaters, and 12.3-36.0% in lower reaches, as compared to the 2002-2011 period. The Ter basin will have the most significant reductions in flows, both at the headwaters and river mouth. Notable reductions are also foreseen for the mouth of the Muga. The basin of the Segre river has a different hydrologic behavior, with more severe reductions foreseen at the headwaters than at the mouth.

More information can be found at:
http://medacc-life.eu/sites/medacc-life.eu/files/docuemnts/deliverable_12_final_version.pdf
More detailed information on these projections can be found at:
http://medacc-life.eu/sites/medacc-life.eu/files/docuemnts/d14_quantificationimpacts_v4_2.pdf





Rialb Reservoir, photo courtesy of Tiurana Town Hall.

SOLUTIONS

The combination of hydrological simulations and the three land use cover scenarios designed by the project (increase in forested areas through reforestation, loss in forested areas due to wildfire, and maintenance of the forested areas through expansion of managed areas) show very similar patterns for the three watersheds.

- The three scenarios show a strong influence of the forested area on the river flows; at the same time, the scenarios highlight the importance of **land use planning as a key tool for mitigating the observed and projected effects resulting from the climate change scenarios.**

The combination of the hydrological simulations and socioeconomic scenarios designed by the project (rational use of water resources and increase in water demand) show a strong modification of water dynamics in the three basins:

- In the Muga basin, the expansion of the Darnius-Boadella reservoir does not have any positive influence on water availability nor in the number, frequency, or intensity of the emptying events, indicating that this measure is not effective as an adaptation measure for reducing the vulnerability of the basin.
- In the Ter basin, a reduction in the volume of water transferred to the Barcelona Metropolitan Area causes a significant improvement in flows (from projected losses of 31.1% to flow reductions of only 16.7-17.4%).
- In the Segre basin, the completion of the Segarra-Garrigues Canal, with an allotment of 342 hm^3/year, greatly affects the dynamics of the water stored in the Camarassa and Rialb reservoirs. Of these, the latter is especially relevant since it is expected that, starting in 2027, the complete emptying of the reservoir will occur during at least one month each year.

The reductions of the flows at the headwaters of the basins over the past few decades and the predictions of estimated future water availability mean that **water management policies will be key** for meeting demands and simultaneously complying with environmental flows established for each watershed. In this sense, **impacts can be reduced by implementing measures that favor the rational use of water resources.**

Hydrological planning becomes a key adaptation measure: in the case of the Muga basin, three alternatives for management of the Darnius-Boadella reservoir have been simulated. The results show that there is no possible management solution which guarantees future demand and compliance with minimum flows. Therefore, efforts must be centered on **reducing demands during situations of recurrent drought, putting new sources of water into place** (desalinization and regenerated water), and **improving the efficiency of water use** (recharge of local aquifers).

In the Ter basin, a hydrologic simulation study of the coastal drainage system on the left bank of the Lower Ter was carried out in coordination with the LIFE PLETERA project and GeoServei S.L. The results show that:

- In comparison with the flooding episode of December 2008, the de-urbanization of the Pletera would lead to a reduction in the flooded area and recorded water depths. With this, the border of flooded inland area would change from 600 to 350 m, and the absolute spot height of the water would be 0.24 m lower.
- In turn, this type of positive impact can be extended to the adaptation of the region to the impacts of climate change such as sea level rise or the higher incidence of extreme meteorological events such as easterly storms.

More detailed information on the scenarios and models used can be found at:
http://medacc-life.eu/sites/medacc-life.eu/files/docuemnts/d13_methodologyseriesmaps_v4.pdf

FORESTS

PAST AND PRESENT

Both for their large area and sensitivity to climate, **forests** are one of the project's main subjects of study due to **their vulnerability to the impacts of climate change**. Over the past few decades, forested area has increased in the watersheds, consuming scrubland or previously farmed areas. This is a general trend in Catalonia, and is especially relevant at the headwaters of the watersheds. At the Muga headwaters this change has been particularly noticeable, with an increase in forested area of over 20% in 30 years (1970-2005). In general, these new **forests are dense and have little or no management,** and for this reason they are **especially vulnerable to drought and large forest fires.** Monitoring of episodes of forest decline in Catalonia shows that during the most recent hot and dry summers, symptoms such as decoloring, defoliation, and mortality were around 3% (2012 to 2016).

FUTURE

Climatic impacts already affected forests will become more severe in the future due to **greater frequency and intensity of drought periods** predicted by climatic models:

- Increase in risk of wildfire.
- Changes in the bioclimatic suitability for current species and species substitution in some areas.
- Changes in forest function and structure: decreases in productivity and carbon storage capacity, more relevant in humid forests than in dry environments.
- Increase in the frequency and intensity of mortality episodes.
- Increase in problems related to forest pests and diseases in the more fragile forests, and the introduction of new pathogens (fungi, insects, etc.)

More detailed information can be found at:
http://medacc-life.eu/sites/medacc-life.eu/files/docuemnts/deliverable_12_final_version.pdf
More detailed information on these projections can be found at:
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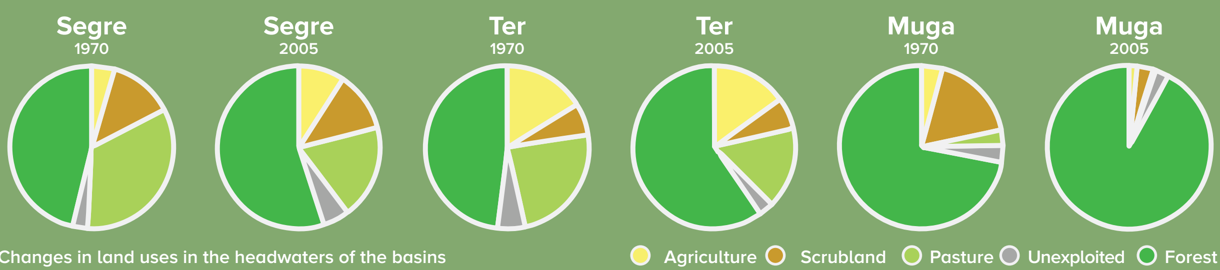
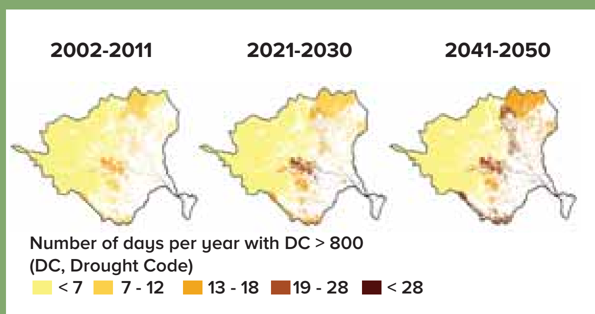


Changes in land uses in the headwaters of the basins

Effects of drought on a holm oak grove at Garrotxa. September 2012.
Image credit: Catalan Forest Rangers



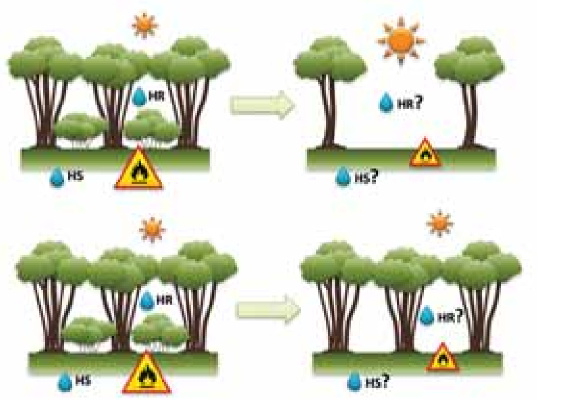
Map of meteorological forest fire risk based on predictions of the RCP4.5 climatic scenario for the Muga (number of days above the extreme risk threshold).

SOLUTIONS

There is evidence that **forest management can help make forests more robust against future climatic conditions**. However, the complexity and temporal scope of these studies makes it difficult to develop decision-making tools and adaptive management strategies based on the evaluation of the effectiveness of different forestry treatments from multiple viewpoints.

It is for that reason that a series of forestry management actions have been designed and executed, reducing the vulnerability of the main forest typologies of the three basins; all this has been carried out using the principles **of adaptive management.** These **actions** have been carried out **in potentially vulnerable forests**, either because of previous episodes of decline or because they have an elevated risk of wildfire.

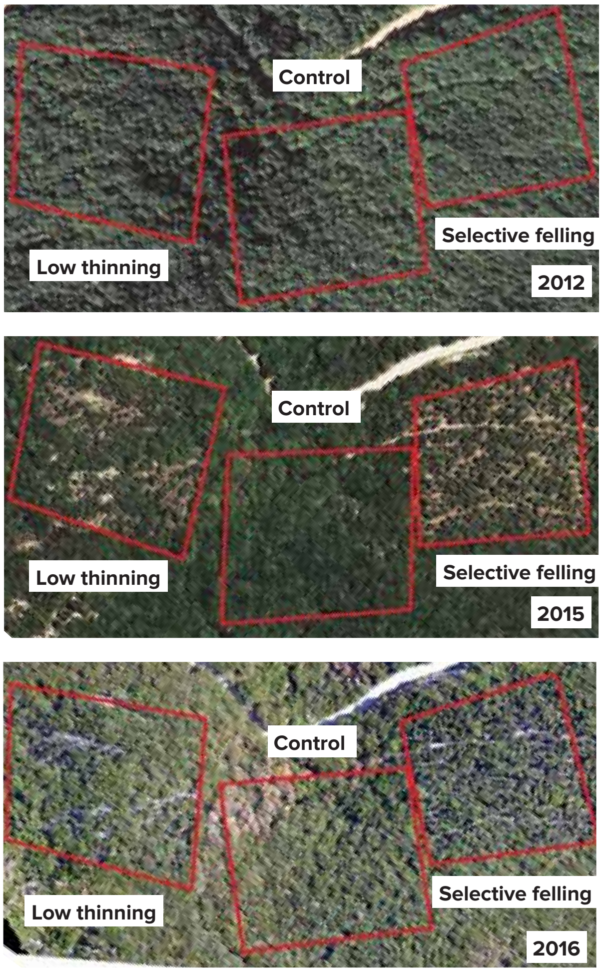
- In some pilot tests seasonal increments in soil humidity were observed where the management actions were carried out. During the spring and summer, high soil humidity is positively correlated with improved tree growth and health.
- **Management also led to higher water contents** of the vegetation in periods of elevated fire risk, which translates to **lower flammability and combustibility** of the vegetation. This was found both in parcels with black pine in the Solsonès region (Segre) and holm oak parcels of the Muga.
- In the case of the Scots pine at Montesquiu (Ter), forest management **clearly reduced forest decline.**
- Problems associated with drought in holm oak forests of Requesens (Muga) in the summer of 2016 barely manifested the managed areas (between 0 and 0.55% of the oaks showed symptoms of decline) while in the unmanaged parcel (control) 9.1% of the oaks showed signs of decline.
- **Forest management** proved key for **reducing the vulnerability of the holm oak** in the Muga basin, and for the **Scots pine** in the Ter basin, during the droughts of the summers of 2016 and 2017. In the case of the black pine in Solsonès (Segre basin) the effect was not as evident because the climatic anomaly was not as pronounced.
- In the Solsonès (Segre), the structural change of the black pine forests made through management **clearly reduced vulnerability to fire** by reducing the vertical continuity of combustible materials.



Representation of the forestry treatments applied in the Muga basin: selective felling (above) and low thinning (below).

- The Muga holm oak forest's resistance to the drought of 2016 was very similar among the two management schemes tested. This leads to the conclusion that even the implementation of **less intensive management treatments** (elimination of the understory and low thinning) with costs 20% than more intensive treatments (selective felling) could have a notable effect of reducing vulnerability.

Orthophoto of Requesens plots in 2012 (before treatment), 2015 (after treatments) and summer of 2016 (after drought, where 9.1% of the Oaks in the unmanaged plot became desiccated)



More detailed information on pilot testing can be found at:
http://medacc-life.eu/sites/medacc-life.eu/files/docuemnts/b2_3_descriptiondemonstrativeactivities_v3.pdf

AGRICULTURE

PAST AND PRESENT

Agriculture of the study watersheds is another one of the most vulnerable sectors to climate change if the **crops are not adapted to new conditions**, above all regarding aspects associated with **phenology and efficiency of water use.** Setting aside changes observed in the structure of agricultural land uses, over the past few decades another **two problems** associated with agricultural intensification have emerged: **water use and nitrogen management.** Irrigation offers greater benefits than dryland agriculture both in terms of productivity and profitability. With this in mind, it is clear that improving **water use efficiency** (increasing the quantity of product produced for each liter of water used) is key for improving sustainability. Dryland agriculture, which proportionally represents the majority of Catalonian agriculture, is more vulnerable since in order to maintain current productivity **new species and more drought-resistant varieties** must be employed, as well as **management strategies** such as crop rotation, fallows, or other cropping systems (including, for example, conservation agriculture, organic agriculture, integrated plant production, and precision agriculture).

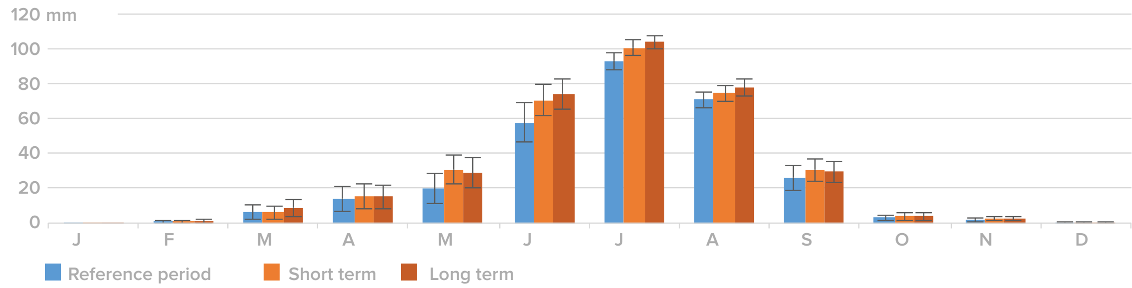
FUTURE

With global warming, **many crops will have increased water requirements**, and the period of irrigation will also need to be expanded in order to maintain the same levels of production. According to climate change projections, this trend will only increase with time.

Along the same lines, expected **changes in phenology** will lead to **earlier seasonal development of vegetation** and a reduction in the time required to complete the life cycle. While risk of frosts could be reduced, it is expected that the number of extremely hot days could increase, causing damages to crops due to heat waves. **Modifying the life cycle of crops could help avoid such impacts.**

More detailed information can be found at:
http://medacc-life.eu/sites/medacc-life.eu/files/docuemnts/deliverable_12_final_version.pdf
More detailed information on these projections can be found at:
http://medacc-life.eu/sites/medacc-life.eu/files/docuemnts/d14_quantificationimpacts_v4_2.pdf

OLIVE GROVES IN LOWER SEGRE REGION: NET IRRIGATION REQUIREMENTS



Water necessities of olive in the Lower Segre region for the reference period and two future temporal periods (short term, 2021-2030, and long term, 2041-2050)

SOLUTIONS

The LIFE MEDACC project has tested different technical agronomic solutions which can promote crop adaptation:

- Mulch tests with plastic and organic ground coverings at Raïmat vineyards (Segre basin) and at IRTA's Torre Marimon facilities. In these tests, it was shown that the plastic, when installed correctly, has **a positive impact on grape vine development,** though this could be more related with increases in soil temperature in the beginning phases of growth than an increase in soil humidity.
- Evaluation of the effectiveness of **relocating vineyards to different altitudes** in the Segre watershed: significant losses were observed as compared to productivities of the traditional grape-growing areas. However, production in these new areas lends to products with **better organoleptic characteristics,** giving an added value to the wines produced, and this may compensate for productivity losses.
- Vinicultural production at higher altitudes is an option that should be considered in the future, though increased risks of frosts or storms must be taken into account since these can negatively affect production. Also, an increased carbon footprint may result as a consequence of transporting the grape greater distances to the processing facilities.
- **Advanced irrigation management** in the alluvial plains of the Lower Ter and Muga **in corn and apple crops.** Improvements in water use efficiency have been recorded in plots which followed the irrigation recommendations of the GIROREG system developed in the context of the project. This was true for both corn and apple crops, where **reductions in water consumption were between 20 and 30%.** In the case of apple, the value of production in the plot in which the GIROREG methodology was employed was 32,850 €/ha, representing a **4.2% increase** with respect to the control plot.
- Though expert irrigation management systems such as GIROREG provide highly valuable information to farmers, in many cases the recommendations have practical limitations: water authority-mandated irrigation shifts, large economic investments, or low pressure are some of such limitations. But the most important limitation is that the current water management framework does not encourage savings - this signals a need for **integration of such strategies involving as many stakeholders as possible** in order to manage water in an efficient and sustainable manner.

Together with the consultant agency l'Espigall, a study was carried out, titled "Adaptation of the agricultural sector of Alt Pirineu and Aran to climate change: risks and opportunities." This study shows that adaptation to climate change can be a stimulus for beginning a deep-rooted change to the agrarian economy of the Catalonian counties of the Pyrenees and western regions, which should be grounded in:

- Increasing areas of extensive grazing in alpine pastures and in uncultivated areas of valleys in order to reduce pressures on agricultural lands - currently dedicated to the production of animal feeds - and to reverse the trends of increasing forested area and biodiversity loss.
- This proposal for intensification of extensive grazing could free 26,103 ha of farmland for the production of food for human consumption, being both more profitable while consuming less water. Gross income for the agricultural sector in this scenario could be as much as 181.1 M€, compared to the current 84.3 M€, or 76.7 M€ which is projected income for the scenario covering the period of 2030-2050 if the situation does not change.

Advanced irrigation management: installation of drip irrigation and soil humidity sensors.

More detailed information on pilot testing can be found at:
http://medacc-life.eu/sites/medacc-life.eu/files/docuemnts/b2_3_descriptiondemonstrativeactivities_v3.pdf

ARE THE WATERSHED ADAPTING PROPERLY TO CLIMATE CHANGE IMPACTS?

The analysis of whether or not the three study basins (the Muga, Segre and Ter) are adapting to the impacts of climate change requires the elaboration of indicators for assessing and monitoring the adaptation measures.

For this task, based on the methodology of the report, "Global indicator of climate change adaptation in Catalonia" (OCCC), the LIFE MEDACC project **has proposed 22 indicators for evaluating adaptation** in agriculture and livestock, water management, and forestry. For each indicator, an evaluation was made of **actual trends** (how the indicator has evolved since data became available), the **desired trend** (how the indicator should evolve to reflect improved adaptation) and a final **evaluation of whether the indicator is on track in terms of adaptation** (comparing the desired with the real trend, with three options: improving, no significant trend, worsening). The following table shows the 22 indicators by sector:

AGRICULTURE	WATER	FORESTS
Crop yield	Management plan for the River Basin District of Catalonia (2016-2021)	General Plan for Catalan Forest Policy 2014-2024
Crop diversity	Water destined to irrigation in Catalonia	Area with forest management plans on private property
Surplus rainwater after agricultural use per kg produced	Status and degree of compliance with planning objectives for surface water bodies	Relationship between forest area having undergone forest management practices and total area with forest management plans on private property
Animal feed VS human food	Volume of water used in urban systems	Area of harvesting on private property
Water productivity	Municipal water utility	Timber harvested on private property
Forest area VS agricultural area		Timber harvested on public property
		Firewood harvested on private property
		Density
		Over bark volume harvested
		Area burnt by forest fires
		Head of sheep and goats

Cadí: Snow, a dwindling resource.

For the **AGRICULTURAL SECTOR**, the Segre has the least favorable situation of the three basins, due to the fact that it does not have the desired trends for indicators such as crop diversity or the agricultural versus forest area ratio. This less favorable situation can be explained by the Segre's consolidated agricultural sector which currently has a significant opportunity to implement adaptation measures which, by and large, have not been applied.

In terms of **WATER MANAGEMENT**, the Ter basin has had the most positive development of improved adaptation to the impacts of climate change, followed by the Segre, and lastly the Muga. In all three cases, adaptation will depend on activating the Program for Measures of the Management plan 2016-2021, and on full integration of management policy for water, agriculture, and forestry.

Concerning **FORESTRY**, again the Ter has the most positive adaptation to climate change, followed by the Segre and lastly the Muga. In all three cases, adaptation of forests to climate change will depend on the application of adaptive forest management which favors mature and healthy forest structures and reduced fire risk; this can be achieved via silvicultural techniques, the stimulation of forest product and the bioeconomy associated with forests (biomass and construction materials) and a return to extensive livestock farming.

A study was carried out together with the consulting company La Vola, titled **"Analysis of the degree of vulnerability and resilience of Catalonia's municipalities to climate change."** This work developed an analytical methodology for evaluating municipal-level vulnerabilities and resiliencies to climate change; more specifically, the analysis centered on the impact of increases in the mean annual temperature. Based on three exposure indicators, 15 sensitivity indicators, and 12 adaptive capacity indicators, a total of 17 indicators of vulnerability were established, with a quantification on a scale of 0 to 10 (not very vulnerable to very vulnerable).

In collaboration with the Catalan Institute of Ornithology, a study carrying the following title was carried out: **"Development and calculation of an indicator of impact on connectivity of bird populations in Catalonia in the context of climate change."** The study concluded that this indicator remained quite stable during the 2002-2014 period, and, as a consequence, there is no evidence of a general displacement of bird populations towards areas which are climatically more favorable. On the other hand, bird populations are affected by the abandonment of traditional land use practices, which has favored natural forest expansion. In this sense, species of open habitats show an overall negative trend, while forest-dwelling species' populations were increased.

A summary table, synthesizing the conclusions by sector, assigns the watersheds the following rankings:

	Agricultural indicators	Water indicators	Forestry indicators
First	TER	TER	TER
Second	MUGA	SEGRE	SEGRE
Third	SEGRE	MUGA	MUGA

More detailed information can be found at:
http://medacc-life.eu/sites/medacc-life.eu/files/docuemnts/metodologia_indicadors_deliverable_10_0.pdf

PARTICIPATION

By way of the project's **Monitoring and Management Committee,** LIFE MEDACC has favored the creation of a permanent network of local actors in the three watersheds, as well as transversal stakeholders throughout the region, all of whose knowledge and experience has contributed to project execution. The participation of these stakeholders was formalized in activities such as:

- **Five annual meetings of the Monitoring Committee**, including the participation of 110 stakeholders representing 49 entities: 21 public administrations, 15 private entities, 4 NGOs, and 9 research centers.
- **Seven smaller meetings with 34 stakeholders from different sectors**: natural areas, administration, university, conservation, agriculture, users, and tourism. These meetings led to an understanding of how the project's evolution influenced actors' perception of adaptation to climate change.
- **Ten technical meetings with a total of 42 participants for:** a) developing socioeconomic scenarios, b) decisions on the location of forest pilot tests, c) decision on the type of silvicultural treatments to apply in the pilot tests, and d) proposal of new adaptation measures for the forestry sector.
- Development of three **action plans for the adaptation of the basins** by means of a collaborative process between project members and actors within the Monitoring and Management team, with planning as follows:

1. Compilation of existing adaptation measures and initiatives. The first compilation defined 32 measures subdivided in 52 actions. By means of a participative workshop with stakeholders, the effectiveness of the compiled measures was evaluated, with the identification of the following measures as the most effective:

- Agricultural sector: improvements in irrigation (improvements in the efficiency and modernity of the system) and fertilization practices.
- Forestry sector: true application of adaptive management that improves resistance to fire risk.
- Water management: reductions in flooding risk, improvements in the hydrological surveillance network, and research on the relationship between land use changes and flows (run-off, recharge, and "blue" water).

Following the workshop, an initial compilation of 42 measures subdivided into 139 actions was completed.

The proposal for new adaptation measures to apply were based on: 1) experience of the members, 2) meetings with key actors, and 3) contributions of the Monitoring Committee. 52 new measures were proposed, which were evaluated and prioritized in a participative workshop with stakeholders, yielding the following results:

- Agricultural sector: prioritization of measures for technology improvement associated with water use in irrigation, research on adapted varieties, and the promotion of best practices in the use of fertilizers, pesticides, and energy. Options related with altitudinal and latitudinal changes in crop cultivation are considered to have lower priority.
- Forestry sector: prioritization of measures for integration of forest management with water management, promotion of planning and implementation of adaptive management. Measures related to training and knowledge transfer are considered to have lower priority.
- Water management: prioritization of measures related with improvements in irrigation and regenerated water for irrigation. The option regarding desalinization lacked a consensus among participants due to the high energetic costs (greenhouse gas emissions), though for conurbations with structural deficits this may be a possible adaptive measure worth considering.

3. Development of three action plans, one per watershed with the objective of organizing, scheduling, and evaluating adaptation measures proposed for each watershed, conceived as a roadmap to face the impacts of climate change.

So that the MEDACC project may have an impact beyond its finalization and so that other adaptation measures proposed by the stakeholders of the watersheds may be implemented, a special effort was made to create **opportunities for debate and regional consensus-gathering.**

Fourth meeting of the Monitoring Committee, Barcelona, 17 January 2017.

Fifth meeting of the Monitoring Committee, Lleida, 14 December 2017.

It is necessary to **create forums** which allow for the due representation for regional actors, administrations, and research and technological centers, with the objective of achieving consensus on and designing adaptation measures to be undertaken. Such forums should be founded in **multilateralism** due to the complex nature of these issues, and since classical bilateralism results in the execution of only those measures which are proportional to the influence of a given actor over the public administration. This creates the need for a **new governing body which facilitates the development and execution of active and efficient adaptation policies.** In this sense, LIFE MEDACC has had a key role in the establishment of the Water Users Community of the Coastal Plain of the Muga; this community constitutes all users of the salinated aquifer in the coastal zone, having the objective of creating consensus and implementing measures to improve the problematic situation. LIFE MEDACC was also present in the conception and initiation of the **Gavarres Plan 2025**, led by the Consortium of Les Gavarres in the Ter basin, with the objective of making the cork industry more resilient to already observed impacts of climate change.

DISSEMINATION

- Until 2017, the web site has been visited more than **5,500 times.**
- More than **90 items** (data and cartographic products) have been uploaded to the project data platform.
- Until 2017, the project has more than **680 Twitter followers.**
- The project has generated 13 information boards.
- Two information panels at the Forum Global Eco in Barcelona were visited by approximately 300,000 people.
- **Nine guided visits** were made to the demonstrative sites.
- 1,000 leaflets describing project were distributed in three languages.
- Four scientific articles were produced.
- More than 30 press releases were made.
- More than 40 conferences and seminars were held.
- Six technical seminars were organized.
- The project participated in three agricultural fairs.
- Two videos were made.
- Dissemination materials: 900 wall and desk calendars, 250 desktop meteorological stations, 175 umbrellas.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Tendencias

Desarrollo y fuentes naturales

Diccionario para otra economía del agua

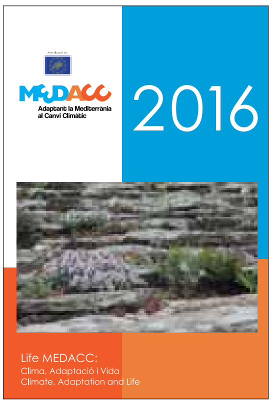
La merma de recursos hídricos exige mejorar sus usos y financiar todo el ciclo, incluida la restauración de los ríos


Cap a una Mediterrània més càlida

Un projecte aborda com adaptar la gestió de l'aigua, el bosc i el camp al canvi climàtic


Information boards installed at the Requesens pilot site (Muga basin)

Press releases




Dissemination materials: umbrellas and desk/wall calendar


Guided visits

RECOMMENDATIONS

Climate change impacts in the Muga, Segre, and Ter watersheds increase the current vulnerability of the three basins. Flow losses and projections based on future scenarios forecast a significant reduction in water availability. Based on this, the **LIFE MEDACC Project Management and Monitoring Committee proposes a series of recommendations** aimed at promoting changes in the development and implementation of policies, summarized below.

- The process of adaptation to the impacts of climate change is an opportunity for the systems (and the region) which should be implemented in order to **maintain the profitability and viability** of these systems (and regions) in the future.
- The abandonment of agroforestry has consequences for water resources. It is impossible to consider forest hydrology independently of land use since these are intimately connected; **management of land use must be considered with hydrology in mind, and the reverse is also true.**
- Depopulation of rural areas, abandonment of farmland, loss of extensive grazing, and a lack of forest management all increase exposure and sensitivity (and vulnerability) to climate change impacts. One of the aspects most detrimental to the key issue of water availability is a **lack of management on a regional scale**; it will be crucial to include this in regional and sectorial planning instruments.
- In Catalonia, farmers represent only 1.7% of the total population (as of the first trimester of 2017). Farmers depend on industries closely tied to the sector, and the number of family farms are steadily dwindling in favor industrial or business-style management. Access to land is an impediment. What model should be pursued? **A cooperative model** tied to a vibrant local economy, or a hierarchical model managed on macroeconomic terms and guided by markets? Both of these routes are possible, but lead to very different outcomes in terms of vulnerability.
- It is necessary that managers, regional and social actors, and general population of coastal cities become **sensitized** to the fact that **the provision of services, culture, wellbeing, and food** all have associated costs; for reasons of resilience, the urban zone should help guarantee the **provision of these services and foodstuffs.** The agenda for adaptation to climate change of any city is incomplete if regional and sectorial planning do not contribute to resilience of the surrounding environment which provides water, food, and services.
- Both the evaluation of climate change impacts and adaptation have **local and regional** components which distinguish them from mitigation. Without a doubt, **success in adaptation to climate change** impacts depends on the accuracy of **climatic predictions**, but above all the consideration of measures and actions should be undertaken in a collaborative manner with local and regional stakeholders.
- It is necessary to **create forums** which allow for the due representation for regional actors, administrations, and research and technological centers, with the objective of generating consensus on the measures to be undertaken, and manage any conflicts which may arise.
- Believing that technology alone will resolve vulnerability is insufficient. What is also necessary is a new model of **governance in the management of water** and more purposeful consideration of the previously-mentioned environmental aspects as well as the **water-energy nexus.** There is room for improvement both in agriculture and forest management; for instance, the application of **new forest management practices** is a promising field for dealing with the impacts of climate change.
- As described in Section C of Article 16 of the Law 16/2017, of 1st of August, on Climate Change, "it is necessary to prioritize the orientation of water resources towards improvements in savings and efficiency with the objective of achieving aquatic ecosystem quality targets." Taking into consideration climatic predictions, failing to do this could signify compromising the implementation of **environmental flow requirements.**
- It is necessary to consider the development of **solutions** which are not only technical but also **environmental, political, and social,** and which are sustainable over time and lead to enhanced integration of the different systems (hydrology, forests, agriculture, grazing, etc.) with local communities.

More information on the recommendations can be found at:
http://medacc-life.eu/sites/medacc-life.eu/files/event_files/recomanacions_medacc_definitives.pdf

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Adapting the Mediterranean to climate change

Project website: http://medacc-life.eu/
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COORDINATION

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