



## **LIFE ADVICLIM: final report**

Hervé Quénol, Meslay Marlène

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LIFE Project Number  
**LIFE13 ENV/FR/001512**

**FINAL Report**  
**Covering the project activities from 01/07/2014 to 29/02/2020**

Reporting Date  
**09/10/2020**

LIFE+ PROJECT NAME or Acronym  
**LIFE ADVICLIM**

Project Data

<b>Project location</b>	FRANCE
<b>Project start date:</b>	01/07/2014
<b>Project end date:</b>	29/02/2020
<b>Total Project duration (in months)</b>	68 months ( including <b>Extension of 08 months</b> )
<b>Total budget</b>	€ 2.885.302
<b>Total eligible budget</b>	€ 2.852.388
<b>EU contribution:</b>	€ 1.426.587
<b>(%) of total costs</b>	49.44
<b>(%) of eligible costs</b>	50

Beneficiary Data

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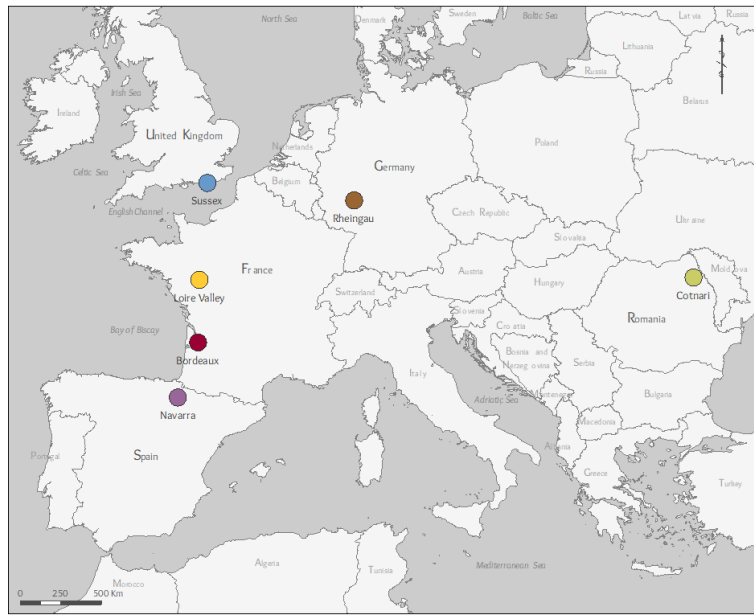
## 2. Executive Summary (maximum 5 pages)

### *Context and objectives*

Given the decisive role of climate on grape and wine production, viticulture is one of the most sensitive sectors to current changes in regional temperatures and rainfall patterns, as well as the likelihood of extreme weather events. Indeed, each wine growing region's long-term climate structure largely determines its grape growing and winemaking potential, where short-term climate variations are key factors influencing seasonal grape and wine production. Across wine growing regions, especially the traditional regions of Europe, the impacts of contemporary climate change on viticulture are already significant, with changes in grapevine phenology and grape composition, the latter leading to increased alcohol levels and altered wine sensory profiles. As a result, projected 21st century climate changes are very likely to continue to have strong effects on wine quality and style, which over time may even cause geographical shifts in suitable grapevine varieties and production areas.

With these potential environmental and socio-economic challenges, winegrowers are increasingly required to respond by adjusting their decision-making and management practices. Indeed, due to the perennial nature of grapevines, and because of the rate of current and expected temperature changes, climate change adaptation in viticulture is an immediate priority. However, this remains a relatively new and uncertain process, involving complex temporal and spatial challenges. Temporally, adaptation strategies and policies will have to address impacts in both the short- and long term, whereas spatially, context-specific adjustments are essential. The issue of mitigation is also crucial as the selected adaptation strategy will contribute more or less to greenhouse gas emissions. For example, shifting to areas more productive under future climatic conditions can be seen as an effective strategy, yet such adjustments may have an even greater impact on mitigation efforts than rational changes in vineyard management practices of existing systems.

In response to these challenges, there is a need to assist the viticulture sector in adapting to climate change. With the contribution of the LIFE financial instrument of the European Union, the LIFE-ADVICLIM project aimed to assess and develop local climate change adaptation and mitigation strategies for a range of wine growing regions across Europe (Figure 1). Namely Bordeaux and Loire Valley (France), Sussex (England), Rheingau (Germany), Cotnari (Romania) and Rioja (Spain). They represent therefore the climatic diversity of European wine growing regions, ranging from the Mediterranean to Oceanic and Continental climates. In addition to their regional prevailing climate, each region consists of unique geographical, social and economic features, providing knowledge and understanding of the various local and contextual factors that define grape and wine production. Accordingly, within the context of the issues surrounding climate change, this project provides important insights to identify and prioritize adaptation and mitigation initiatives and efforts, from local to European level.



*Figure 1: Geographical position of the six European wine growing regions that are studied in the LIFE-ADVCLIM project.*

### ***The LIFE-ADVCLIM project***

The LIFE-ADVCLIM project “*aimed to improve local management of vineyards in the face of climate change. It has developed tools to measure and model both contributions to climate change and the impact of climate change. It has built on these to help identify the best responses to mitigate and adapt to the impact of climate change in vineyards*”.

In order to achieve these objectives, several Technical Actions (field experiments and modelling) have been set up to develop operational tools at vineyard scale, combining a model for adapting wine-growing practices to climate change with greenhouse gas calculation model. The general approach and structure of the LIFE-ADVCLIM project are presented in Figure 2. The first action A1 was the employment of an experimental protocol, designed to provide key inputs on temporal and spatial variability in viticulture. The measurement networks were installed in each pilot site, allowing the acquisition of climatic and agronomic data. The fine-scale agroclimatic models, derived from measuring data, made it possible to model and evaluate the spatial variability in local climate. With a better understanding of the local climate and grapevine performance, generated results were linked with regional climate change projections. Coupling bottom-up with top-down models allowed the construction of higher resolution outputs of current and future agro-climatic potentials (RCP4.5 and RCP8.5 by 2031-2050 and 2081-2100). The integration of local climate variability (bioclimatic indices and phenological modelling) into regionalized climate change simulations provided an assessment of the impacts of climate change for European viticulture at the vineyard scale (voir A1\_deliverable). The data generated from this Action A1 has been used in Actions B1 and B2. In Action B1, a multi-agent model (SEVE) was developed to assess the effect of climate change, and associated increased climate variability, on grapevine growth and on vineyard management practices. The objective of this model was to define climate change adaptation scenarios, based on climatic spatial variability and winegrowing practices. With an important involvement of local winegrowers and their inputs, this multi-criteria modelling

approach was applied to each pilot site, which allowed adaptation scenarios to be defined on the scale of the vineyard. The objective of Action B2 was to calculate pilot site carbon footprints according to the different climate change adaptation scenarios identified in Action B1. Carbon footprints have been calculated, according to the winegrower's cultivation practices, on representative test plots for each pilot site. This scale provided a detailed diagnosis that allowed to emit recommendations for climate change mitigation. Actions B1 and B2 are linked in order to provide winegrowers with a manual on adapting and mitigating to climate change. Although there are many management tools or options that hold great potential for winegrowers, there is yet little guidance on how practices should be undertaken at different temporal and spatial scales in response to climate change. Action B3 monitored the results of B1 and B2 on several plots representative of each pilot site. Action B3's objective was to recommend effective adaptation and mitigation techniques to each pilot site, thus generating knowledge and promoting communication between policy-makers and decision-takers. This action was delivered in three formats: the VIDAC web platform (Action B4), published material (in the form of pilot site-specific leaflets) and a Story Map (a pedagogical tool presenting each action of the project in the form of interactive map). Finally, Action B4 is the direct communication of results to winegrowers, seeking to influence their management and decision making. The VIDAC platform was therefore created, which has a user-friendly interface, allowing to visualize the collected field data and information relevant to ongoing decision making. Action C, separated into two sub-actions, was intended to monitor the impact of actions in this project. Action C1, estimating the environmental impact of the project's findings, followed a two-step approach: a general environmental assessment for each site, followed by a specific environmental assessment based on the adaptation scenarios defined in Actions B. The action plan of the C1 project has been restructured. It has been difficult to assess the impact of individual adaptation measures on the environment in quantifiable terms. Direct implementation of the results of Action B in plots representative of pilot sites is only possible in the long term. Action C2 sought to assess the impact of the adaptation responses generated by the project from an economic point of view. The costs of viticultural practices for representative plots in each pilot site were estimated for the current situation and for future climate change scenarios.

It is important to note that all the actions of ADVICLIM have been carried out in a close relationship with the winegrowers of each study region, representative of European viticulture. Indeed, all studied vineyard plots in pilot sites belong to local winegrowers, except in England where the pilot site is owned by the partner (Plumpton College). Therefore, firstly, the different viticultural practices and strategies implemented in the Technical Actions were defined with and by winegrowers through participatory surveys and workshops. From here, the results and the various recommendations were discussed with the concerned grape and wine professionals in order to valid project outputs before diffusion. The LIFE-ADVICLIM project therefore placed a strong emphasis on working closely with winegrowers.

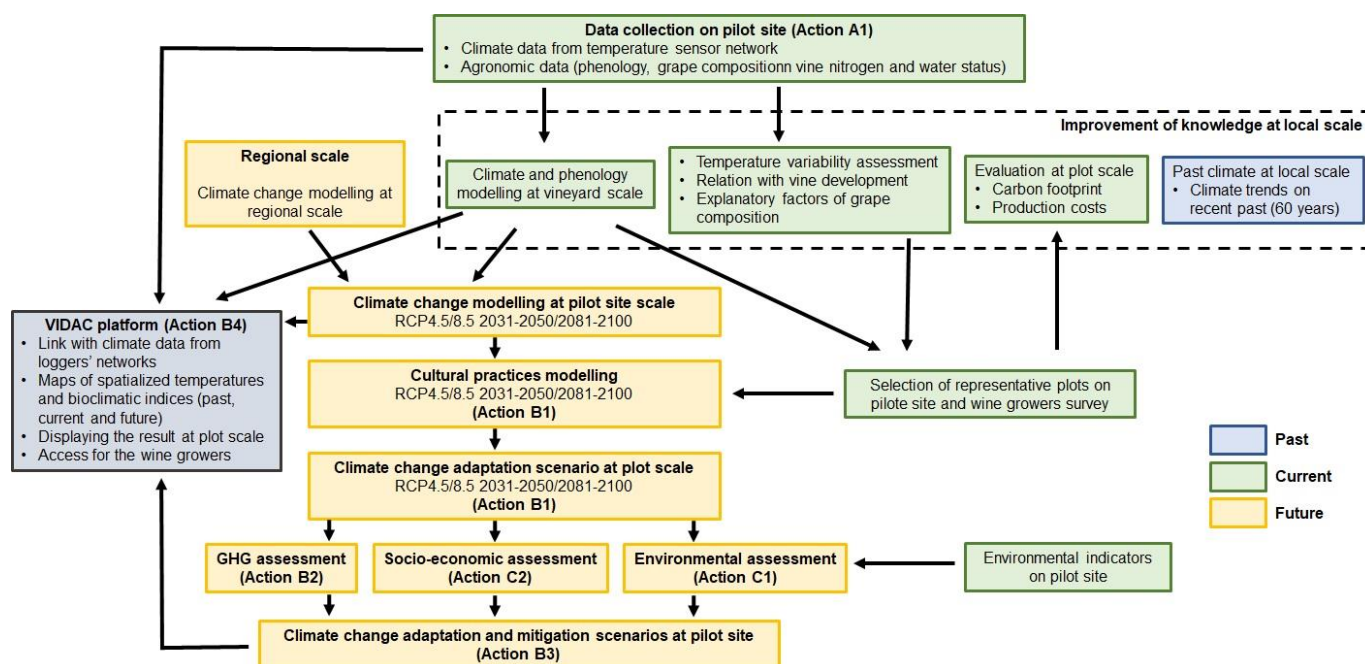


Figure 2: General approach and structure of the LIFE-ADVCLIM project.

Action D is being used to disseminate the project information and results via several means, such as newsletters, social networks, a multi-lingual website, and scientific and technical conferences. Local meetings of winegrowers and stakeholders were held to present and validate the results obtained on local pilot sites. For example, the local meetings held in Saint-Emilion, Val de Loire and Navarre were attended by between 100 and 200 winegrowers and stakeholders. The final meeting of the LIFE-ADVCLIM project was held in Navarre (Spain) from 28 January to 30 January 2020. The overall results of the project (including adaptation scenarios with carbon footprint calculations) are disseminated through synthesis leaflets.

## Main results

By 2050, whatever the climate change scenario, the suggested adaptation methods are based on the use of plant material and viticultural management strategies. Although these methods have low greenhouse gas emissions, multi-criteria environmental analysis has made it possible to optimize the number of interventions and practices in relation to the local characteristics of the plots and the winegrowers' strategies. The most effective mitigation actions are in agronomic and technological innovations (e.g. practices that reduces the need of an intervention, ...). The optimization of these actions therefore has direct environmental benefits. By 2100, By 2081-2100 under the RCP8.5 scenarios, the thermal increase is greater and involve other adaptation methods such as changing grape varieties. Knowledge of local climate variability makes it possible to optimise adaptation scenarios according to the specific characteristics of the vineyard by proposing a reasoned adaptation strategy. This approach also offers a direct environmental benefit because the winegrower will be able to define his strategy for planting new grape varieties according to local climate variability. This will avoid the translocation of winegrowing area. The environmental benefit is also important on carbon foot print even if it is necessary to complete the GHG assessment on adaptation equipment for extreme scenarios (e.g. irrigation, solar protection systems in vineyards, etc.).

### 3. Introduction (1 page)

Various studies on vine's climate adaptability under different climate change scenarios show that we can expect major upheavals at global level, with the disappearance of some wine-growing regions by 2100. These studies, based specifically on climate simulation, propose fairly radical methods to adapt to climate change, for instance moving wine-growing regions. Studies on the impact of climate change only cover major global wine regions, however, without taking into account the spatial variability of climate on finer scales. However, atmospheric parameters at the level of the boundary layer depend on surface conditions (surface roughness and type), and these can cause significant spatial variability in relatively small areas (from a few square metres to a few square kilometres). A wine's specific features are determined by these fine-scale variations (e.g. slope, exposure, type of soil, etc.), and it is at the scale of the plot that winemakers manage their estate and adapt to the climate, notably by agricultural practices (tillage, work on the vine, etc.). The spatial variability of climate at local scale should therefore be taken into account when defining a rational climate change adaptation policy. Despite the huge progress made in the last ten years in terms of the spatial resolution of climate projections (narrowed down to a few square kilometres), they are not yet sufficiently precise enough to take into account the influence of local parameters (such as topography and soil types), although these parameters are decisive for the vine's and wines' characteristics. Combined with regional climate scenarios, analysing the spatial variability of local climate makes it possible to fine-tune the models' spatial resolution and to propose rational adaptation methods at the level of the estate rather than at the level of major wine regions. In the LIFE-ADVICLIM project, spatial climate variability at the local scale has been integrated into the outputs of regionalized climate change models. Fine scale agro-climatic modelling, combined with winegrowers' production strategies in a multi-agent system, has enabled to create climate change adaptation scenarios based on spatial climate variability at the vineyard scale. An assessment of greenhouse gas emissions was then carried out to assess the carbon footprint for each adaptation scenario. This project aimed to inform and assist winegrowers on climate change impacts, on rational adaptation scenarios and on greenhouse gas emissions related to their practices at the scale of their vineyard plots. These methodologies have been applied in several wine-growing pilot sites - Bordeaux and Val de Loire (France), Sussex (England), Rheingau (Germany), Cotnari (Romania) and Rioja (Spain) - representative of the climate diversity of European wine-growing areas, ranging from Mediterranean, oceanic and continental climates.

Adaptation of plant material and cultural practices in order to preserve wine production in the current winegrowing areas is of major environmental benefit. A better understanding on the impact of climate on vine physiology, grape ripening and diseases also limits the use of inputs like herbicides, spraying products and fertilizers. Adaptation scenarios with GHG assessment at vineyard/plot scale enable an individualised adaptation strategy to be established. This makes it possible to implicate the winegrower in the positive and negative impacts on the environment.

The adaptation scenarios resulting from the LIFE-ADVICLIM project will have long-term environmental benefits. Based on the evolution of winegrowers' practices, these scenarios make it possible to propose reasoned adaptation methods that avoid "brutal" changes (e.g. vineyards translocation) that could lead to significant environmental damage (e.g. biodiversity, land clearance, water quality, etc.).



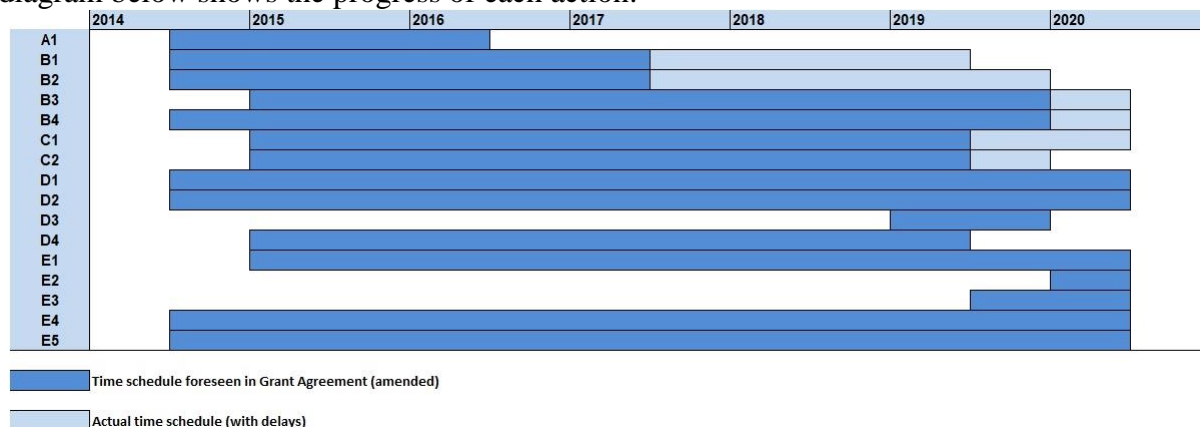
## 4. Administrative part (maximum 3 pages)

### 4.1 Description of the management system

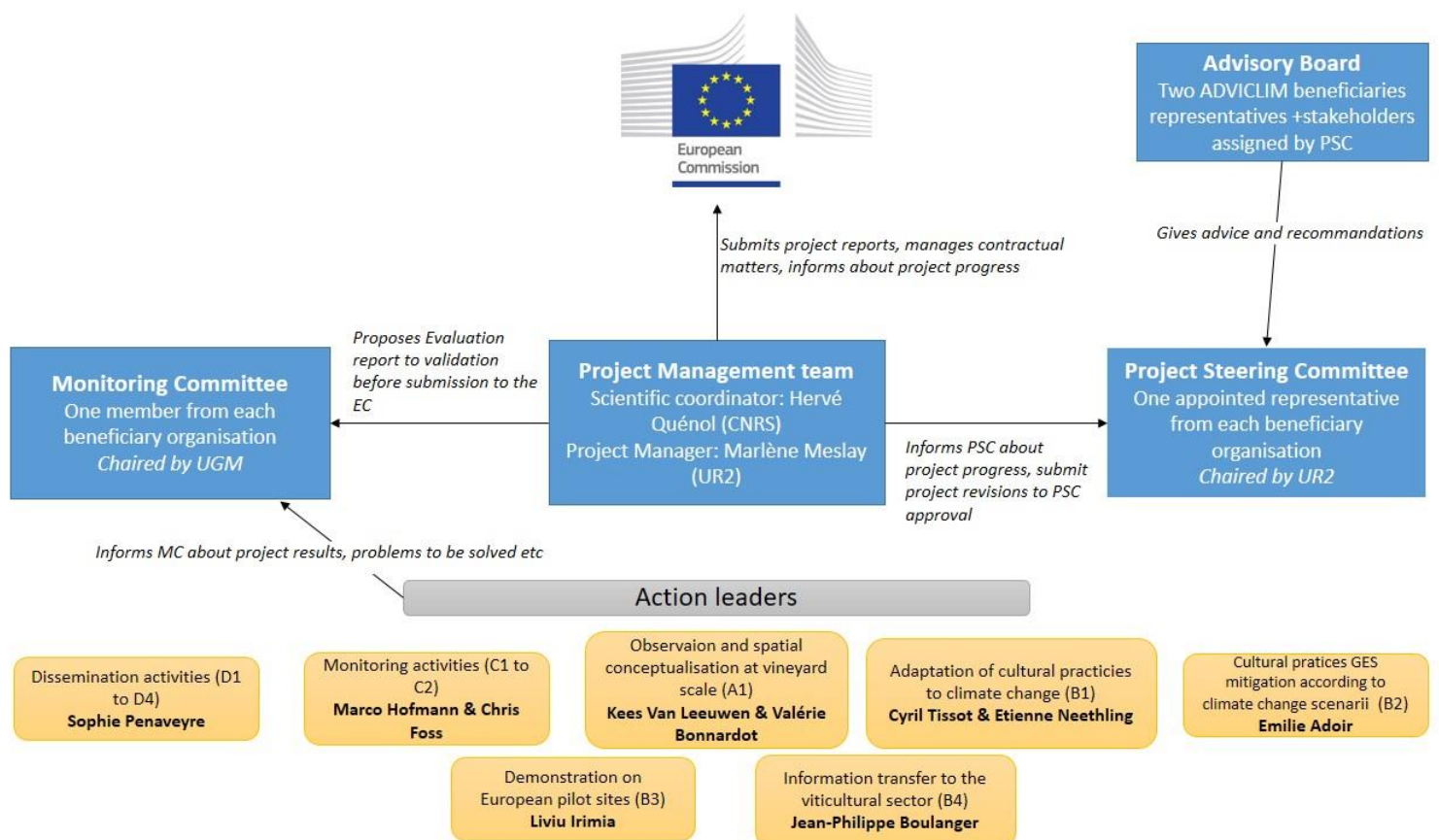
The project management system was designed by the coordinating beneficiary and the associated beneficiaries, according to the specificities of the consortium and the project needs. The project is divided in 14 actions which were allocated a specific period of time and a task manager among the associated partners:

- A1: Observation and spatial conceptualisation at vineyard scale;
- B1: Adaptation of cultural practices to climate change;
- B2: Cultural practices GES mitigation according to climate change scenario;
- B3: Demonstration on European pilot sites;
- B4: Information transfer to viticultural sector;
- C1: Territorial analysis of adaptation to climate change and mitigation of GIS emission measures impact;
- C2: Socio-economic and financial assessment;
- D1: Project website;
- D2: Communication and dissemination activities;
- D3: Layman's report;
- D4: Notice boards;
- E1: Project management;
- E2: Final Audit;
- E3: After-life communication plan;
- E4: Networking with other European projects;
- E5: Monitoring of project progress.

The diagram below shows the progress of each action:



The organisation chart with the role of the beneficiaries is presented in this figure:



Hervé Quérol is the scientific coordinator and overall responsible for the project, supported Marlène Meslay as financial and administrative manager. Since September 2016, Hervé Quérol has been expatriate to New Zealand. He coordinates the project through videoconferences and several visits to France. These circumstances requiring reinforced communication and organisation, Hervé Quérol is in daily contact with the project manager by email, and videoconference conversations are held every week.

The project management team, for its management and progress monitoring mission, is seconded by each Action leaders which represent all beneficiaries. These Action leaders ensured a smooth running of actions and a reporting process for the coordinator every six months. The steering committee (one member per partner) meet on a regular basis, in face-to-face project meetings or by videoconference (please refer to the list of the steering committees below). Each topic discussed and decision taken is recorded in minutes validated by all participants.

The Advisory Board (associated members selected by project partners), chaired by Valérie Bonnardot (UR2) and Samuel Louvet (ECS), have met 5 times in face-to-face to monitor project progress and provide advices and recommendations to AVIDCLIM partners. Reports of the meetings in French and English have been addressed to all members by the Advisory board chairmen.

Consortium meetings held since the beginning of the project:

Face to face meetings:

- Kick-off meeting, 21-22/07/2014 (Rennes - France): introduction of each beneficiary, their specialisation and role on the project. Presentation of the general GANTT, the tasks to be carried out on each action and the financial and administrative requirements.
- Consortium meeting, 15-16/06/2015 (Plumpton - UK): assessment of evaluation strategy, determination of how to improve the evaluation process and results, introduction of the forthcoming milestones and deliverables and establishment of the work plan from June 2015 to July 2016
- Consortium meeting, 14-15/04/2016 (Bordeaux - France) : assessment of evaluation strategy, determination of how to improve the evaluation process and results, introduction of the forthcoming milestones and deliverables and establishment of the work plan from May 2016 to July 2017
- Consortium meeting, 18-19/05/2017 (Geisenheim - Germany): assessment of scientific progress since the last report in June 2016, preparation of the mid-term report concerning administrative and financial matters, visit of the monitoring team.
- Consortium meeting, 6-8/09/2018 (Iasi – Romania): assessment of scientific progress, visit of the external monitoring team
- Final Conference, 28-30/01/2020 (Pamplona, Spain): Restitution of the results of the project for each action and each pilot site, networking and with other LIFE project covering the topic of adaptation to climate change, workshop with winegrowers from Navarra and other stakeholders of the wine industry

#### Videoconferences:

- Steering Committee videoconference, 10/09/2014: launch of the scientific activities and review management and administrative needs.
- Steering Committee videoconference, 06/02/2015: reflection about the partnership agreement (to be communicated to the EC) and the consortium agreement (internal to the consortium), to report on the annual visit of the external monitoring team, to state the progress of each action by the actions leader, to introduce, to discuss and vote the dissemination plan, to monitor the state of progress for the inception report.
- Steering Committee videoconference, 20/11/2015
- Steering Committee videoconference, 06/02/2016
- Steering Committee videoconference, 08/06/2016
- Steering Committee videoconference, 29/11/2016
- Steering Committee videoconference, 29/02/2017
- Steering Committee videoconference, 06/03/2017
- Steering Committee videoconference 13/06/2018
- Steering Committee videoconference 24/10/2018
- Steering Committee videoconference 20/11/2018
- Steering Committee videoconference 07/12/2018
- Steering Committee videoconference 19/12/2018
- Steering Committee videoconference 29/01/2019
- Steering Committee videoconference 27/02/2019
- Steering Committee videoconference 03/04/2019
- Steering Committee videoconference 20/05/2019
- Steering Committee videoconference 18/06/2019

Three amendments have been introduced during the course of the project, confirming the following modifications:

- June 2016:
  - Introduction of two additional beneficiaries: CNRS and Bordeaux Sciences Agro
  - Revision of the budget breakdown
- May 2019:
  - Extension of the project duration until 29 February 2020
  - Change of legal name of beneficiary INRA Pays de la Loire
- September 2019:
  - Modification of the legal status of beneficiary Institut Français de la Vigne et du Vin (from Public body to Private body)

## 4.2 Evaluation of the management system

The management system evolved several times throughout the project. This is mainly due to the high turnover of managers. Indeed, five different persons followed each other in the position of project manager, in charge of the administrative and financial coordination of the project.

Adviclim project managers:

01/07/2014 – 30/09/2016: Marie Grosset  
01/10/2016 – 24/04/2017: Tristan Le Metayer  
25/04/2017 – 15/04/2018: Timothée Chareyre  
16/04/2018 – 11/02/2019: Nina Bailet  
12/02/2019 – End of the project: Marlène Meslay

This important rotation complicated the administrative and financial management of the project. However, the good communication practices put in place have helped to overcome these difficulties. For example, the current project manager Marlène Meslay, who arrived in February 2019, was able to easily understand the project's history and issues thanks to detailed documentation and a well-prepared handover.

Also, the European Commission raised points of vigilance following the submission of the mid-term report, regarding financial monitoring and reporting. Measures have been taken to address these difficulties, with closer tracking of the budget. Since 2018, an internal reporting is organised every three months. Partners send their updated financial statement, and supporting documentation, to the coordinating beneficiary for review.

On another note, the Covid19 outbreak complicated the preparation of the final report. The audit, initially planned in April, had to be postponed because some partners could not provide the requested documentation under the circumstances of lockdown. The project management team has therefore requested some additional time to submit the final report in order to be able to finalise the audit certificate on time. This extension was granted by the European Commission.

Overall, the communication with the European Commission and with the external monitoring team was smooth and helpful. Our advisor Aurore Lopez has been of great help, on both administrative and technical issues. Mathilde Redon took over in June 2020 and guided us through the finalisation of the Final report.

## 5. Technical part (maximum 50 pages)

### 5.1. Technical progress, per task

Name of the Deliverable	Action number	Expected deadline	Delivered	Comments
Management plan	E1	09/2014	03/2015	
Dissemination plan	D2	09/2014	06/2015	
Notice board	D4	11/2014	11/2015	
List of progress indicators	E5	12/2014	12/2014	
Monitoring protocol	E5	12/2014	12/2014	
Monitoring tool	E5	12/2014	12/2014	
Project website	D1	01/2015	10/2015	
Compilation of maps of climate change modeling for each vineyard	A1	12/2015	07/2016	
Data Archive Center and Data Visualization Platform	B4	06/2016	12/2016	
Compilation of cultural practices adapted to climate change for each pilot site	B1	12/2016	02/2017	
Adaptation of cultural practices to climate change: results synthesis	B1	Not initially planned	09/2020	
Compilation of cultural practices of integrated agriculture for each pilot site	B2	12/2016	12/2018 (1) 02/2020 (2)	
Specific section on project website for information transfer	B4	12/2014	04/2020	
LIFE-ADVICLIM project results. A specific deliverable for each pilot site.	B3	Not initially planned	06/2020	
Guidelines for professionals, scientific experts and local authorities	D2	12/2017	04/2020	
Technical Assessment and evaluation of demonstration activities on each pilot site	C1	06/2018	02/2020	
Socio-economic assessment of demonstration activities on each pilot site	C2	12/2018	02/2020	
After-life Communication Plan	E3	06/2019	02/2020	
Layman's report	D3	07/2019	07/2020	
Dissemination report	D2	07/2019	04/2020	
Final Evaluation report	E5	07/2019	09/2020	To be completed during the After Life Communication Plan
Final report	E1	09/2019	09/2020	

## Action A1: Observation and spatial conceptualisation at vineyard scale

**Action leader :** Cornelis VAN LEEUWEN (Bordeaux Science-Agro/INRA) and Valérie BONNARDOT (Université Rennes 2)

### ○Context and objectives

Action A1 was a preparatory action, intended to apply the methods of agroclimatic analysis and climate change modelling on different experimental sites of ADVICLIM project.

The activities of A1 include fieldwork (with the development of a fine-scale climatic network with a data transmission system as well as the monitoring of grapevine phenology, water and nitrogen status at each site) and the construction of a fine scale climate model (one per pilot site).

In order to characterize temperature variability over each pilot site and the link with grapevine development and berry composition, networks of temperature sensors, phenological observation plots and plots for monitoring maturity, were set up. Using this measurement and observation networks, the study of the link between climate at a local scale and grapevine development became possible. The spatial distribution of temperature was analysed, and temperature maps at a local scale have been produced. The grapevine response to temperature variability has been studied, as well as the relationship between temperature, vine water and nitrogen status, and grape composition. The climate and phenological models developed in this first step permitted the downscaling of climate change modelling to a local scale. This was then coupled with regional climate change models based on RCP (Representative Concentration Pathway) scenarios 4.5 and 8.5, and the effect on vine development assessed.

### ○Activities undertaken and outputs achieved

#### ●Data collection on pilot site

In order to characterise the temperature variability in each pilot site, networks of temperature sensors were set up. At local scale, it is important to take into account the topography (exposition, slope, and elevation), the latitude and longitude, but also local parameters, such as rivers, urban areas, and soil types, which can have an influence on the spatial distribution of temperature. More than 250 sensors were deployed on the pilot sites: 8 sensor networks on 6 sites. In the frame of LIFE-ADVICLIM project, an automatic data recovery system has been developed using the LoRa technology. Gateways were installed on the pilot site to retrieve the temperature data to an *Orbiwise* computer server, then on to *Ecoclimasol's* VIDAC platform (Figure A.1.1). The objective was to have direct access to climate data for project members as well as winegrowers. Only 3 sensor networks distributed over the 2 French pilot sites have been equipped with the data transmission system (please, see problem encountered in the text further below). During the LIFE-ADVICLIM project, temperature data could be acquired at least 3 growing seasons (from April to October), which made it possible to build and validate the climate modelling for each pilot site.

Ecophysiological measurements were carried out, to monitor grapevine development and berry composition, on blocks located near temperature sensors planted with grapevine varieties representative of the wine-growing region of each pilot site (e.g. Merlot for Pomerol/Saint Emilion). All the blocks were monitored for phenological stages (budbreak, flowering and veraison) with the specific day when 50 percent of vine organs reached stage

“C” for budbreak, stage “I” for flowering and stage “M” for veraison being recorded. A maturity control on berry samples was carried out for all the blocks at the same date, each year. The mean berry weight, total reducing sugars, total acidity (TA), malate (MAL) and pH levels were determined. In order to determine vine water status and vine nitrogen status,  $\delta^{13}\text{C}$  and yeast available nitrogen (YAN) levels were measured.

Each partner has been performing this task on its own site. Observations of vine growth and grape maturity were conducted at each pilot site. Vine water status and vine nitrogen status were measured in Pomerol/Saint Emilion, Loire Valley and Rheingau pilot sites.

#### • *Climate modelling at vineyard scale in climate change context*

After acquiring the temperature and agonomy data, the next phase consisted of spatial modelling at the scale of the pilot sites. Statistical methods are particularly appropriate for modelling spatial climate variability at the local scale. These methods are based on establishing the relationship between surface characteristics (e.g. landscape morphology and land use) and weather variables. The non-linear regression model (SVR) was used to map temperatures in each pilot site. Using the data extracted from the temperature sensors, the model allows to spatialize the relationships between the temperature distribution and the local environment and to map the daily maximum and minimum temperature over the studied years. Based on these daily maps, the average minimum and maximum temperatures and bioclimatic indices (e.g. Huglin and Winkler indices) were mapped in order to visualise their spatial variability. The model results (Tmin, Tmax, WI, HI) showed a recurring spatial structure as well as a vintage effect. It was therefore decided to average all the temperature maps in order to be able to quantify the temperature distribution and produce a temperature zoning.

Several phenological models were used including the *Grapewine Flowering Veraison* model. *Grapevine Flowering Veraison* (GFV) is a simple linear temperature summation model) which sums the temperature degrees exceeding 0°C starting from the 60th day of the year up to the blooming (F) and to the veraison (V). The original parameterization of this model offers robustness, especially when testing its response to temperature variations. For this reason, the GFV is used in the ADVICLIM project to elaborate the forecasts for grapevine flowering and veraison in the perspective of the climatic change. For each pilot site, the GFV model was applied and the results were validated with the phenological observations. These phenological models, combined with climatic models developed in this project allowed the creation of maps predicting the different phenological stages.

In order to achieve the Action A1's objectives, it was required to improve the spatial resolution of regional climate change model outputs. The "downscaling" of climate models consisted in taking the output information from global and then regional climate models and projecting it to the local scale (for past and future periods). Data from a set of RCMs simulations from the CORDEX Project [Coordinated Regional Climate Downscaling Experiment] over Europe were used for generating climatic information on the recent-past and the future climate at regional scale. The geostatistical model (climate and phenology) was combined with regional climate change data (from the Euro-CORDEX model) for the periods 2031-2050 and 2081-2100 for the climate change scenarios RCP4.5 (less extreme) and 8.5 (more extreme). This methodology has made it possible to obtain climate information at an increased horizontal resolution that better meets the needs of winegrowers (Figure A1.2). The integration of spatial climate variability at the local scale was successfully completed for each pilot site.

Climate modelling and climate maps developed according to climate change scenarios



(EuroCORDEX data) were produced by the CNRS and University of Rennes2.

#### ○Key Deliverable

A compilation of maps of climate change modelling for each wine region (bioclimatic indices 2050-2100) of ADVICLIM project was produced (please see A1\_Deliverable). The acquisition of data during each growing season at each pilot site and the construction of plot-scale agroclimatic models were the initial phase of the LIFE-ADVICLIM project. This phase was essential for the implementation of the others actions.

#### ○Action indicators

The main indicators of progress can be listed as follow:

- Installation of temperature sensor networks at each pilot site;
- Acquisition of climatic and ecophysiological data of the vine during each growing season;
- Agroclimatic modelling at vineyards scale. The model could be validated on each pilot site with the data acquired for each vintage;
- Agroclimatic modelling at vineyards scale according to climate change future scenarios. The integration of spatial climate variability at the local scale into climate change model outputs.

#### ○ Planned output and time schedule

	2014	2015	2016	2017	2018	2019	2020
A1							

Time schedule foreseen in the Grant Agreement (amended)

Actual time schedule (with delays)

Initially, the schedule for Action A1 consisted of a preparatory action, notably with the installation of the agroclimatic measurement networks on the pilot sites and the construction of the agroclimatic models.

As indicated in previous reports, the acquisition of climate change model outputs (Eurocordex) has led to a delay in the agroclimatic modelling for each pilot site. Deliverable A1 was completed in mid-2016 with the "*Compilation of maps of climate change modelling for each vineyard*". It is important to note that the outputs of local-scale agroclimatic models were improved regularly during the project in order to reduce biases. The EuroCordex regional data have been updated according to the latest data availability. The agroclimatic data obtained during each vintage made it possible to validate the quality of the models for each pilot site.

The acquisition of temperatures and agronomic data (phenology and grape characteristics) was performed each year (each vintage) during the project. This phase was conducted under Action B3.

#### ○Main results

- Modelling of bioclimatic indices at vineyards scale under climate change conditions

The main results of the Action A1 are that the spatial variability of climate within the pilot sites is similar to, if not higher than the rise in temperature (sums of degree/day) between the current period and future periods (2050 and 2100). Considering the short term, i.e. by 2050,

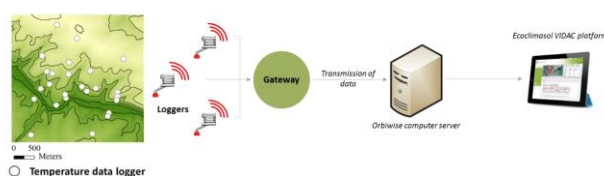
the trend in the Huglin index is similar whatever the scenario (RCP4.5 or RCP8.5) under consideration. Considering the long term, by 2100, the results are very different according to the RCP scenario under consideration. By 2031-2050, the Huglin index is projected to increase by 100 to 400 GDD depending on the region compared to the reference period (1950-2005) while there is an increase of 100 GDD to 300 GDD within each pilot site. This difference corresponds to 1 climate class. For example, the Huglin index would shift from "Temperate" to "Warm temperate" classes in Pomerol/Saint Emilion. However, within the pilot site, the northern part would still be in the "Temperate" class while the other part of the area would be in the "Warm Temperate" class. On the other hand, by 2081-2100, the Huglin index sharp increase i.e. between 300 and 500 GDD and between 600 and 1000 GDD for RCP4.5 and RCP8.5 respectively, would lead to a spectacular shift by 2 or 3 climate classes in all pilot sites. Climate variability within the pilot sites is projected to remain very high. For example, the Coteaux du Layon would fall under the Huglin index classes ranging from the "Cold" to the "Warm" classes according to RCP8.5 (in comparison with the reference period). Within the pilot site, the coldest parts (valley bottom and slopes facing north) would fall under the "warm temperate" class, while the warmest parts (mid-slope facing south) would fall in the "warm climate" class (figure A1.3). In general, under the RCP8.5 scenarios, climatic conditions would be less favourable for the pilot sites of Saint Emilion, La Rioja, Loire Valley and Cotnari. The Huglin index would be higher for the Geisenheim and Plumpton pilot sites.

- Modelling of Grapevine Phenology (GFV) at vineyards scale under climate change conditions

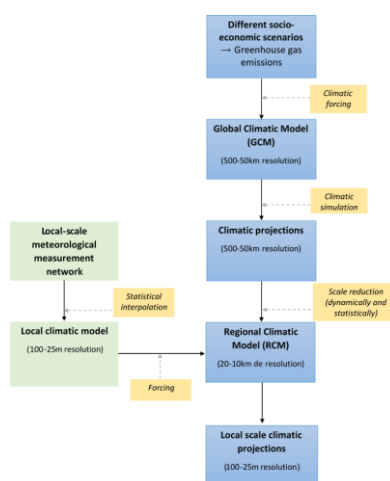
The GFV model was applied for several grape varieties representative of each pilot site: Merlot (Pomerol/Saint Emilion), Cabernet Franc (Saumur Champigny), Chenin (Coteau du Layon), Riesling (Geisenheim), Tempranino (Rioja), Pinot Meunier (Plumpton) and Fetească (Cotnari). The results highlight earlier phenological stages whether by 2050 or 2100, particularly flowering and veraison than during the current period. This earliness is projected to reach a few days to several weeks depending on the phenological stage (greater for veraison than for flowering), the RCP scenario and the period under consideration. Spatial variability within the pilot site is also significant. A difference of 10-15 days in the phenological timing is projected to occur between the later and earlier ripening plots. As for the modelling of bioclimatic indices, the simulations of flowering and veraison dates are similar for the two scenarios (RCP4.5 and 8.5) for the period 2031-2050. For 2081-2100 under the RCP8.5, the simulated phenological stages are 5 to 8 days earlier for flowering and 10 to 15 days earlier for veraison than those of the reference period. Within the pilot site, the flowering period is from 2 to 6 days and from 3 to 10 days for veraison. For example, in the Coteaux du Layon, flowering would occur from 11/06 to 17/06 according to RCP4.5 and from 04/06 to 09/06 according to RCP8.5. The veraison would occur from 18/08 to 28/08 (RCP4.5) and from 04/08 to 13/08 (RCP8.5). Pilot sites with high spatial variability of temperatures and bioclimatic indices are also the sites where the differences in vine growth level are the most important. In conclusion, phenology modelling at the vineyard scale according to the grape varieties currently cultivated at each pilot site highlighted: (1) for flowering, one week earlier in 2031- 2050 (compared to the reference period) according to scenarios RCP4.5 and RCP8.5 and more than 2 weeks in 2081-2100 for RCP8.5 ; (2) for veraison, up to 20 days earlier in 2081-2100 for RCP8.5 (compared to the reference period) i.e. a veraison which would occur around July 20 instead of late August in Pomerol/Saint Emilion leading to a ripening period under the highest temperature conditions (Figure A1.4). In 2100 according to RCP8.5, the very earliness of phenological stages (especially veraison) will certainly require changes in the grape varieties.

- Conclusion

The integration of local climate variability (bioclimatic indices and phenological modelling) into regionalized climate change simulations provides an assessment of the impacts of climate change for European viticulture at the vineyard scale. The knowledge gained using this methodology is the increasing horizontal resolution that better suits the winegrowers concerns. Overall conclusion highlights the fact that thermal differences within each site are similar to the thermal differences simulated by the climate model between 1986-2005 and 2031-2050 (increase of 200-500 GDD). Hence, these results give the local winegrowers/stakeholders information necessary to understand the current functioning as well as historical and future viticulture trends at the scale of their site that may facilitate decisions about future strategies. These results allow suggesting adaptation methods (Action B1) and mitigation methods (Action B2) based on the use of plant material and viticultural management strategies. By 2081-2100 under the RCP8.5, the thermal increase is greater (500-1000 GDD) and will certainly involve other adaptation methods such as changing grape varieties. However, knowledge of local climate variability will make it possible to optimise adaptation scenarios according to the specific characteristics of the vineyard.



*Figure A1.1: Automatic data recovery from the sensor network to the web platform.*



*Figure A1.2: Different stages of downscaling (from global to local) climate change projections*

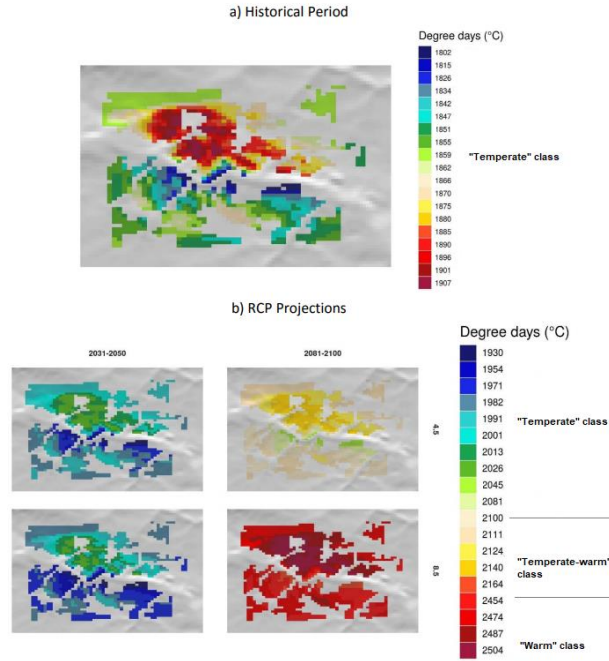


Figure A1.3: Maps of the Huglin Index over the Coteaux du Layon pilot site for the period 1986 to 2005 (a) and expected changes in the Huglin Index (b) for the period 2031 to 2050 and 2081 to 2100 according to the climate scenarios RCP 4.5 and RCP 8.5.

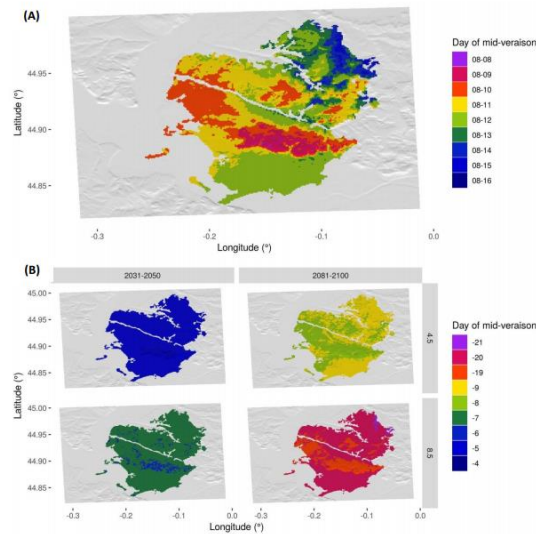


Figure A1.4: GFV modelling of the changes in the timing of the mid-veraison of Merlot in the Pomerol/Saint Emilion area in 2031-2050 and 2081-2100, according to scenarios RCP 4.5 and RCP 8.5 (B), relative to the historical period 1986-2005 (A)

#### ○ Major problems encountered

Orbiwise, a Swiss company was selected to equip the sensors network with automatic data transmission. Orbiwise installed the system in Pomerol/Saint Emilion, Coteaux du Layon and Saumur Champigny pilot sites. Orbiwise faced technical problems in Saint-Emilion. It turned out to be necessary to install an additional gateway to solve the transmission problem and receive the data properly. Orbiwise finally managed to make the automatic data transmission work both in Val de Loire and Saint-Emilion (Bordeaux region, France). Numerous additional

developments were necessary, in particular for the acquisition of climate data and their integration into the VIDAC platform. Delay in the implementation of data transmission and technical problems caused B4 action to run behind schedule.

The implementation of the data transmission system on the other pilot sites was planned in the LIFE-ADVICLIM project. However, the system was not installed at the other pilot sites for the following reasons:

In Rüdesheim, the “Geisenheim University” partner had previously decided to choose a different supplier for the data loggers. Extensive on-site tests with the wireless system of this supplier (WiSenSys, UPGmbH, Düsseldorf, Germany) showed strong transmission problems, hence delaying the installation of the sensor network (was due on 2015, yet installed in 2016). The project coordinator proposed to install the Orbiwise system on "Rüdesheim" pilot site. Finally, the "University of Geisenheim" partner did not want to install the data transmission system. As a result, the temperatures from the sensor network were downloaded regularly and then integrated into the VIDAC platform.

At Rock Lodge, the “Plumpton partner” decided to install the sensor network on the experimental vineyards of the Plumpton College. There was no need to install the data transmission.

In Cotnari, we have decided to install data transmission in the vineyard. The first quotations were validated in 2015. Initially, we interrupted the order after the delay in the implementation of data transmission and technical problems in the French pilot sites. Then, administrative problems of the partner "Iasi University" did not allow us to validate another quote until the end of 2017. In 2018, an order form (Orbiwise company) was validated to install the data transmission system in the Cotnari vineyard. Other technical problems have caused further delays and therefore we have decided to cancel this order.

It seems complicated to continue the collaboration with the Orbiwise company. In 2019 and 2020, others technical problems (e.g. permeability of enclosures, ...) caused data acquisition problems at the Pomerol/Saint Emilion site. After the LIFE-ADVICLIM project, we will subcontract another company for data transmission.

○Complementary action outside LIFE and perspectives for continuing the action after the end of the project

This approach of measurement and agroclimatic modelling at vineyard scale has been applied in other wine-growing regions during the LIFE-ADVICLIM project.

In 2015 and 2016, two additional pilot site were established in Rioja (Spain) including more than 40 thermal sensors. Several Life ADVICLIM Actions (A1, B1 and B3) were being implemented on this site (free of charge for the EU).

In France, a cooperative in a small appellation in the foothills of the Pyrenees wanted to implement a study of the climatic structure in their production area and the responses of vine behaviour in terms of phenology and grape ripening with a methodology similar to the one developed in the Saint-Emilion pilot site of the Life ADVICLIM project. They obtained funding from the regional government (region Nouvelle Aquitaine) and with the help of the Life ADVICLIM Bordeaux partner and extension services from Bordeaux Sciences Agro (Vitinnov company) they set up a network of 30 temperature sensors and grapevine monitoring in 2016. AOP Chignin-Bergeron (Savoie) was also equipped with temperature data loggers in 2017. In 2018, a new network of sensors has been installed in the "Entre deux Mers" appellation (south of the Pomerol/Saint Emilion appellation). The aim is to apply the climate models developed as part of the LIFE-ADIVICLIM project throughout the Bordeaux

wine region. In New Zealand, in Brazil and in Argentina, several agroclimatic measurement networks have also been installed in pilot vineyards.

These complementary actions outside LIFE are conducted within the framework of national and international scientific projects (e.g. LACCAGE 2.21, AVVENIR, IRP-VINADAPT, ...) or with international cooperation (e.g. EMBRAPA in Brazil, ...). (Please see section 5.4)

## **Action B1: Adaptation of cultural practices to climate change**

**Action leader:** Cyril TISSOT (CNRS) and Etienne NEETHLING (ESA)

### ○ Context and objectives

As climate is a key factor of grapevine growth and fruit ripening, winegrowers are constantly adjusting their plot- to farm-level decision-making in response to climate variations as they pursue the production of quality-orientated wines. With a global changing climate, winegrowers are therefore required to continue developing adaptation strategies that deal with both short- and long-term climate changes, while likewise accounting for local vulnerability to avoid mal-adaptation. In this context, the action B1 is an implementation action, seeking to assist winegrowers in managing these new and uncertain challenges. Based on a modelling approach, the action B1 aims to simulate the impact of environmental conditions and constraints on vine behaviour and agronomic practices. The objective is to identify and prioritise some rational adaptation strategies at local vineyard scales.

To that end, the B1 has several goals:

- Define actual and future agro-climatic potentials across different temporal and spatial scales.
- Study the impact of short-term climate variability and long-term climate changes on grapevine phenology and grape ripening.
- Assess the dynamic and complex nature of vineyard management practices and decision making in response to short- and long-term environmental changes.
- Outline potential adaptation strategies at medium and long term according to two scenarios of climate change.

### ○ Activities undertaken and outputs achieved

In response to the action objective and its various goals, an Agent Based Model (ABM) name SEVE (Simulating Environmental impacts on Viticultural Ecosystems) has been implemented and tested in different pilot site during the ADVICLIM project. Based on GAMA simulation framework (<https://code.google.com/p/gama-platform/>), the baseline of SEVE includes three main class of Agents:

- the "Supervisor" Agent plays an overseeing role in the model. It sets the specifications of the various wine designations and imposes specific grape and wine production regulations. It is directly related to the "Winegrowers" and "Plot" Agents, who provide synthetic information about phenology and agronomic action. According to this information, the "Supervisor" agent may modify production policies and regulations;

- "Winegrower" Agents aim to grow grapes and produce wine that meets precise specifications according to their end-product goals. This action involves growing the grapevine in optimal conditions given the agronomic specificities of the wine grower's plots;

- "Plot" Agents are grape production entities. They represent a vineyard plot that reproduces grapevine growth and grape ripening dynamics, according to spatial and temporal environmental variations.

These three main classes are complemented by specific agents. The "Winegrowers" agents have "Winegrowing workers" and "Tractors" agents which enable them to implement agronomic actions. The "Plot" agents are associated with a "Pathogen" agent that simulates the dynamics of diseases such as mildew depending on climatic conditions. Finally, "Sensor" agents provide climate information (meteorological data, bioclimatic indices) useful to "Plot", "Winegrower" and "Supervisor" agents.

According to biophysical properties of plots (topography, soils type, maximum soil water holding capacity ...) and climate condition SEVE model provide a general framework to simulates vine's phenological cycle and agronomic action (figure B1.1)

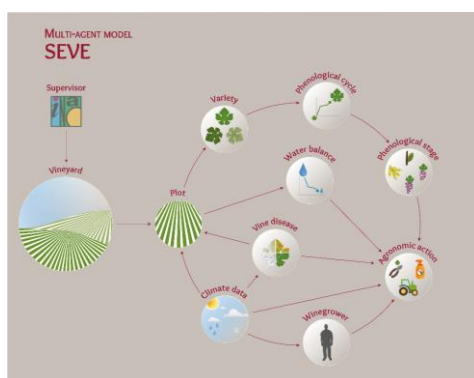


Figure B1.1: simplified modelling sequence of SEVE model

The SEVE model has been applied to the 6 pilot sites of the ADVICLIM project. All prototypes were implemented in the same instance of the model. There is therefore a single model coupled to a database containing a knowledge base for each of the pilot sites. This database centralizes all the knowledge available for the pilot sites around four themes (table B1.1):

Table B1.1: Main themes of SEVE model database

Biophysical data	Climate data	Vine data	Winegrower
<ul style="list-style-type: none"> <li>•Soil nature and type</li> <li>•Maximum soil water holding capacity</li> <li>•Topography (digital elevation model)</li> <li>•Slope</li> <li>•Geographical position and boundaries of vineyard plots</li> </ul>	<ul style="list-style-type: none"> <li>•From weather stations (rainfall, humidity, temperature, wind speed, potential evapotranspiration)</li> <li>•From data-loggers (temperature)</li> <li>•From global climate model (CORDEX data at regional scale, same data as weather stations)</li> <li>•From statistical model (temperature simulated at local scale)</li> </ul>	<ul style="list-style-type: none"> <li>•Vine variety and rootstock</li> <li>•Training system</li> <li>•Planting density</li> <li>•Row orientation</li> <li>•Vine age</li> <li>•Dates of phenological stages for several years according to their climate profile</li> </ul>	<ul style="list-style-type: none"> <li>•Working periods</li> <li>•Agronomic practices</li> <li>•Techniques and machinery involved</li> <li>•Favourable and unfavourable climatic variables</li> </ul>

#### ○ Key Deliverables

The action B1 has two deliverables that are focused on assisting the winegrowers to adapting viticulture to climate change.

The first deliverable is to provide a common guidance manual, meant to generate knowledge and communication among local actors and stakeholders in European wine growing regions. Published in June 2017, this manual was divided into three parts. The first part provides a general introduction of climate change in the viticulture sector; the second part aims to present guidelines on performing various adaptation measures at different temporal and spatial scales; lastly, the third part deals with the modelling framework used in action B1 to evaluate, identify and prioritise rational adaptation strategies at local vineyard scales.

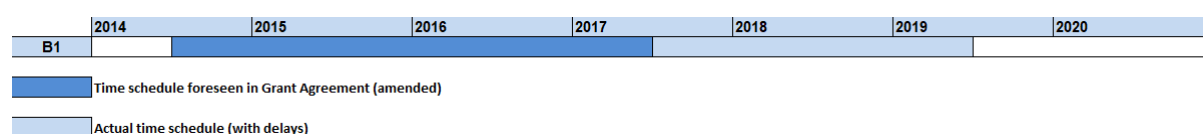


The second deliverable seeks to present some synthetic results at vineyard and plot scale for each pilot site. Some key indicators for analysing the evolution of phenology are compared at European level. They are supplemented by simulations of potential adaptations strategies at vineyard and plot scale. This deliverable has been scheduled for the end of the project in order to integrate and complete the modelling framework in each study area of ADVICLIM.

○ Planned output and time schedule

The initial time schedule of action B1 was respected, notably with the development of the first prototype in the Loire Valley and the publication of the guidance manual on adapting viticulture to climate change. The implementation of the other sites took much longer than expected due to the difficulty in compiling the knowledge base for each site. Please see the time schedule of action B1 here below:

Time schedule of action B1.



However, all the information required for the SEVE model to work properly was collected and all the sites were integrated into the simulations. In particular winegrower's management practices and decision making has been integrated. This has been achieved through study surveys carried out with local winegrowers in each pilot site (acquired with questionnaires Q2 co-developed with Action B2).

Thanks to this knowledge base, it was possible to carry out equivalent simulations for each pilot site. The achieved results can therefore be compared without bias due to a lack of data.

○ Action indicators

B1 action has been implemented in all pilot site integrated in the project. This includes the integration of six prototypes in SEVE model, i.e. 61 plots in total. The main indicators of progress can be listed as follow:

- A global database, compiling for all pilot site information about climate, vineyards and plots properties and wine grower's agronomic practices, has been implemented,
- This database is coupled with a story map in order to highlight synthetic results at plot and vineyard scales (bioclimatic indices values, phenological cycles variability, potential adaptations strategies according to different scenarios and periods. It is a dynamic tool which enable a real time visualization of simulation outputs provided by SEVE model (see Story Map deliverable),
- Simulation results were validated with field data on climatic and agronomic observations,
- Evaluation of modelling approach and results with local inputs from winegrower's responses has been tested through several participative workshops,
- The integration of simulation outputs in the designed web platform *Climavista* is functional (action B4) and allows winegrower's access to SEVE model results.

Compared to its initial description in 2014, the action B1 has been modified by the proposal of providing two deliverables on adapting viticulture to climate change, instead of one. As mentioned before, these two deliverables are complementary, as the first enable the



communication on general aspects of climate change and adaptation in viticulture, whereas, the second allows to provide more detailed results at global and local scale. The second deliverable is therefore more effective as winegrowers have been already informed on the current and expected issues of climate change and the necessity to adapt their management practices and decision-making. It should be noted that these changes did not entail any modification in the budget plan.

- Action problems and drawbacks

SEVE model mobilizes an important knowledge base informing all biophysical and agronomic parameters of the grapevine, but also requires a fine description of viticultural management practices and decision making. By applying in-depth surveys, winegrowers are asked to describe working periods, techniques and machinery involved, and importantly to define environmental variables that determine favourable and unfavourable working days. These technical data are quite difficult to obtain because pilot sites do not have the same level of information. To solve this problem, local input data are being acquired from winegrower with questionnaires Q2 and Q3 (action B2) but the data collection time was much longer than expected. It explains the delay of the extension of the multi-agent model to all pilot sites.

- Main results

The results of action B1 refer to the findings obtained from the developed multi-agent model SEVE. Across different spatial and temporal scales, the modelling outputs provided results on:

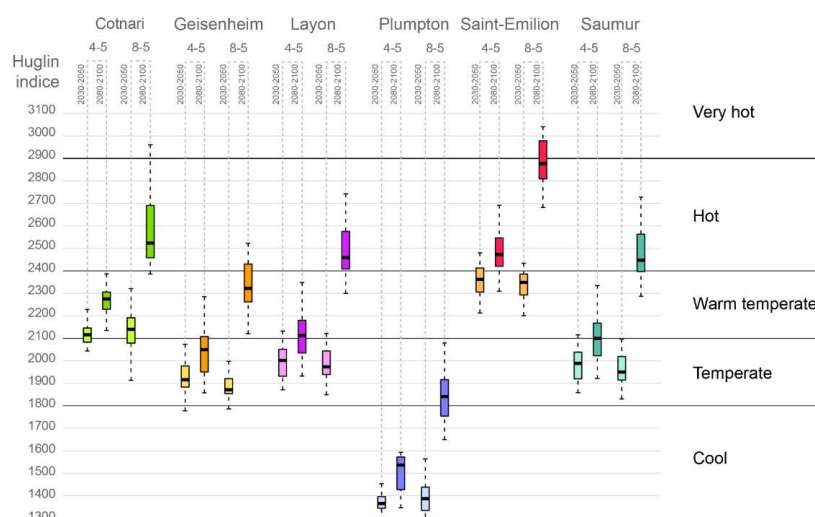
- The values of climate variables and bioclimatic indices that are specific to climatic requirements of grape growth and production.
- The timing and duration of the key grapevine growing stages, in particular the stages related to grape development (flowering, veraison and harvest).
- The agronomic practices undertaken during each simulated growing season, which not only varied because of environmental conditions and constraints, but also because of the production profile of each simulated winegrower.

With regards to the issues surrounding viticultural adaptation to climate change, the objective is to use these multi-scale results to respond to the need of developing local solutions to a changing climate. Firstly, model outputs for climate variables and bioclimatic indices are presented, followed in the second part by the evolution of agronomic practices. Finally, in a third part, some adaptation strategies are highlighted.

- Climate variables and bioclimatic indices*

In SEVE model grapevine growth dynamics uses simple algorithms based on bioclimatic indices (GDD, GFV and Huglin) specific to grapevine behaviour. These indices allow to study climate variability and change in relation with local environment characteristics and type of grapevine variety.

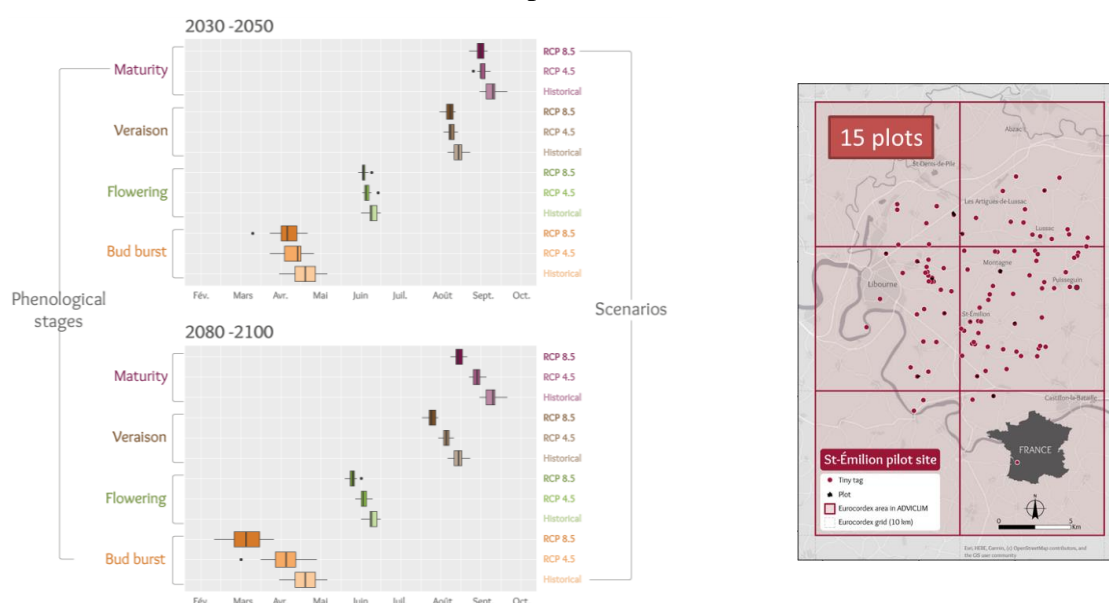
Looking at the pilot sites as a whole, there has been a significant increase in the value of bioclimatic indices on a European scale. If we consider Huglin Index this evolution is more or less significant depending on the site and the selected climate scenario (figure B1.3).



*Figure B1.3: Evolution of the value of the Huglin Index in the different pilot sites according to two climate change scenarios (RCP 4.5 and RCP 8.5)*

This increase leads to a change in climate class for several vineyards. The evolution of temperatures affects the phenological cycle of the vine and leads to an advance in the phenological stages and an earlier reaching of technical maturity.

In St-Emilion pilot site (figure B1.4), for the most pessimistic scenario, the maturity can be reached one month before the current average date (at the end of the century). This precocity can be observed whatever the simulated pilot site.



*Figure B1.4: Timing of key phenological stages according to different climate scenarios*

This results show a strong annual variability in the grapevine development cycle. Indeed, key phenological stages (e.g. flowering, veraison) are much depended on the climatic characteristics of each season. For historical period the agreement with the agronomic observations that were carried, validating the model outputs on grapevine phenology.

### •Agronomic practices

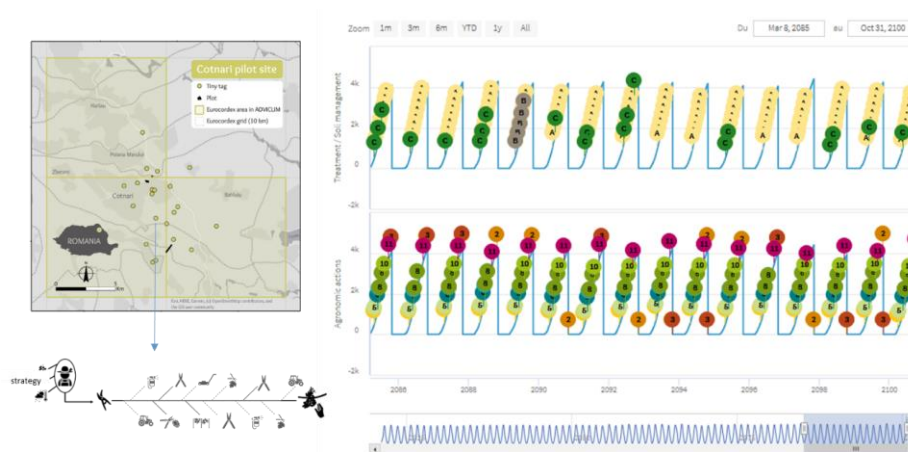
Climate variability affects agronomic practices, i.e. their timing and frequency depending on the conditions of each growing season.

- In hot and dry climate contexts, shallow soil tillage activities were favoured to reduce the grapevine water stress and allow a more optimal soil water availability.
- In normal to wet years, inter-cropping management practices were used to manage grapevine vigour, increase soil tractability and reduce erosion risks.
- For specific practices such as the use of pesticides, they were less correlated to the global climatic profile of the growing season as they depended more on daily temperatures and rainfall amounts, which are highly variable over time.

The agronomic actions are simulated at plot scale in SEVE model. According to winegrower strategy an agronomic itinerary can be calculated for each year. The results are displayed in dynamic graphs integrated into the story map (figure B1.5).

The more general practices such as pruning or trimming only varied in timing depending the grapevine phenology, but not significantly in frequency. Understanding the human dimension of decision making is extremely important in the context of climate change, as each winegrower will respond differently to changing environmental conditions.

Simulation outputs highlight an increase in the number of actions varying according to the pilot site and the winegrower's production profile. The comparison of the number of actions on a global scale is not very relevant because the agronomic itinerary is very different depending on the vineyard and the style of wine produced.



*Figure B1.5: Agronomic action variability at plot scale in Cotnari pilot site for scenario 8.5*

At the local scale, for example at the Layon pilot site, simulation results show a significant increase in the number of actions, especially for organic plots. This result is largely related to the increase in the number of fungicide treatments. In organic production, the use of contact products requires a high spray frequency during periods of pathogenic risk (a few days between each spray). In conventional production, by using systemic product, wine growers reduce significantly this frequency (usually at least 15 days between spraying).



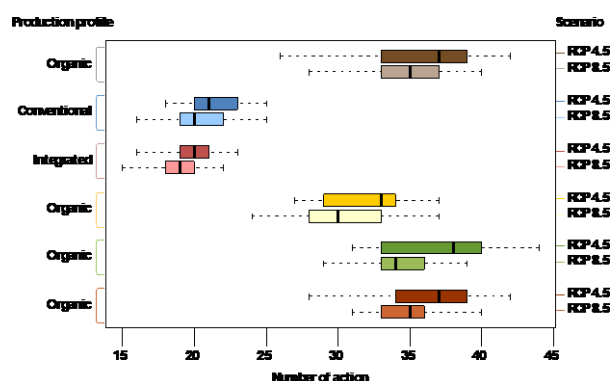


Figure B1.6: Comparison of agronomic action numbers between two climate change scenarios (RCP 4.5 and RCP 8.5) during 2030-2050 period for Coteaux du Layon pilot site

These results show that with a changing climate, the risk of disease is higher in most of the pilot sites. In some cases, the increased earliness of the grapevine partly compensates for this risk by reducing the exposure period.

### •Adaptation strategies

With an expected increase in temperatures over the next century, the prospective simulations show that phenology will become earlier (e.g. in Bordeaux as shown in figure B1.4), regardless of the climate scenario. One of the principal challenges for winegrowers will be to manage increasing temperatures in order to delay grapevine phenology. Indeed, optimal grape ripening should occur in Europe during the month of September. A too early onset of ripening will lead to unbalanced grape compositions.

There are several options that winegrowers can employ, where each option vary in its effectiveness. They vary from short-term and less effective adjustments in harvest management practices to long-term and effective measures in varietal selection (e.g. clonal selection or choice in grapevine variety).

Simulations were carried out to test the conditions for a change of grape variety. They are based on a decision rule of the winegrower who makes a change of grape variety when the technical maturity of the vine occurs 1 month before the current average maturity date at least 4 years out of 10. At global scale, the model outputs show that all sites are affected by a change of grape variety which occurs more or less early depending on local climatic conditions (figure B1.7)

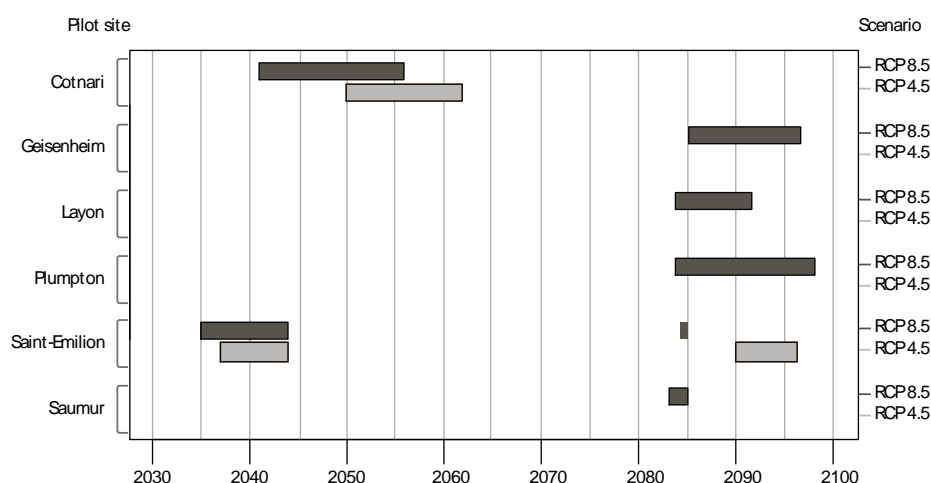


Figure B1.7: Potential period of vine variety change according to two climate change scenarios (RCP 4.5 and RCP 8.5)

On a local scale, the change of grape variety can take place at different periods depending on the initial variety cultivated in the plot and the differences in temperature observed in the vineyard concerned.

On the Cotnari pilot site for example (figure B1.8), differences of several years can be observed between changes of grape varieties. The choice of the replacement grape variety varies according to the style of wine targeted. In this vineyard the Merlot and Cabernet Sauvignon grape varieties could be suited to future climate projection and local environmental conditions.

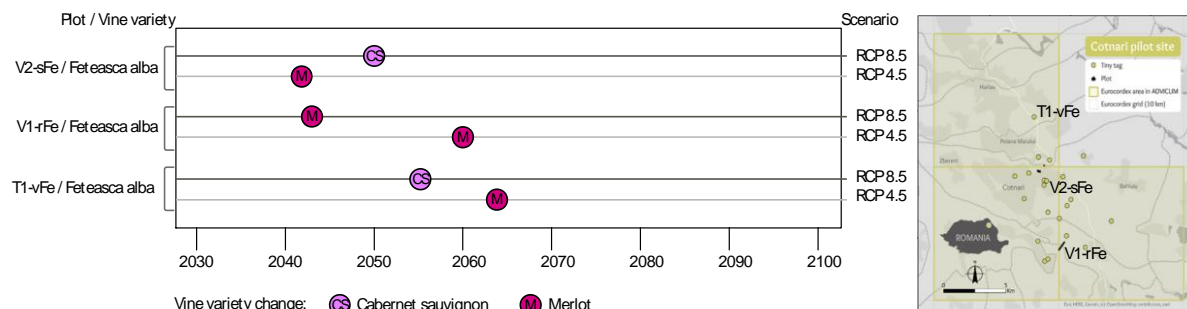


Figure B1.8: Comparison of variety change dates in three test plots in the Cotnari pilot site

Increased early phenology can also lead to an increased risk of frost during bud-break and flowering period. Linking the results of the SEVE model with the climate projections of RCP 4.5 and 8.5 shows that the risk of spring frost may be significant in some sites such as Cotnari or Saint-Emilion due to an increased earliness of the vine in the future (figure B1.9).

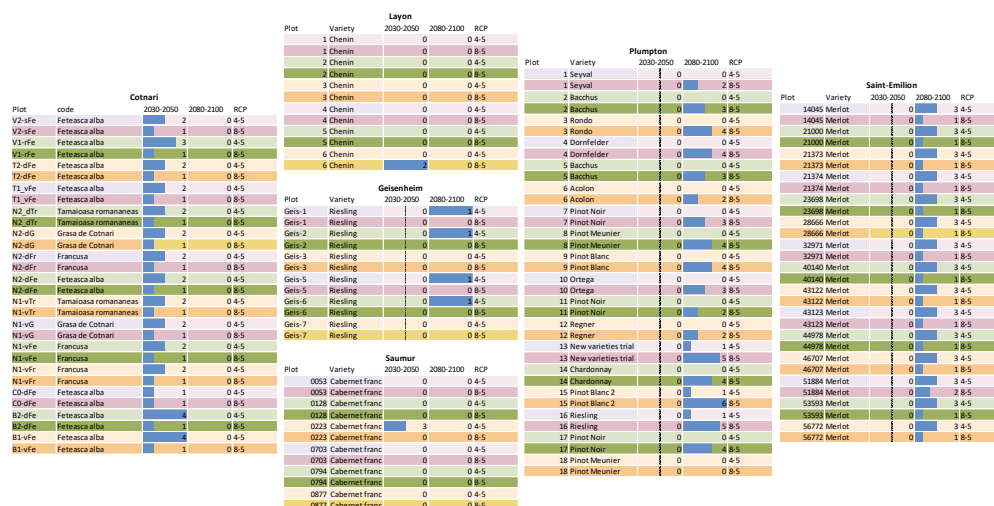


Figure B1.9: Projection of frost risk during bud-break and flowering according of two scenario of climate change (RCP 4.5 and RCP 8.5)

In some test plots the results show an occurrence between 20% and 30% of frost risk. Given the risks for the vines, this could lead winegrowers to use frost protection methods. In case of passive protection includes indirect methods (e.g., site and vine variety selection, pruning techniques) the choice of grape variety could lead to late-ripening varieties selection. As the incidence of late-spring frosts is highly variable over time, active protection based on direct method (e.g., wind machines, heaters, over-vine sprinklers), applied just before or during frost events, could be used by winegrowers.

- Conclusion and perspectives for continuing the action after the end of the project

The modelling approach presented in this action addresses the impact of environmental conditions and constraints on grapevine behaviour and the dynamics of viticultural activities. Through the development of this modelling approach, the impact of climate variability on grapevine performance and winegrowers' production strategies was specifically targeted, both over time and space. The results obtained during the ADVICLIM project show that SEVE model is able to reproduce the dynamics of vine growing and agronomic choices and practices according to climate variability. In the context of climate change, such a dynamic and complex model will help to better assess potential impacts on viticulture and to frame adaptation solutions at different temporal and spatial scales.

Thanks to this approach, simulation outputs illustrate some potential agronomic strategies among a set of potential strategies. However, even if we used bias-corrected climate data, there is uncertainty in the data included in SEVE and the model at different scales propagates this uncertainty. Therefore, the results must be interpreted with caution given this uncertainty.

Many perspectives are still considered. They are mainly focused on improvements for assessing various adaptation measures on grapevine growth and grape quality. Technically, this means introducing feedback loops in the model in order to simulate the implications of viticultural practices on the grapevine (level of vigour, vine earliness, resistance to pathogens, etc.). The integration of other indicators including measuring the potential quality of grapes at harvest is also considered.

Several prototype based on SEVE model framework are under development in Europe (Spain), south America (Argentina) and New Zealand (International Research Project Vinadapt). We also plan to extend the story map to other pilot site in Europe.

Finally, a spatial optimization model is under development in a Phd hosted by UMR LETG team. Complementary to SEVE model, this approach will test several spatial configuration of vineyards in Brittany and New Zealand according to different climate change scenarios. The objective will be to identify well-suited agroclimatic pattern in the context of optimized adaptation to climate change.

## **Action B2: Cultural practices GES mitigation according to climate change scenario**

**Action leader:** Sophie PENAVAYRE (IFV) and Emilie Adoir (IFV)

- Context and objectives

Adaptation of climate change at plot scale (Action B1) can mean new actions, new equipments, new tools. But what consequences of those changes on the carbon footprint, and what impact of the wine sector on climate change? Even if viticulture is not the wine sector step the most contributing to the carbon footprint (compared to conditioning and transport), this action focused on viticulture impacts to answer the specific questions of ADVICLIM project.

To make sure that the adaptation scenarios to climate change don't generate more emissions responsible of climate change than current situation.

The objectives of doing this assessment were to:



- Identify the main processes responsible for greenhouse gases (GHG) emissions and to characterize some interventions frequently producing high GHG emissions for each pilot site;
- Identify the proportion of indirect emissions against the proportion of direct emissions from the plot, on which the vine-growers can make modifications;
- Compare GHG emissions of observed practices against the practices modelled in scenarios with SEVE model (action B1);
- Ultimately integrate new constraints in the multi-agent's model for systematically reducing GHG emissions when the model proposes new scenarios of adaptation of practices to global warming;
- Extrapolate, if possible, the emissions produced by sampled plots to the pilot site scale according to plots representatively.

○ Activities undertaken and outputs achieved

Action B2 consisted in developing and applying a carbon footprint assessment tool (computed in Excel) for the viticultural stage and at fine scale (details for each type of viticultural intervention). This scale provided a detailed diagnosis that allowed to emit recommendations for climate change mitigation (decrease the number of interventions, use of low power rate motors, etc.) A split in the results between direct and indirect emissions was also done in order to make winegrowers aware of the life cycle approach, and the impact of manufacturing of their inputs and equipment's. Two questionnaires (Q1 for pilot site information, and Q2 for wineries information) were built to get knowledge on the context of viticultural practices and wineries. A link between VIDAC platform and the Excel carbon footprint assessment tool was done to make the data collection work on pilot sites easier (= Q3 questionnaire).

All in all, 27 plots over the 5 ADVICLIM pilot sites were assessed with this tool.

The methodology was built by Maxime Demarez and Sophie Penavayre (IFV), the implementation of data to collect in VIDAC platform by Samuel Louvet (Ecoclimasol), and the collection of data on pilot sites by Etienne Neethling (INRA), Corentin Cortiula (Plumpton College), Liviu Irima (University of agriculture sciences of Iasi), Théo Petitjean (Bordeaux Sciences Agro) and Marco Hoffman (Gesenheim University). Finally, the carbon footprint calculations were done by Emilie Adoir (IFV).

○ Key Deliverables

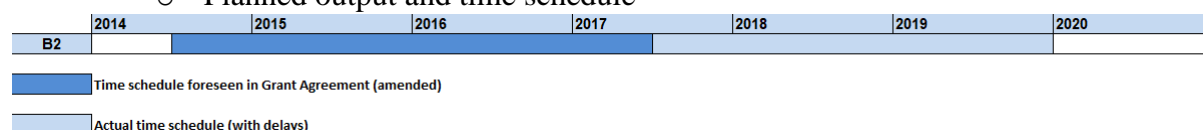
The final version of the deliverable has been provided: *Greenhouse gases emissions assessment of viticulture technical itineraries: method and results*. See Folder Technical annexes > Deliverables.

Appendices :

Annex T1. B2 - Rapport méthodologique. Evaluation des émissions de Gaz à Effet de Serre des itinéraires techniques viticoles

Annex T2. B2 – Cahier des charges

○ Planned output and time schedule



The detailed timetable for Action B2 is as follows:

	2014	2015	2015	2016	2016	2017	2017	2018	2018	2019	2019
	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2

Redirection of action B2 – coordination with other ADVICLIM actions												
Creation of Q1 and Q2 questionnaires												
Creation of methodology and carbon footprint tool												
Link with VIDAC platform (Q3 questionnaire)												
Data collection for Q1												
Data collection for Q2												
Data collection for Q3												
Data processing and results presentation												

○ Action problems and drawbacks

Three major problems were encountered during the implementation of Action B2:

- Difficulties in getting VIDAC platform extractions for filling the Excel carbon footprint tool: IFV adapted to this situation by making the Excel tool accessible to partners, so that they could fill in directly their data into the Excel tool;
- Delays of some pilot sites partners to provide required data for Q3: the carbon footprint calculations have been then possible only during the last year of the project;
- Delays in the acquisition of adaptation scenarios from Action B1;
- The accumulation of biases related to climate change models (e.g. precipitation, etc.) and downscaling result in significant uncertainties in adaptation scenarios.

Climate change adaptation scenarios (from Action B1) are based on an evolution of the winegrower's cultural practices or changes in vine varieties. Considering their probability of having no impact on GHG emissions (changes in vine variety, early pruning for frost risk, canopy management practices for heat waves, ...), GHG emissions assessment for climate change adaptation scenarios has not been done. But the methodology for assessing them would have been exactly the same. Some adaptation measures (e.g. more equipment such as shading or irrigation systems, etc.) that can produce significant GHG emissions require improved modelling to reduce uncertainties in adaptation scenarios.

○ Methodology and Main results.

- The Life Cycle approach: a diagnosis tool of greenhouse gases emissions

The carbon footprint is an environmental assessment method based on life cycle approach, accounting for Green House Gases (GHG) emissions from cradle to grave. It is first a diagnosis tool, useful for analysing the hotspots of an activity in terms of GHG emissions. The originality was to get deep inside the technical itineraries to distinguish the vineyard operations and the type of emissions: direct emissions on the field (by diesel combustion) and indirect emissions (by tool and equipment manufacturing) (Figure B2.1).

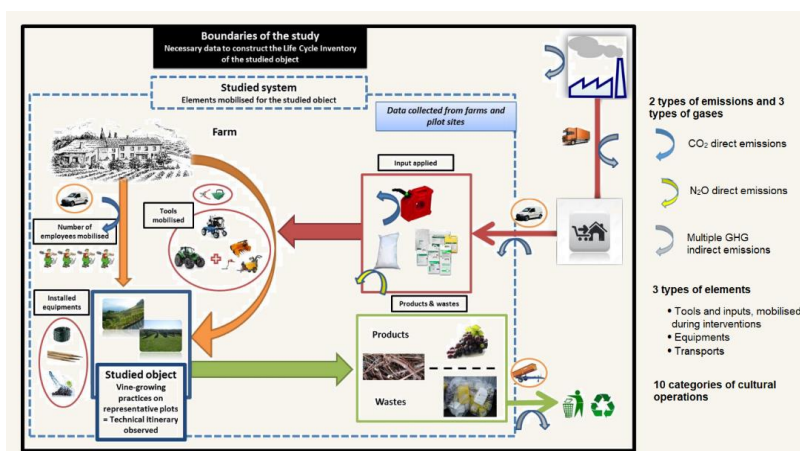


Figure B2.1: Life cycle of the cultivation of a plot planted with vine (Demarez et al, 2016)



- A prospective tool to make adaptation consistent

The aim is to make sure that adaptation actions to climate change don't generate more emissions responsible of climate change than the current practices. Some of adaptation actions are likely not to have impact on GHG emissions (vine variety changes, early pruning for frost risk, canopy management practices for heat waves...) as it does not imply new mechanical work or new equipment. But some will have to be studied with care: more trimming, more tillage or more equipment's such as shading or irrigation systems.

For example, in Pomerol/Saint Emilion pilot site, results highlighted a high variability in GHG emissions between every plot (Figure B2.2). Plant protection and soil maintenance were identified as the most emitting (direct and indirect emissions) operations. The variation in GHG emissions between operations is mainly caused by the engine power of vineyard tools and the frequency of interventions. Harvest, trellis management and vine maintenance are the most emitting practices, due to the use of high engine powered vehicles (Figure B2.3).

The SEVE model produced adaptation scenarios for three plots, which differed from current practice due to the number of pesticide applications: they remain stable or increase slightly for the period 2031-2050, then increase significantly for the period 2081-2100. The increases of GHG emissions from pesticide applications can have a significant environmental impact due to the high level of GHG emissions induced by fungicide treatment during a year (Figure 2.4).

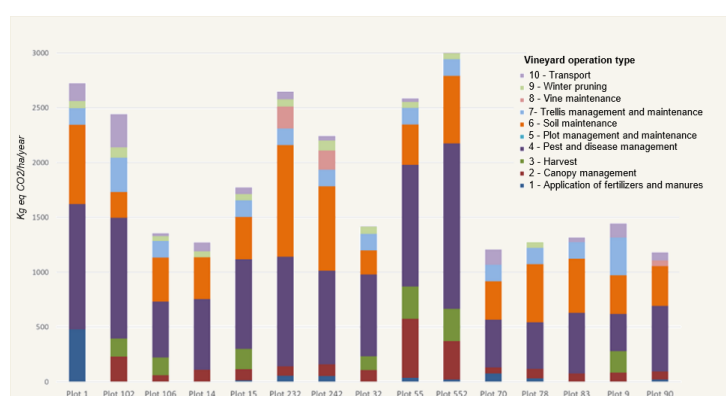


Figure B2.2: Total GHG emissions for each plot and each viticultural operation

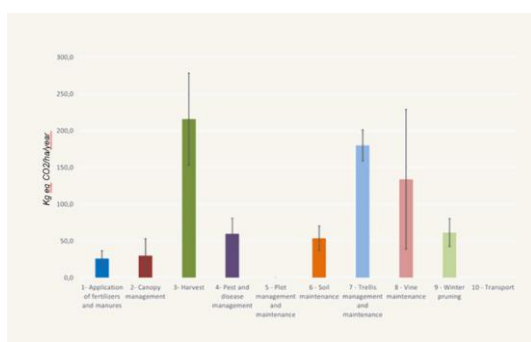


Figure B2.3: Mean of GHG emissions per single operation for each vineyard intervention

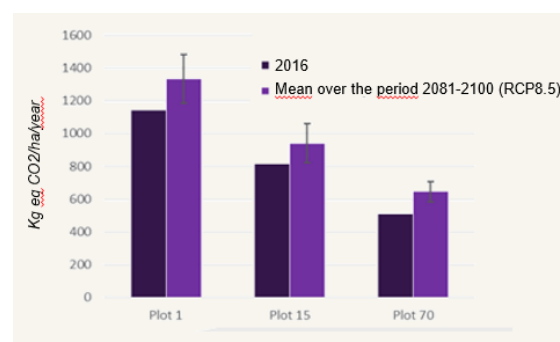


Figure B2.4: Adaptation scenarios assessment integrating pest and disease management actions changes

- Conclusion: a prospective tool to be proactive in climate change mitigation

Probably the first mitigation action that can be proposed, decreasing the number of interventions for pest and disease management and Soil maintenance, is simplistic, as there is

an agronomic and environmental logic behind it. However, the large variability of the number of interventions among the 27 plots suggests that there might be progress margins for some winegrowers. A comprehension on how the winegrowers manage the systems that need the least interventions would be very interesting to transfer to others.

Apart from optimization on current systems number of interventions, the most efficient mitigation actions seem to be in agronomic and technologic innovations, such as:

- operations combination (two operations during the same intervention);
- practices that reduces the need of an intervention (e.g. mulching);
- resistant vine varieties;
- carbon storage (through vine shoot shredding for example, in the regions where it is not yet widespread);
- electrical robots, namely for Pest and disease and Soil maintenance.

Need to complete GHG assessment on adaptation equipment for extreme scenarios (e.g. irrigation, solar shading system in vine...).

- Action indicators.

B2 action has been implemented in all pilot site integrated in the project. The main indicators of progress can be listed as follow:

Objective	Interim report (June 2016)	Mid-term report (April 2017)	Report (January 2019)	Final report (June 2020)
<b>Indicators of progress</b>				
<i>Winery carbon footprint budgets and the detailed emission entries</i> Objective: no objective in the project proposal	action is prepared for the moment with the goal to answer to this indicator	Action is ongoing. A new agenda has been defined: - December 2017: carbon footprint assessment for Bordeaux and Loire Valley pilot sites - December 2018: carbon footprint assessment for Cotnari, Sussex and Reinghau pilot sites	Action is ongoing. Carbon footprint assessment realised for all the 15 plots from Saint-Emilion pilot site. Time schedule defined for the others plots and pilot sites.	Completed action. Carbon footprint assessment realised for all the 27 plots over the five pilot sites, for one cultural campaign.
<i>Classification of the carbon footprints identifying the universal, winery-profile and winery specific emission entries</i> Objective: no objective in the project proposal	action is prepared for the moment with the goal to answer to this indicator	Action is ongoing. A new agenda has been defined: - December 2017: carbon footprint assessment for Bordeaux and Loire Valley pilot sites December 2018: carbon footprint assessment for Cotnari, Sussex and Reinghau pilot sites	Action is ongoing. Carbon footprint assessment realised for all the 15 plots from Saint-Emilion pilot site. Time schedule defined for the other pilot sites.	Completed action. Generic and specific conclusions presented in the deliverable <i>Greenhouse gases emissions assessment of viticulture technical itineraries : method and results.</i>
<i>Potential evolution of the carbon footprints in a context of climate change (impact of climate on winery practices)</i> Objective: no objective in the project proposal	action is prepared for the moment with the goal to answer to this indicator	Action will be done at the end of the project, using deliverable from B1 and B2 actions.	Cf. Time schedule of January 2019 report.	Action modified, due to the adaptation scenarios developed by Action B1.

○Summary of Expected results

Objective	Interim report (June 2016)	Mid-term report (April 2017)	Report (January 2019)	Final report (June 2020)
<b>Expected results</b>				
<i>The expected results are a quantification of carbon footprints of wineries representative of the European winery profiles, and a classification of the emission entries according to three categories: universal, winery- type and winery-specific</i>	action is prepared for the moment with the goal to achieve this expected result	Action is ongoing. A new agenda has been defined: - December 2017: carbon footprint assessment for Bordeaux and Loire Valley pilot sites December 2018: carbon footprint assessment for Cotnari, Sussex and Reinghau pilot sites	Action is ongoing. Carbon footprint assessment realised for all the 15 plots from Saint-Emilion pilot site. Time schedule defined for the other pilot sites.	Completed action. Carbon footprint assessment realised for all the 27 plots over the five pilot sites, for one cultural campaign. Generic and specific conclusions presented in the deliverable <i>Greenhouse gases emissions assessment of viticulture technical itineraries : method and results.</i>
<i>Quantification of the impact of climate variability and changes on the winery practices and thus on the winery carbon footprints</i>	action is prepared for the moment with the goal to achieve this expected result	Action will be done at the end of the project, using deliverable from B1 and B2 actions.	Cf. Time schedule of January 2019 report.	Action modified, due to the adaptation scenarios developed by Action B1.

(Projects submitting final reports after 1 January 2014 must use this format.)

- Perspectives for continuing the action after the end of the project

All the methodology built for organising carbon footprint assessment data collection and results presentation will be valorised in other projects, namely adaptation to climate change projects such as ADACLIM (funded by Pays de la Loire region), and ONAURAVITCHAU (funded by Auvergne-Rhône-Alpes region).

The assessment of adaptation scenarios regarding GHG emissions was not carried out during Adviclim project (except for Pomerol/Saint Emilion pilot site), but is still important to pursue, as some of adaptation actions can make the GHG balance changing (more trimming, more tillage or more equipments such as shading or irrigation systems).

## Action B3: Demonstration on European pilot sites

**Action leader:** Liviu IRIMIA (USAMV) and Laure de RESSEGUIER (Bordeaux Sciences Agro/INRA)

- Context and objectives

The B3 action is a key part in this project because it allows to make the link between the different actions. At the end, a synthesis of all the results found in this project per pilot site was produced to propose strategies adaptation and mitigation for relevant stakeholders. The methodology developed and apply per action is similar on each pilot site in order to produce a synthesis representative of the climate diversity of the European vineyards. A deliverable and a leaflet have been produced for each pilot site.

These results were disseminated through different types of communication: VIDAC platform, story map, leaflet, technical meetings and conferences. These results will give real tools to anticipate the future adaptations of climate change in viticulture by taking into account sustainability of these actions.

- Activities undertaken and outputs achieved

Methodology developed in the Action B3 and applied over each pilot site is summarizes on Figure B3.1:

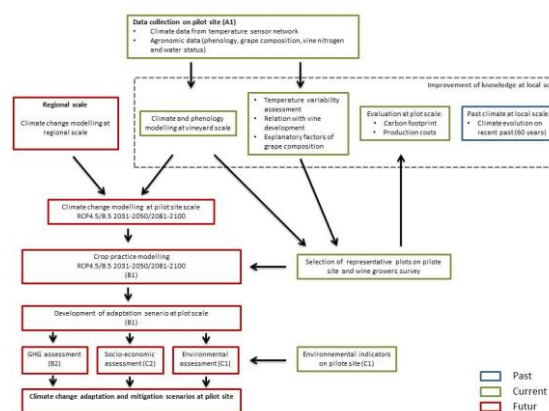


Figure B3.1: Synthesis of the B3 action

- For each pilot site a network of temperature sensors and ecophysiological measurements have been set up (Action A1).

- Historic data from a weather station of each pilot site have been collected.
- All these data allowed to improve our knowledge at pilot site scale:
  - Historical data have been analysed in order to determine the climate evolution of recent past (70 years) by using bioclimatic index calculate on two periods (1951-1990/1991-2010) (Action B3/A1/Q1);
  - Temperature variability have been analysed and climatic models developed to produce fine temperature maps at local scale (Action A1/B3);
  - The vine response at this temperature variability has been studied as well as the relation between temperatures, vine water and nitrogen status and grape composition (Action A1/B3);
  - Phenological models have been developed in order to produce maps of phenological stages (Budbreak, flowering, veraison, 200g/l of sugar content) (Action A1/B3).
- For the future and for each pilot site, climate change modelling has been set up at regional scale according to 2 scenarios (4.5 and 8.5) and two periods (2031-2050 and 2081-2100) (Action A1/B3).
- By combining these future regional maps and the climatic models developed at local scale for the current period, climate change modelling at pilot site scale have been produced (Action A1/B3) (Please, see deliverable A1).
- To evaluate consequences of the climate change on cultural practices, selective representative plots on each pilot site in terms of environment, climate, wine production, cultural practices... have been selected and survey have been realized with winegrowers (questionnaires Q2 et Q3). These plots allowed to characterize the current cultural practices management and to follow their evolution according to different scenario of climate change by using the SEVE model. These prospective scenarios will help winegrower in their reflection on climate change adaptation (Action B1).
- The sustainability of these practices in the current period and in the future have been evaluated in several aspects: production of GHG emissions, environment impacts and socio-economic impacts. These results allow to establish climate change adaptation and mitigation scenarios at pilot site scale (Action B2 C1 C2).

To communicate all these results to the winegrowers, wine professionals and others stakeholders, 4 major strategies are used:

●VIDAC platform:

The VIDAC platform, developed by Ecoclimasol, gathers all the project data (from meteorological stations, satellites, model outputs, carbon footprint results, etc...). A user-friendly interface for the viticultural stakeholders involved in the project allows them to visualise data collected in their fields, as well as other relevant data for their decision-making processes (Action B4).

●Local professional workshop (Action D):

Technical workshops were held in several pilot sites in order to present the main results of this project to the winegrowers and consultants. There was a very important day to communicate on climate variability, climate change and impact on vine development and grape composition. In November 2018, a local meeting with winegrowers and other

stakeholders was held in Saint-Emilion to present the results obtained on the local pilot site. This workshop was a great success, with more than 200 participants (please see the synthesis of the Saint Emilion workshop in Deliverable\_D2). The INRA Bordeaux team organised others technical days with winegrowers in other Bordeaux wine appellations (e.g. Fronsac, ...) and with other winegrowing organisations (e.g. viticultural colleges, cooperatives, winegrowing unions, etc.). A professional day in the Val de Loire was held during the regional meeting on adapting viticulture to climate change, organised by TechniLoire and INRA (March 2019). This meeting was held as part of the LACCAGE 2.21 prospective work on defining adaptation strategies to various climate outcomes. Around 80 wine actors of the Loire Valley attended this meeting. During the final meeting, a technical day was held with the winegrowers of Navarre and La Rioja. The workshop gathered 100 winegrowers and stakeholders, which shows the interest of local actors in the research findings and the importance of the dissemination action. The research topic transferred to winegrowers included adaption tools (on vineyard management, plant material and cultivation practices - canopy management and irrigation). The day ended with a round table with local winegrowers and discussions on the importance to combine adaptation and sustainability (Please see Deliverable\_D2).

•Story map (Action B3):

The construction of a story map allowed to produce a chronological and thematic document describing the overall implementation of the scientific approach associated with the LIFE-ADVCLIM project. Story maps are digital narration documents that combine text with static or dynamic illustrative elements and interactive maps. These communication supports have shown their ability to support the valorisation of results from research. In the context of ADVCLIM, the objective of the story map was to produce a summary document to facilitate the dissemination of knowledge acquired in the different actions of the project. The story map is used to communicate with wine professionals (managers, cooperatives, winemakers, stakeholders...) and one of the objectives is to exchange with professional on the result of the SEVE model in order to develop adaptation strategy scenarios.

The full version was made for the Pomerol/Saint Emilion pilot site: <https://www.advclim.eu/storymap>. The other sites are currently under progress (please see After Life plan).

•Leaflets (Action D):

The overall results of the project (including adaptation scenarios with carbon footprint calculations) are disseminated through information leaflets. Two types of leaflet are produced: specific documents for each pilot site, and a general leaflet at European level. The leaflet for each pilot site has been created. The specific summary leaflet for European viticulture will be published before the end of 2020 (delay due to the COVID19 crisis).

○Planned output and time schedule

	2014	2015	2016	2017	2018	2019	2020
B3							
	Time schedule foreseen in Grant Agreement (amended)						
	Actual time schedule (with delays)						

Action B3 is a transversal action which explains that the final results were provided at the end of the project. Major part of this action was achieved on all pilot sites.

○Key Deliverable

Action B3 includes one deliverable per pilot site which aims to present all the actions of the LIFE-ADVCLIM project.

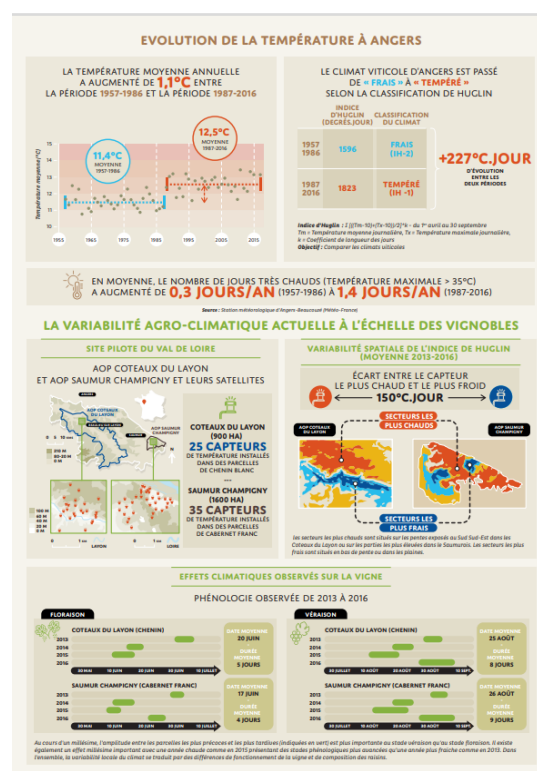
- Deliverable\_B3\_Pomerol\_SaintEmilion\_pilot\_site
- Deliverable\_B3\_LoireValley\_pilot\_site
- Deliverable\_B3\_Cotnari\_pilot\_site
- Deliverable\_B3\_Rheingau\_pilot\_site
- Deliverable\_B3\_Plumpton\_pilot\_site

Action B3 also includes a leaflet for each pilot site which aims to disseminate the main results for winegrowers and stakeholders (available in Annex T3).

- Leaflet\_B3\_Pomerol\_SaintEmilion\_pilot\_site
- Leaflet\_B3\_LoireValley\_pilot\_site
- Leaflet\_B3\_Cotnari\_pilot\_site
- Leaflet\_B3\_Rheingau\_pilot\_site
- Leaflet\_B3\_Plumpton\_pilot\_site

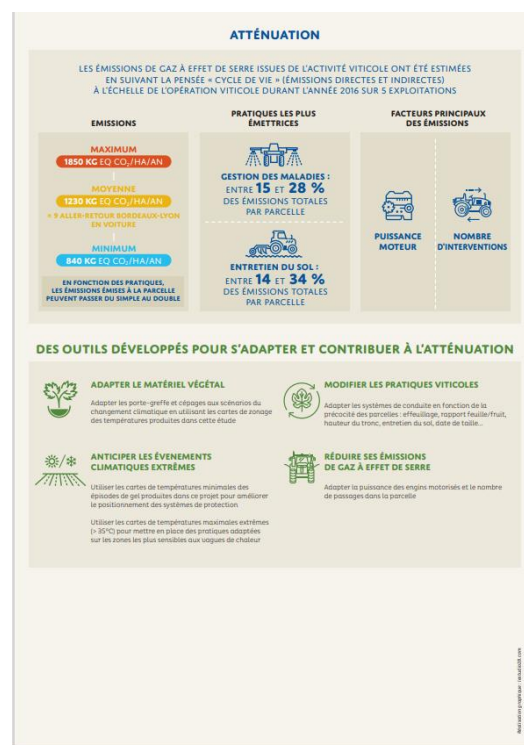
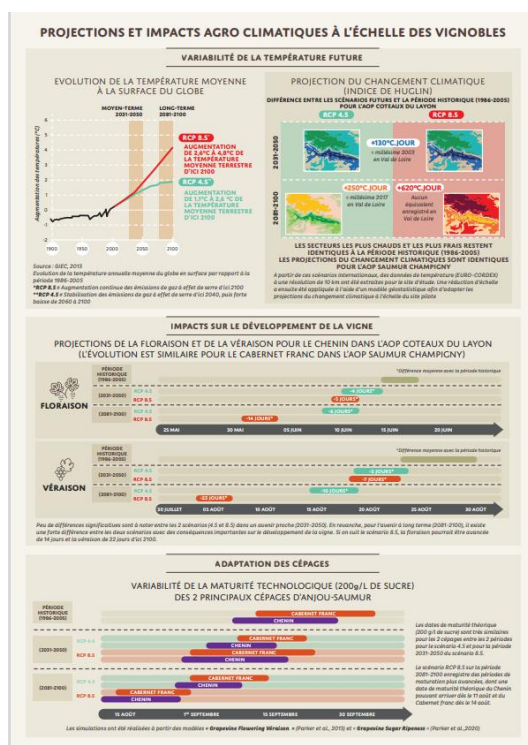
A general synthesis brochure of the LIFE-ADVCLIM project is in progress.

○Example of a result: Leaflet of Loire Valley pilot site (in French)





(Projects submitting final reports after 1 January 2014 must use this format.)



## Action B4: Information transfer to the wine industry sector (VIDAC platform)

Action leader: Samuel LOUVET (Ecoclimasol)

○Activities undertaken and outputs achieved

LIFE-ADVICLIM project has a main objective to make the transfer between "research and development" towards applications (shift from "laboratory" to application) that will allow changing the behavior of wine professionals and policies. For this purpose, the *ClimaVista®* Wine web platform, developed by ECOCLIMASOL, has been adapted to respond to the needs of the ADVICLIM Project teams and stakeholders through the VIDAC platform (VID Data Archive Center and Visualization) in the context of the action B4. The VIDAC platform aims at providing project researchers and stakeholders with a large set of project data (meteorological stations, satellite data, model outputs, carbon footprint results, etc...). These data are helpful for research as well as for responding to the needs of the actors (viticultural sector, public organizations, political ...) in order to easily release information to the wine sector and raise their awareness of climate change.

### ●Access to the VIDAC platform

There are two levels of access to the platform:

#### *Access for the ADVICLIM partners*

Every ADVICLIM partner has a login and password and uses the platform since the start of the project. Their accounts are supra-user accounts at the scale of a particular pilot site. It means that each account enables to visualize data from the whole georeferenced vineyards for a given pilot site (Figure B4.1). In the supra-user account, the map view of all plots and



vineyards helps the responsible to have a better geographical visualization of the pilot site he manages.

### ***Access for the wine growers participating to the project***

Access has been given firstly to winegrowers who have participated to the fulfilment of the forms (carbon footprint and multi-agent models) and in second time to winegrowers who have sensors of temperature installed on their plots. All in all, we have created on <https://wine.climavista.com/> :

- 95 winegrowers accounts from the Saint Emilion pilot site,
- 7 winegrowers accounts from the Coteaux Du Layon pilot site,
- 3 winegrowers accounts from the Cotnari pilot site
- 8 winegrowers accounts from the Saumur-Champigny pilot site,
- 1 winegrower account from the Plumpton college pilot site.

In order to facilitate the visualization of ADVICLIM results, we have created the accounts and we have georeferenced the plots as well so that they were ready to use by winegrowers.

All these accounts are single-user accounts, which only give access to their own data. At the beginning of the project, access was reserved for the responsible of pilot sites who had access to the whole pilot site data. Later, we were asked to create accounts for winegrowers so that private data (temperature data from sensors, technical and crop data from vineyards) could only be viewed by their owner. We therefore had to modify our databases to add the concept of private data. Single-user accounts are particularly intended to wine growers. As professionals, their critical feedback was really relevant to improve our services.

Two different strategies have been chosen in order to facilitate the use of the VIDAC platform for the new accounts.

- For French pilot sites we made a tutorial in video format, as required by the site managers. All single users received the link to download the video. In addition, the responsible of the Saint-Emilion pilot site organized a technical meeting on November 12, 2018, to present the ADVICLIM project and its preliminary results to wine growers. In that meeting *Ecoclimasol* presented the VIDAC platform.
- For Cotnari and Plumpton we made a videoconference with the pilot sites managers. They have explained to winegrowers personally how to use the platform.
- For Rüdesheim pilot site, a meeting with the winegrowers was held at the end of January 2019 to inform them about the platform and how to use it.

### **•Results provided**

#### ***Archiving and visualization of temperature data from sensor networks***

As previously stated, the concept of private data has been added in the VIDAC platform and its databases, and led to some modifications in the platform. For example, the map view of the stations available for a given account are now indicated according to their status (private or public, and the nearest one) (Figure B4.2).

We give access (visualization and download) to temperature data from the sensor networks with the best update available, depending on the data we receive from each pilot site. Three timescales are available: hourly, daily and monthly. At hourly timescale, users can also have an estimation of the evapotranspiration (calculated by the Hargreaves method) (Figure B4.3).

The VIDAC platform enables to make pluri-annual comparison of meteorological variables for a given sensor. This service is available for temperatures (selection of different years and

displaying a graph of the monthly mean temperatures for the selected years). It is really helpful as winegrowers can compare the current year with the past ones, and therefore set the campaign among the previous ones (Figure B4.4).

In the special case of the French pilot sites connected with the *Orbiwise* system (data in real time), the platform enables to quickly detect and locate meteorological events such as frost or thermal stress.

The Saint Emilion pilot site makes a posteriori quality control of the data. Every few months, the Bordeaux team asks us to extract data from our database. They carry out quality control and replace anormal / missing data from their sensors with their own method. This method has never been implemented on *Ecoclimasol* servers because it is far from being automated (visual control + local knowledge). Afterwards, the managers return the corrected data to us in a daily time step (unlike the raw data which is every 15 minutes). What we have set up is that for a data consultation  $\geq 1$  day if we have the raw data and the corrected data, it is the corrected data which appear. On the platform the features involved are:

- visualization temperature data (daily, monthly)
- bioclimatic indices at the sensor scale (Huglin and Winckler)
- bioclimatic index maps.

Finally, the Saint-Emilion pilot site was equipped with temperature sensors before the beginning of the ADVICLIM project. These sensors were exactly in the same place than the current ones. We were asked to integrate temperature data recorded between 2012 and 2016 by these previous sensors into the platform. It is therefore possible for winegrowers and managers of Saint-Emilion to visualize temperature data, derived bioclimatic indices at fine scale and maps since 2012. Moreover, Saint-Emilion has the distinction to be equipped by double sensors in each point (called hereafter T1 and T2). We therefore modified the platform in order it allows the visualization and download of the two sources of data.

### ***Bioclimatic indices***

Two scales are available on VIDAC: local (sensor) and regional (pilot site).

At sensor scale, we constantly improved the visualization until the end of the project and added information for helping the interpretation of the temporal evolution of bioclimatic indices over the growing season. For example, in the case of the Huglin index, a table showing the suitable conditions for grape maturity according to sugar criteria is available (Tonietto and Carbonneau, 2004). The VIDAC platform allows to make pluri-annual comparison of the Winkler (Growing Degree Days) and Huglin indices for a given sensor. As for the multi-year comparison of the meteorological variables, it is really helpful as winegrowers can therefore compare the current year with the past ones.

At pilot site scale, maps of different indicators are provided: average of minimum, maximum, or mean temperatures, growing degree days index, Huglin index, and cool night index (Figure B4.5). The time periods available are not only the years observed during the project. Indeed, some pilot sites provided us with temperature data measured before the start of the program. In addition, future forecasts (horizons 2040 and 2090) are also available for the Huglin index only (Le Roux et al 2018). For each time horizon two scenarios can be viewed. These are two Representative Concentration Pathway (RCP) of global emissions of greenhouse gases (4.5 optimistic and 8.5 pessimistic).

### ***Online forms***

The online form on VIDAC have been fulfilled. Collected data allowed to run the carbon footprint (B2) and SEVE multi-agent (B1) models for the different vineyards at plot scale.

Information from the forms were recorded in a database and extractions were done to furnish data to run the two models.

### ***Carbon footprint, scenarios of adaptation at pilot sites scale***

The results of the modelling of actions B1 and B2 are available on the VIDAC platform. They are in private access on winegrower's accounts who participated in the collection of information.

For the carbon footprint, the results present the GHG emissions emitted by viticultural practices at the scale of a plot, through life cycle analysis. They integrate direct emissions, generated on the plot, but also indirect emissions emitted during the stages of creation of inputs, tools, equipment. Interpretation of results and comparison with the average of the other analysed plots are also available for users.

Regarding to the scenarios of adaptation, the results proposed on VIDAC present, at the plot scale, a projection of the future evolution of climatic conditions (in terms of bioclimatic indices), phenology and grape varieties (Figure B4.6 and B4.7).

### **•Services not planned into ADVICLIM but helpful for wine growers**

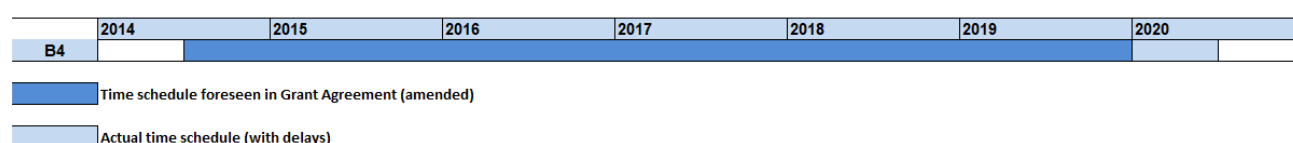
The VIDAC platform provides to users an estimation for past years and a forecast for the current year of the main phenological stages of the grapevine (bud break, flowering and veraison) based on the models of Parker et al., 2011 and Garcia de Cortazar Atauri et al., 2009. The calculation is done at the plot level for the variety informed when registering the vineyard, and from temperature data from sensors inside or very closed to the plot. Moreover, it informs about risk of frost around bud break and flowering, and risk of thermal stress (according to 2 temperature thresholds detrimental for grapevine) between veraison and harvest. This service is very helpful to have a monitoring of grapevine development and anticipate meteorological risks at key stages.

Wine-growers can also inform and record cultural practices in a logbook (batch management, agrochemicals, fertilizers, yield and harvest) on the online platform.

The platform furnishes also meteorological forecasts at seven days (precipitations, temperature, cloudiness, wind, surface pressure and relative humidity). Three timescales are available: 3-hours, hourly and daily time-step. At hourly and daily time steps, the platform informs, by a color code (green-orange-red), if the weather conditions are favorable and in accordance with the regulations for applying phytosanitary products.

The pilot site of Cotnari asked us to activate the service of remote sensing for their plots. Accounts can now visualize the photosynthetic activities of the vineyard at a 15-meters-spatial- scale every 16 days. They can also make an intra-plots classification (based on NDVI pixels distribution) in order to separate homogeneous zones inside the plot. This zonification is editable (according to the terrain knowledge of the winegrower) and exportable by the users. It is regularly used to make different technical operations according to the places of the plot.

#### **○Planned output and time schedule**



#### **○Key Deliverable**

Action B4 includes 3 deliverables:

- Deliverable\_B4.1: Data Archive Centre and Data Visualization Platform**
- Deliverable\_B4.2: Specific section on project website for information transfer**
- Deliverable\_B4.3: Information transfer to the viticultural sector (Final Deliverable)**

- Action indicators

- Creation of Data Archive Centre and Data Visualization Platform (VIDAC)
- VIDAC Web platform with every experimental vineyards
- Link with climate data (data loggers' networks)
- Creation of accounts (manager of pilot sites and winegrowers)
- Forms online (for actions B1 and B2)
- Maps of spatialized temperatures and bioclimatic indices (past, real-time and future)
- Displaying the result of B1 and B2 actions at plot scale

The main performance indicator for action B4 is frequent and repeated access to the platform by users (managers of pilot sites and winegrowers). We list below a number of points illustrating the interest of users for the platform:

- The managers of the pilot site asked us to update the identifiers of “winegrower” accounts, for reasons as varied as changes of owners, managers of the vineyard, etc. Sometimes these requests were urgent.
- The regular sending, by the managers of the pilot sites, of the corrected temperature data so that they appear on VIDAC.
- One of the winegrowers asked us to show the data from his connected rain gauge on VIDAC. The display and download of this type of meteorological data was not initially planned in the specifications for action B4. However, we wanted to meet his request.
- Following the ADVCILIM project, our partners from the Saint Emilion pilot site asked us for another research program. Indeed, this project, piloted by the CIVB needed a partner to make available the temperature data recorded by a large number of sensors in the field. This is why, as our partners were very satisfied with the performance of VIDAC, they called on us for the AVVENIR project.
- The online forms for entering the information necessary for actions B1 and B2 have been widely used. The managers of these two actions regularly asked us, during the ADVICLIM project, for extractions from our databases for the inputs of their modeling.
- Finally, the managers of the Cotnari pilot site requested the Romanian translation of the VIDAC platform. We could not meet this demand because we do not have the language skills. On the other hand, in the specifications for the creation of the VIDAC platform, only French and English were mentioned.

- Action problems and drawbacks

***Concept of private data and single-user/supra-user account added into the platform***

Modifications of our databases (the privacy can concern meteorological data or data from the vineyards).

Creation of two distinct types of account: according to the type of account, not the same rights (a supra-user account can have special rights and access to the private data of single-user accounts).

There are no wine growers accounts in Germany. Indeed, despite numerous reminders we never received contacts (names and associated emails) from the responsible of this pilot site.

### ***Integration of old data (previously recorded before the start of ADVICLIM)***

This integration required us some work. Indeed, the data collected in the context of ADVICLIM have a frequency of 15 minutes whereas the data previously collected had a frequency of one hour. Therefore, we had to create a new station family in our database. To allow the visualization of data recorded at daily and sub-daily time-scales on a same graphic we had to develop also new functionality of the VIDAC platform.

These problems do not have impact on the other actions of the project. They have been solved. For *Ecoclimasol*, it is very interesting and useful to add this new concept because the supra-user account is completely adapted to the case of agriculture cooperative groups with whom we are currently working.

### ***Integration of new source of data***

The data of the German meteorological stations are stored on a cloud. This was, for us, a new way to access at automatic loggers. So, we needed to develop new scripts and to create a new family of stations on our database.

### ***Receiving data from loggers***

To get data from the temperature sensors, different solutions have been chosen by pilot sites managers. Among the different solutions, the French pilot sites work with the Orbiwise company (automatic data transmission system). The advantage of this solution is the real time aspect. *Ecoclimasol* downloads the data through an Orbiwise API which is very often modified without any warning from Orbiwise; in addition, data loggers and gateways have suffered of numerous problems which needed attention.

Sensors and gateways have experienced problems during the project. Many times, we had to re-download data. Given the slow transmission of data, downloading in real time was not sufficient because it would have resulted in the loss of certain data. We have therefore implemented a double data recovery procedure: real-time recovery with data interrogation every 15 minutes and recovery of older data (6 months) every 15 days.

- Outline the perspectives for continuing the action after the end of the project

In a process of continuous improvement of its web solutions for climate-sensitive sectors, *Ecoclimasol* has developed a specific web platform for vineyards: *ClimaVista Wine*. The ADVICLIM project helps to develop and improve *ClimaVista Wine* services. These services are consistent with the needs of wine growers, as tools for decision support, but also with the needs of wine cooperatives as tools of management support. The interaction between ADVICLIM experts and wine producers, and the *Ecoclimasol* R&D team allows not only to improving the existing services, but also to focusing priorities in new developments, most useful for the wine producer decision-making process. Thanks to the ADVICLIM results, *Ecoclimasol* launched the commercialization stage of the platform *ClimaVista Wine*. A cooperative in the South of France is currently in a trial mode of the platform, a famous international vineyard used it in China, and the platform together with the ADVICLIM project results is currently promoted in Mendoza, Argentina.

All data and services provided by VIDAC / *ClimaVista Wine* platform will be accessed after the ADVICLIM project lifetime. At present time, more than 100 wine producers have a free access to the platform and numerous super-users at each ADVICLIM site. Moreover, we will maintain the automatic loading and processing of temperature sensors installed during the ADVICLIM project. The data, their post-processing and the interpolated maps will be available to all the wine producer accounts.

- Tables, figures to illustrate the action

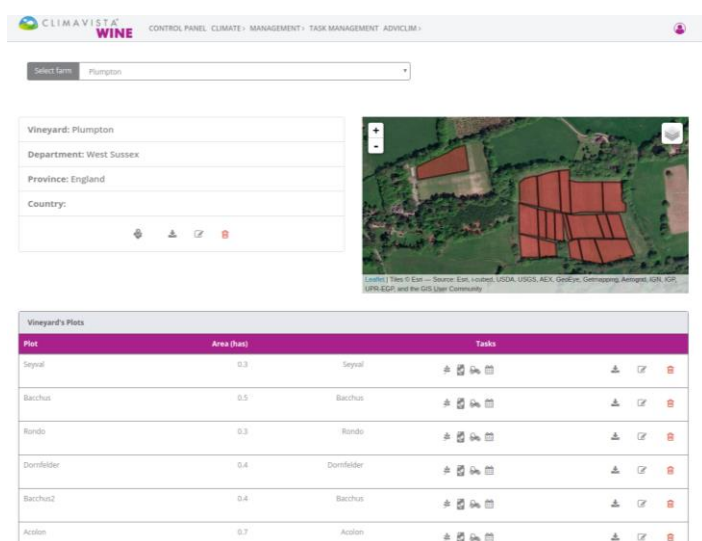


Figure B4.1: Geolocalised experimental plots of the Plumpton college pilot site.

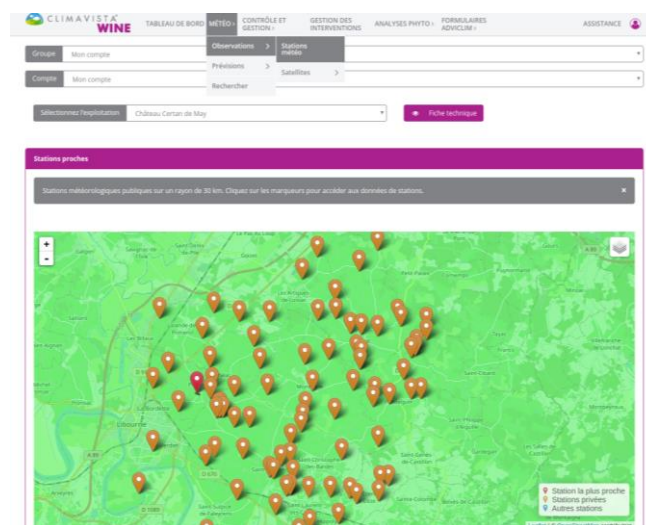


Figure B4.2: LIFE-ADVICLIM temperature sensors and public weather stations monitored by ECOCLIMASOL at Pomerol/Saint-Emilion pilot site.

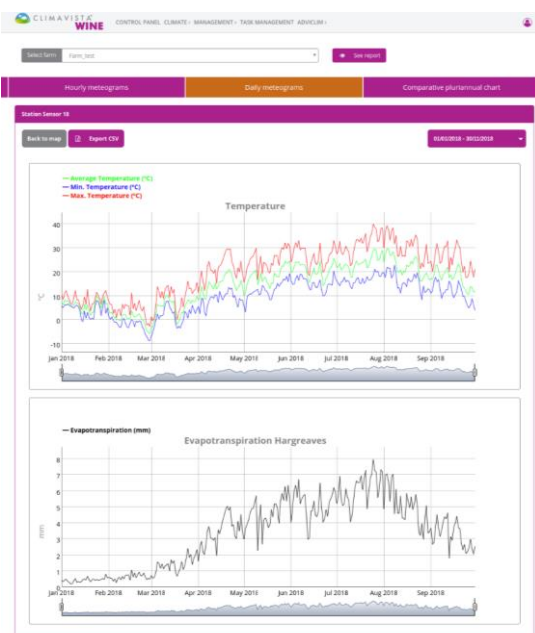


Figure B4.3: Visualization of the daily temperature and evapotranspiration for a sensor installed in Geisenheim (Germany)

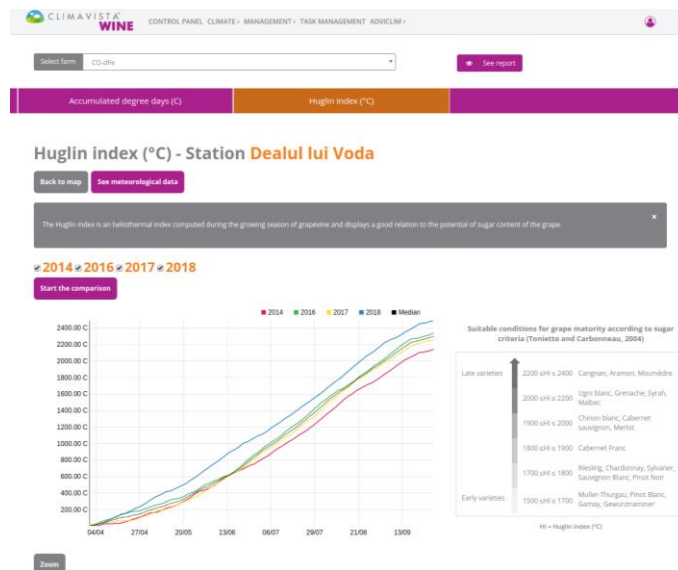


Figure B4.4: Temporal chart of the Huglin index for a Cotnari sensor in 2018, compared to the previous years. Table showing the suitable conditions for grape maturity according to sugar criteria.



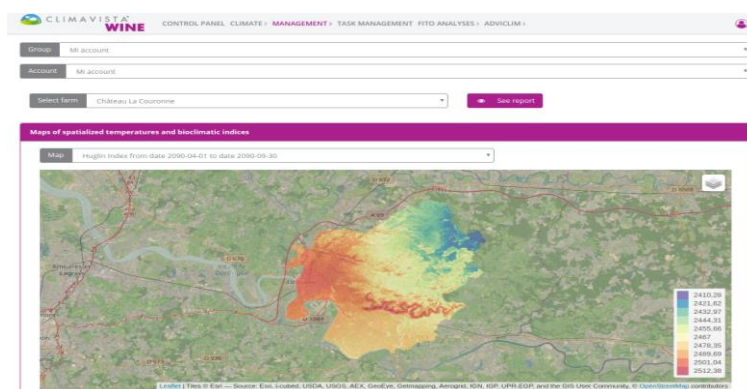


Figure B4.5: Map of the Huglin index computed between 2090-04-01 and 2090-09-30 over Saint Emilion pilot site for the scenario RCP 4.5.

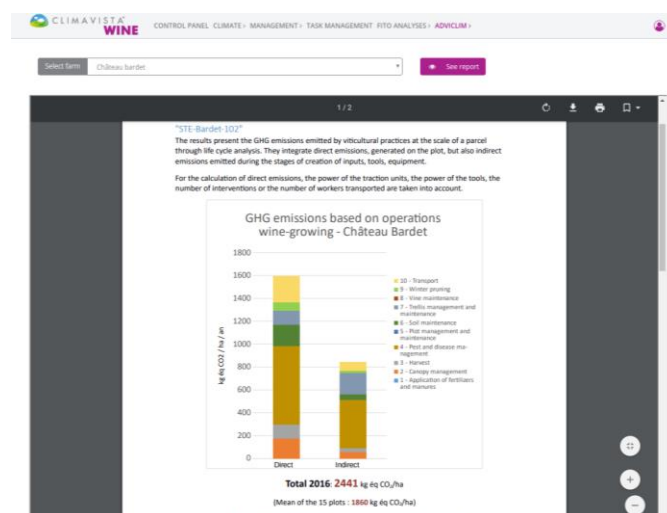


Figure B4.6: Illustration of results of the carbon footprint model on a plot of the Saint Emilion pilot site.

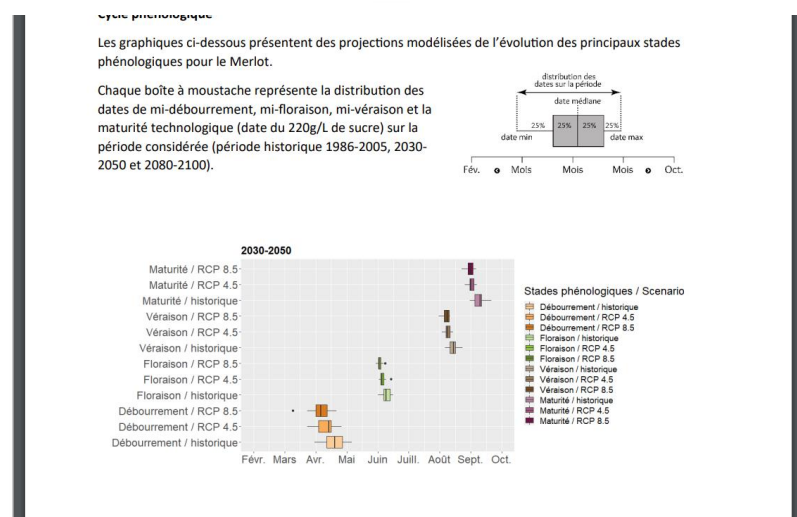


Figure B4.7: Illustration of results of the SEVE model on a plot of the Saint Emilion pilot site.

## Action C1: Territorial analysis of adaption and mitigation measures based on an environmental assessment

**Action leader:** Marco HOFMANN (Geisenheim University)

### oContext and objectives

Within the LIFE-ADVICLIM project, the aim of action C1 is monitoring the environmental impact of the project measures concerning adaptation to climate change and mitigation of greenhouse-gas emissions (GHG) at a regional scale. In general, the viticultural sector, as well as agriculture, is associated with a high use of natural resources like fossil energy, mineral fertilizers and the risk for soil degradation, but also with high output volumes of environmentally problematic substances like GHG emissions, pesticides, fertilizers and other

by-products. Also, the type of land use has considerable effects on the environment. Therefore, the whole production chain in viticulture has environmental impacts in many ways. Viticultural cultivation practices are adapted to site specific characteristics and also some traditional reasons are responsible for differences among the winegrowing regions. But viticultural cultivation practices have also to some extent aligned, with a decrease of traditional cultivation forms, as a result of a more intense mechanisation and globalisation of the industry. Currently, the winegrowing regions share also similar environmental issues and risks like nitrate and pesticide pollution or loss of biodiversity. Furthermore, the environmental conditions are changing due to the ongoing climate change and also the production methods are adapted due to technical developments and a better knowledge of the whole agricultural system. Although widely discussed, environmental issues receive too little attention in this dynamic situation. Technical developments primarily aim to reduce production costs, to increase resilience, to lessen external dependencies and are often combined with an increase of CO<sub>2</sub> emissions because of an increased use of fossil fuel. One of the ADVILCIM outcomes are experiences with small scale temperature networks and the development of modelling skills of temperature distributions within growing regions, supplemented with approaches to model the dynamic structures of wineries. This much more detailed environmental monitoring increases knowledge and paves the way for further applications regarding data acquisition and analysis in the field of digitalisation and “smart agriculture” which could also help to reduce the environmental impact in future.

#### ○Activities undertaken and outputs achieved

During the course of the project it became clear that the ADVILCIMs adaptation and mitigation measures were developed based on modelling approaches conducted by actions B1 and B2. The results of these analyses were only available at the end of the project and it was not possible to collect data during the project regarding individual adaptation measures in the pilot sites in order to assess their environmental impact. Also, the different environmental impacts of viticulture are entangled with established production methods and their economic efficiency, which are also adjusted to actual weather conditions. These reasons made it difficult to assess the impact of single adaption measures on the environment in quantifiable terms. Therefore, we decided to follow a more general approach based on a general environmental assessment regarding the most important environmental indicators for all ADVILCIM pilot sites. The indicators were, climate change (Figure C1.1), water and water management (Figure C1.2) including fertilizer use and plant protection agents, disposal and use of waste, soil erosion, soil compaction, soil acidification (Figure C1.3 and C1.4) and the biodiversity. Where possible, the environmental impact of modelled future changes of cultivation strategies, proposed by the results of action B1 and B2 at the end of the project, were assessed. The results were presented with respect to consisting political frameworks and finally discussed with respect to new policy initiatives around the European Green Deal.

#### ○Key Deliverable

Action C1 includes one deliverable and one section in each pilot site deliverable (Action B3).

#### **-Deliverable\_C1\_Environmental\_Assessment**

#### ○Planned output and time schedule

	2014	2015	2016	2017	2018	2019	2020
C1							

Time schedule foreseen in Grant Agreement (amended)

Actual time schedule (with delays)



The deliverable of the action C1, “Environmental Assessment” has been delayed as the previous action B1, B2, B3 were still under development. The action C1 was mainly carried out from January 2018 to February 2020.

- Action problems and drawbacks

Project plan of action C1 was restructured, because the first project plan based on the outline, that findings and results of actions B1 and B2 were implemented by action B3 in representative plots of the pilot sites, that the results and data of the implementation were collected by a monitoring protocol (questionnaire Q3), giving the possibility to monitor the impact of the project actions. We had to realize, that these ideas only partly meet the reality of the project progress, because B1 adopted and enhanced a multi-agent system and has mainly produced results concerning grapevine phenology, cultural practices and water budget. The resulting viticultural adaptation strategies of B1 are currently under development, exist in form of general recommendations or refer to future climates (2031-2050 or 2081-2100). In view of action C, a direct implementation of measures of B1 in representative plots of pilot sites proved difficult. The same applies also to B2, where also mitigation strategies (calculation of greenhouse gases) are under development but not implemented in representative plots or vineries of the pilot sites, useable for action C. That means, that the data and result produced by ADVICLIM, didn't allow an environmental or socio-economic assessment of the project actions as planned by action C. That was maybe a result of a too optimistic project plan at the beginning, where the assumption that developing and implementation of adaptation measures could happen simultaneously. Also, concerning action C, the first project plan did not consider sufficiently, that viticultural activities act in very complex environment, where it is in general very difficult to interpret results as one dimensional cause and effect impacts. Also, it is possible that environmental and socio-economic impacts of the project actions will come to full advantage many years after the ADVICLIM project and are therefore hardly to assess quantitatively.

To overcome those problems, we decided to perform a two steps approach. The advantage of this approach is the robustness in terms of getting valuable results and the flexibility. It establishes an open framework, where the impact of adaptation measures could be assessed against the most relevant environmental factors of the pilot sites. That makes it possible to link action C1 with the results of other actions of ADVICLIM and allow to assess the environmental impact of ADVICLIM at all.

The first step comprised a general environmental assessment for the most relevant environmental indicators including a quantitative description of the current state in each pilot site. The second step included a specific environmental assessment based on the adaptation scenarios defined by actions B1 and B2.

- Tables, figures to illustrate the action

(Projects submitting final reports after 1 January 2014 must use this format.)

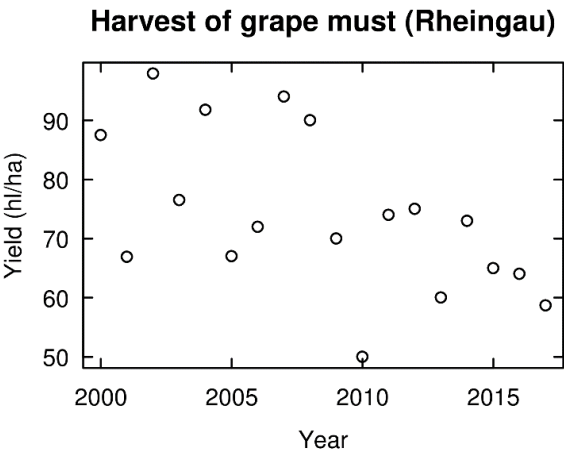


Figure C1.1: Harvest of grape must for the German winegrowing region Rheingau. Data based on “Deutscher Wein Statistik”, published by the German Wine Institute, [www.germanwines.de](http://www.germanwines.de)

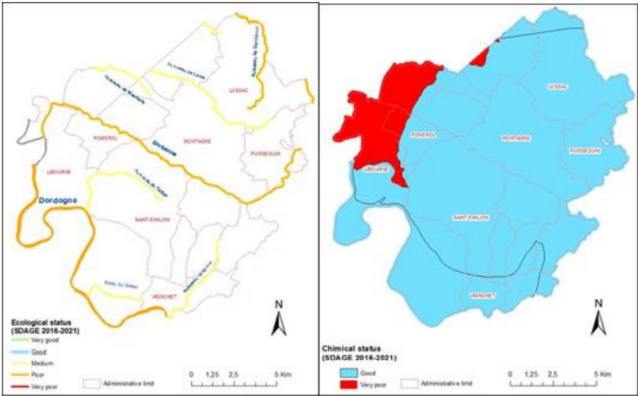


Figure C1.2: Ecological status of surface water (left) and chemical status of groundwater (right) on the Saint-Emilion/Pomerol pilot site (Data source: Water Agency - SDAGE Adour-Garonne 2016-2021)

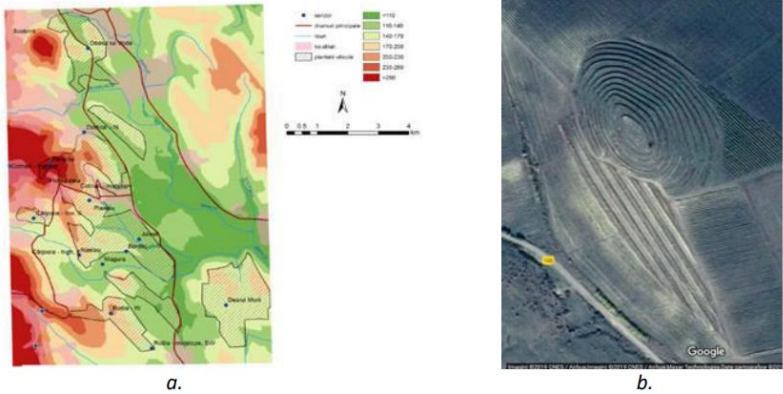


Figure C1.3: The map showing the relief of the Cotnari winegrowing region (a.); and anti-erosion arrangement in terraces in the Cotnari pilot site (b.)

	Plot 552	Plot 32
Inter-row	Alternating	Grass on entire surface
Intervine	Mechanical weeding	Chemical weeding
Rainfall per year in mm	904	904
Runoff per year in mm	83	44

Figure C1.4: Soil runoff calculation for two representative plots in Saint Emilion pilot site

## Action C2: Socio-economic and financial assessment of the project actions

**Action leader:** Chris Foss (Plumpton College)

○Context and objectives

According to the LIFE+ proposal guide, each proposal must include an action aimed to assess the socioeconomic impact of the project actions on the local economy. By using data from the environmental and financial assessments, a socioeconomic assessment of the project results

will be carried out that can present the impacts such as direct or indirect employment growth, financial viability of the vineyards which have been pilot sites. Consequently, the impact of the adoption of the new practices will be evaluated from an economic point of view, both at the vineyard scale and at the local scale. The new practices that are recommended by the ADVICLIM project will generally consist of vineyard climate change adaptation strategies, in such areas as:

- Vineyard operations; delaying the winter pruning operation, reducing the level of leaf-stripping and fruit thinning
- Vineyard floor management; cultivating the soil, or planting a specific cover crop in the vineyard alleys
- Management of frost risk; passive (site selection) and active (wind machines or heaters)
- Plant protection; varying the frequency of pesticide applications
- Clonal selection; to select hardier clones of established varieties, which ripen later
- Grape variety; planting varieties that ripen later
- Choice of rootstocks; using rootstocks that are more drought resistant, or that delay the ripening date of the fruit on the plant
- Vine training systems; systems that position the vine higher off the ground, or allow a greater level of fruit shading
- Irrigation; watering the vines in order to reduce drought stress in drier summers
- Vineyard site selection; seeking cooler areas to plant. All these practices will have some financial effect on viticulture in the region in which they are implemented, which may then have consequences for the region's local economy and its community.

#### ○Activities undertaken and outputs achieved

The objective of Action C2 is to estimate the costs of different viticultural practices used in the ADVICLIM trial vineyards, both for the current period and for different future scenarios, as calculated in Action B1.

The cost of the different vineyard operations was calculated using two main references:

- Roby, J. P., van Leeuwen C., Marguerit E., 2008. *Références vigne : références technicoéconomiques de systèmes de conduite de la vigne*. 2nd ed. Lavoisier. This publication starts with an introduction to the main French viticultural regions, with details of their location, climate, soils, and surface area. It then lists the major viticultural interventions with their cost, objective (result), the tools needed, and their pro and cons.
- Chambre d'Agriculture de la Gironde, 2016. *Référentiel Economique du Vigneron, vignoble de Bordeaux*. Bordeaux.

This publication compares different vineyard investments, technical itineraries, and price variations according to their productivity and management. It was used mostly to estimate areas not covered by Roby J.P., Van Leeuwen C., Marguerit E. (2008).

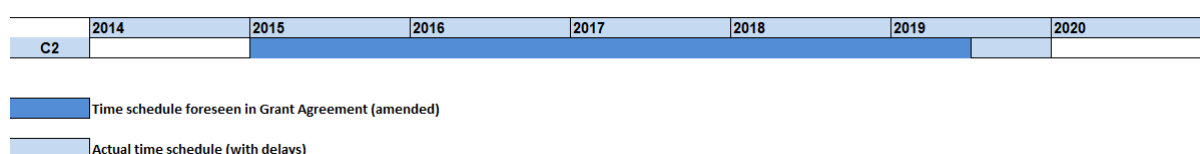
A list of vineyard operations, and their costs was generated from these references (Table C2.1).

An inventory of all the viticultural operations carried out in selected plots from the different project pilot site vineyards was generated from Questionnaire 3 (Q3), part of Action B2. An Excel spreadsheet was then created for each plot (Table C2.2).

When calculating the costs, the following adjustments were made:

- Roby et al (2008), estimated their costs on a vineyard density of 5000 vines per hectare, so all costs for vineyards with a greater or lesser density were adjusted accordingly.
- The number of times each operation was carried out in the plots had to be factored into the overall costs.
- Some operations were not described in the references, so their costs had to be estimated from similar operations.
- Roby et al (2008), estimated the cost of soil cultivation on alternate alleys. These costs were doubled for the plots where all the alleys were cultivated.
- The hourly labour cost was adapted for the different countries in the project
- If two viticultural operations were carried out at the same time, the price of labour and the tractor used was discounted for one of them.
- Each assessment was built and validated with experts from each pilot site.

#### ○Planned output and time schedule



The deliverable of the action C2, “Socio-economic and financial assessment” has been delayed as the previous action B1, B2, B3 were still under development and the results were needed to continue to calculate the different cost in the different climatic scenario. The action C2 was mainly carried out from early 2018 to February 2020.

#### ○Key Deliverable

Action C2 includes one deliverable and one section in each pilot site deliverable (Action B3).

### **-Deliverable\_C2\_ Socio-economic assessment**

#### ○Action problems and drawbacks

Initially, the first project plan did not take into account that viticultural practices are performed in a complex and changing environment; they are difficult to interpret as one-dimensional cause and effect impacts. This study showed that the evaluation of socio-economic impacts in vineyards could benefit from further work beyond the scope of this project. In particular, costs should be calculated at a local level, rather than applying the costs derived from published sources.

As a starting point, cost estimates at the Pomerol/Saint Emilion pilot site identified shortcomings in the analysis process and therefore improved it. The cost estimation of the different vineyard practices in Bordeaux has revealed shortcomings in the main reference source (Roby et al., 2018), particularly with regard to the range of viticultural practices, the different types of machinery used and the soil management practices. This has resulted in numerous discussions with colleagues from INRA Bordeaux, who resolved these problems by agreeing different guidelines on practices and tools, and supplementing the data from Roby et al. (2018) by another work, published by the Chambre d’Agriculture de Gironde (see reference list below). This cost analysis approach was applied to all pilot sites for the current period and future scenarios.

## ○Main results

This study generated some interesting observations from comparing data from different plots within the same wine producing region. The evaluation of the St Emilion/Pomerol plots was particularly interesting, due to the wide range in the number of interventions per operation, varying from 27 (plot 9) to 62 (plot 1), with the average total number of interventions per year being 41. This was reflected in a very considerable range (3,680 €/ha) in the cost of maintenance of one hectare of vineyard; the minimum being 6,262 €/ha and the maximum 9,943 €/ha. A major factor in this difference was the management systems, with Organic vineyards spending significantly more on a greater number of interventions (particularly pesticide applications) throughout the year. Apart from one Organic plot, canopy management and pruning were the main expenses, both costs increasing with higher vine planting densities (Figure C2.1). There was also a significant variation in the annual costs of vineyard maintenance for the Geisenheim plots, with the average cost being 6,753 €/ha, minimum 5,819 €/ha and the maximum cost 7,254 €/ha. This was primarily due to the effect of plantation density on winter pruning (the main expense for all the plots), and to the broad range of operations included in canopy management (the second largest cost). On the other hand, there was a very small range in the annual vineyard maintenance costs for the Cotnari sites: 1437 €/ha for Plot 1 and 1456,5 €/ha for Plot 2. Pest and disease management was the main expense, followed by trellis management and winter pruning. A smaller range in costs was also observed for the Val de Loire sites: the minimum cost (5,385 €/ha) and the maximum cost (6,236 €/ha). Winter pruning was the main expense for all the plots, then canopy management. The number of interventions, and the range of operations involved in canopy management was the factor which most induces variability. The standard deviation for fungicide treatments and for soil management was affected mostly by the power of the tractors used.

As the Rock Lodge (Plumpton College) vineyard was studied intensively as one vineyard, there was no possibility of comparing costs between different plots, however, it was noted that canopy management and pruning, the main expenses, both cost around 1150 €/ha, which represents 28% of the annual cost for maintaining the vineyard.

Regarding predictions for adaptation to future climate change scenarios, the most significant finding was that there would be a change in plant protection, particularly fungicide application, costs. These were set to increase for the St Emilion/Pomerol site (due to an increase in humidity) during the 2081-2100 period, but decrease for the Rock Lodge (Plumpton College), Geisenheim, Cotnari and Val de Loire sites. This will have a significant socio-economic impact, as fungicide application costs represent more than 10% of the overall maintenance costs of a vineyard, but they are impossible to quantify accurately. As they will affect the viability of the wine producing enterprises, they could have an impact on the local employment situation in the area. On the other hand, it is to be expected that the viticulture industry will develop more effective strategies for plant protection than pesticide applications in the next 20 years. These could include stimulation of plant natural defences, use of biological control agents, or the development of resistant classic varieties.

Winegrowers will no doubt need to perform other vineyard operations, such as reducing the level of leaf-stripping and fruit thinning, and changing vineyard floor management systems, to adapt to warmer climatic conditions and changing rainfall patterns, but these will probably not have a significant effect on vineyard operational costs. Winegrower will also have to adapt their plant material; changing the clones, grapevine varieties and rootstocks that they plant, but this will be a gradual development that will not have an impact on maintenance costs. Marginal wine producing areas, such as the UK, will greatly benefit from a wider range of varieties to choose from, as the heat summation in their area increases. On replanting, the

grower will need to assess the vine training systems they have been using, as these may need to change. Fortunately, none of the scenarios generated by the SEVE model predicts the need to irrigate vines on a regular basis; this would certainly be a very significant increase in cost to the grower, and may even be impracticable in certain areas, thus having a very high impact on the socio-economic circumstances of the region. One of the most important findings of this report is that the viticultural climate of a region varies very considerably on at the plot (or even sub-plot) scale. Further work in this area, and on the climatic responses of different grapevine varieties and their clones, will enable growers to continue to produce wine with the same characteristics in currently successful regions. However, vineyard management costs, and the viability of commercial wine production in the areas studied in this project, will be affected by the expected increase in the frequency of atypical and extreme weather events, such as warm spells at the end of the winter period (leading to a rise in the risk of spring frosts), storms, and drought events in summer. Unfortunately, these increased costs cannot be accurately estimated for a region. Future research will be required in frost and vineyard floor management to overcome these problems.

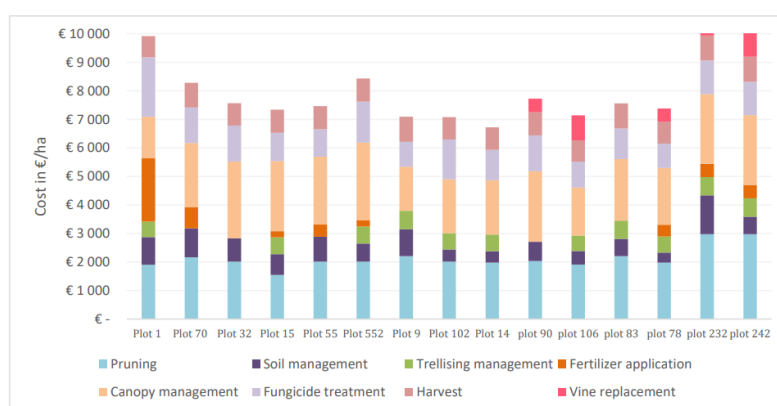
○Tables, figures to illustrate the action

*Table C2.1: costs used in Action C2*

Main practices	Viticultural practices	Time /5000 grapevines	Cost / 5000 grapevines (in €)
Pruning and similar practices	Dropping the wires	6h40	86.67
	Manual pruning	57h30	747.5
	Electric-assisted pruning	57h30	52.5
	Cane removal	35h	390
	Cane shredding	1h40	25
Trellis management	Machinery	1h40	33.33
	Shredder	1h40	8.33
	Trellis management labor	15h	195
	Trellis materials	N/A	300
Vine management	Cane attachment	30h	390
	Debudding	N/A	285
	trunk attachment	15h	195
Fertiliser application	Labour	2h30	37.5
	Machinery	1h25	25
	Spreader	1h25	6.25
	Fertiliser	11h0	110
Soil management	Soil management (5 passes)	3h45	56.25
	Machinery	3h45	75
	Tools	3h45	7.5
	Intervine soil management (2 passes)	3h20	50
	Machinery	3h20	66.67
	Herbicide applicator	3h20	16.67
	Herbicide	N/A	110
	Inter-row soil management (4 passes)	3h	45
	Machinery	3h	60
	Mower	3h	15
Complantation		N/A	400
Vine canopy management	1st manual shoot removal	22h50	292.5
	2nd manual shoot removal	12h30	162.5
	1st manual tucking in	12h30	162.5
	2nd manual tucking in	27h30	352.5
	Trimming: 3 passes (labour)	3h45	56.25
	Machinery	3h45	75
	Trimmer	3h45	45
	Non thermal leaf removal	N/A	101
	Mechanised harvest	2h50	500
	Harvest transport	5h	25
	Machinery	5h	100
	Tractor	5h	50
	Fungicide applications x 12 (labour)	6h40	100
	Machinery	6h40	133.33
	Pesticide application	6h40	66.67
	Pesticides	N/A	600

*Table C2.2: an example of the application of costs, to the St Emilion/Pomerol test site*

Practices	Sub-practices	Times	Ref	Cost	Total	Coef	Gross cover	Total estimated cost
Pruning	Electric pruning	1	1	86.67	529.17	1	N/A	€ 698.50
			3	52.5				
			4	390				
	Shredding	1	5	25	66.66	1	N/A	€ 87.99
			6	33.33				
soil management	Inter-row soil management (Mechanical)	1	7	6.33	16.25	1.4	2	€ 432.06
			16	56.25				
			17	75				
	Inter-row soil management Duo	1	18	7.5	82.5	0.2	2	
			17	75				
	Inter-row soil management : Sowing	1	26	400	400	1	N/A	€ 528.00
			23	45				
	Inter-row soil management : Mowing	1	24	60	120	0.25	N/A	€ 39.60
			25	15				
	Trellising management	Intervine soil management	1	19	50	125	0.5	N/A
24				60				
25				15				
Trellis		1	8	195	495	1	N/A	€ 653.40
			9	390				
Vine management	Cane attachment	1	10	390	390	1	N/A	€ 534.80
Fertilizer application	Application	11	12	37.5	178.75	11	N/A	€ 2,273.15
			13	25				
			14	6.25				
			15	150				
	Application Duo	2	14	6.25	116.25	2	N/A	
Canopy management	1st Tuck in	1	29	162.5	162.5	1	N/A	€ 214.50
	Others Tuck in	2	30	352.5	352.5	2	N/A	€ 930.60
	1st Manual shoot removing	1	27	292.5	292.5	1	N/A	€ 386.25
	2nd Manual shoot removing	1	28	162.5	162.5	1	N/A	€ 214.50
	Fungicide treatment	Application	26	38	100	900	2.25	N/A
39				133.33				
40				66.67				
41				600				
Application Duo		1	40	66.67	666.67	0.083333	N/A	
Harvest	Manual Grape harvesting	1	41	600	675	1	N/A	€ 891.00
			34	500				
			35	25				
			36	100				
			37	50				
TOTAL								



*Figure C2.1: Cost estimation per hectare for each plot in the Saint-Emilion/Pomerol pilot site, split into different vineyard operations*

## **Action E: Project management and monitoring of the project progress**

**Action leader:** Hervé Quénol (CNRS) and Marlène Meslay (University of Rennes 2)

### **Deliverables**

**E1:** *E1.1: Management plan. (due by 01/04/14). Completed on 01/09/14 and provided with PR 1 (inception report) on 30/03/15*

*E1.2: Final report (due by 30/09/20)*

**E3:** *E3.1: After-life communication plan (Completed on 29/02/20)*

**E5:** *E5.1: List of progress indicators (due by 15/12/14). Completed on 15/12/14 and provided with PR 1 (inception report) on 30/03/15*

*E5.2: Monitoring protocol. Completed on 15/12/14 and provided with PR 1 (inception report) on 30/03/15*

*E5.3: Monitoring tool. Completed on 15/12/14 and provided with PR 1 (inception report) on 30/03/15*

*E5.4: Final Evaluation report due on 30/09/2020).*

## **Action E1: Project management**

### **Main objective**

Coordination of project activities and communication between partners.

### **Specific objectives**

- To organise meetings and seminars
- To elaborate of reports
- To implement transversal activities

Besides the organisation of meetings and seminars, the project management team, in the framework of E1 action, has done a lot to ensure the coordination of project activities and the communication between partners.

Following the many issues raised by the Commission, the coordinating team is improving its management and proceeds to a very close monitoring of each tasks and expenses. The relationship between the partners remained positive and the attendance to the consortium meetings (face to face and videoconference) was high. Please refer to *4. Administrative part* for a more detailed description of the management system.

The Final meeting was organised in collaboration with the Public University of Navarra (external partner of the ADVILIM project). This event brought together researchers, international experts, representatives of other LIFE projects and stakeholders of the Spanish wine industry, to discuss the issue of adaptation of viticulture to climate change. The three days of the meeting were organised as follows:

- Day one: Consortium meeting. Restitution of the results of the project, for each action and each pilot site
- Day two: Knowledge transfer and networking. Round table discussion and debate on the topic of adaptation of agricultural practices to climate change and mitigation of the environmental impact of viticulture.
- Day three: Tools for adaptation. Conference and workshop with winegrowers from Navarra (around 100 participants), on strategies for adapting winegrowing practices to climate change



## **Action E2: After-life communication plan**

In order to reach a broad external audience and showcase the learning gained from this project, Life ADVICLIM needs to effectively communicate with professional from the wine sector, policy makers and other stakeholders in topics related to "climate change and wine" across Europe and World.

In order to efficiently approach and involve the relevant stakeholders, the communication and dissemination strategy was to develop tools to involve the wine profession and stakeholders from the beginning (e.g.: co-construction of climate change adaptation scenarios during workshops or technical days) to the end (e.g. guidance manuals to support winegrower's decision-making) of the project.

The dissemination of information is implemented from the local level (e.g. winegrowers of the pilot sites) to the international level (e.g. OIV, EU), as well as the various regional and national institutions.

One of the goals of the "After Life" communication strategy is to extend the application of the tools developed to all wine-producing countries. The Organisation of Vine and Wine (OIV) is involved in this objective.

Also, continuing to work on evaluating the results (particularly through surveys) will help to better communicate and promote the tools developed.

The deliverable "*After-Life communication plan*" presents the communication strategy that will be followed in the continuity of the LIFE-ADVICLIM project.

## **Action E3: Final audit**

The audit company KPMG was selected as external auditor. M. Jérôme Rivalin, west director of the KPMG S.A., directed the control activities.

The period of control, initially scheduled for April 2020, was delayed due to the exceptional circumstances caused by the Covid19 outbreak. The audit was eventually launched on June 2<sup>nd</sup>, and the audit report, attached in Annex F15 (Folder *Financial annexes*), was delivered on October 7<sup>th</sup>.

The controls, on the basis of the constituted sample (representing 30% of the total amount declared), did not reveal any significant anomaly.

However, the costs prior to May 2018 audited for UGM could not be certified because proof of payments could not be provided in paper form. Indeed, UGM's accounting department could not provide bank statements, as the individual expenses are not listed as single sums. However, the individual expenses appear on the SAP accounts concerned, but proof of payments are only available retroactively until May 2018. Proofs of payments made prior to this date can only be viewed on the premises of the accounting department of the UGM on site.

Despite of the other supporting documentation, KPMG omitted the costs concerned for UGM from the eligible costs, because of the absence of these proofs of payments.

The expenses can be certified by the accounting officer of the UGM. This certificate will be available on request from the European Commission

An English translation of the audit report is attached in Annex F15bis.



## **Action E4: Networking with other European projects**

### **Main objective**

To share experiences and information between consortia that have been working in the past or present on similar topics

### **Specific objectives**

- To identify previous and present projects on the issues of agriculture and climate change, in order to identify methodologies and tools that can be integrated and promoted in ADVICLIM activities
- To build an informal network with relevant Life project and to find synergies through study visits and meetings.

Networking has been developed with others LIFE, H2020 and ER4CS European projects, and with different stakeholders (local, national and international).

The networking strategy was implemented through different channels:

- Social media: More than 80 followers in ADVICLIM Twitter from European projects (+50 from LIFE projects; +30 from H2020 and ER4CS projects)
- Networking section in Websites: Our main partners and stakeholders are presented in the Networking section of the website. The LIFE-ADVICLIM project is also listed on the websites of other LIFE projects
- Participation and organisation of workshops/seminars with other LIFE projects.

The second day of the final conference held in Navarra in January 2020 was dedicated to networking. Representatives of other LIFE projects participated in a round table discussion and debate on the topic of adaptation of agricultural practices to climate change and mitigation of the environmental impact of viticulture. This event was co-organised by LIFE ADVICLIM and LIFE NAdapta, the discussions were recorded in the minutes of the final conference. Participation of LIFE-ADVICLIM, LIFE-PRIORAT-MONSANT, LIFE-SARMIENTO, LIFE-CLIMAVIT21, LIFE-NAdapta, POCTEFA VITISAD and POCTEFA VITES QUALITAS projects.

## **Action E5: Monitoring of project progress**

### **Main objective**

To measure and document the effectiveness of the project actions as compared to the initial situation, objectives and expected results

### **Specific objectives**

- Setting up a monitoring strategy
- Collecting quantitative and qualitative data to assess the project outputs and outcomes
- Evaluating the success of each action and the overall impact of the project

### *Monitoring the progress of the project*

A monitoring protocol was established by the project manager and validated by the monitoring team at the beginning of the project. This document fixes the framework for the

monitoring activities and describes the common procedures for monitoring the advancement of the project. Indicators of progress were identified for every action, serving as reference to measure the achievements of the project.

The progress of each action was evaluated during the steering committee meetings held on a three monthly basis until November 2018, then monthly until June 2019. These meetings allowed every action leader to:

- Update on the activities carried out, the milestones attained
- Assess the impact of the activities and the achievement of the objectives
- Evaluate the compatibility of the results obtained with the strategic objectives of the project, in terms of economic viability, environmental policy, sustainability, etc.
- Update on the budget achieved compared to the planned budget

The discussions and conclusions of these steering committees were recorded in minutes, which were sent to each partner at the end of these meetings for validation.

#### *Evaluating the results and the impact of the project*

The final evaluation report (deliverable E5) presents the quantitative and qualitative data that was collected to measure the achievement of the project's objectives.

The evaluation strategy included the realisation of a satisfaction survey among winegrowers and actors of the wine profession, based on qualitative data collected with questionnaires. However, as the project experienced delays, the results and deliverables of actions B1 and B2 (on which the planned qualitative survey focused) could not be evaluated in this way. This evaluation is underway and will be completed as part of the After Life plan. However, a more general survey was carried out, focusing on the winegrowers' perception of climate change and their attitude towards this challenge. The main results of this survey, which show a strong awareness of environmental issues among winegrowers, are presented in deliverable E5.

## 5.2 Dissemination actions

### 5.2.1 Objectives

The table below summarizes the objectives of the dissemination plan. Also, it shows what have been achieved at this point in regard of the indicators of progress we have had set at the beginning of the project.

Action	Objective	Final progress report (January 2020)
<b>Action D.1 : Project website</b>	<b>Indicators of progress</b>	
	<i>Project web site launched</i> Objective: 2015, January the 5 <sup>th</sup>	achieved
	<i>Number of web site visits</i> Objective: 50 000 during the project's lifetime	10 000
	<i>Objective: 15 links in partners and stakeholders web sites</i>	More than 30
	<i>Number of documents downloadable from ADVICLIM web site</i> No objectives during the project's lifetime	60 files are available and can be downloaded on the website
	<b>Expected results</b>	
	<i>Project website created within 6 months of the project's initiation, continuously updated</i>	achieved
	<i>At least 50,000 visits during project's lifetime</i>	10 000
	<i>15 links to ADVICLIM websites in partners and stakeholders websites</i>	more than 30
	<b>Deliverables</b>	
	<i>Project website - 05/01/15</i>	achieved
<b>Action D.2: Communication and dissemination activities</b>	<b>Indicators of progress</b>	
	<i>First press release in every country</i> Objective: 2015, January the 15 <sup>th</sup>	
	<i>Awareness and increased interest for the project</i>	Website visitors and social networks followers monthly increase.(currently : Twitter = 1035 followers)
	<i>First seminar before 01/05/2015</i>	achieved
	<i>Percent of targeted number of participants</i>	33 %
	<i>Percent of targeted number of Newsletter recipients</i>	11 % (220 / 2000)
	<i>Number of publications relating to project results</i>	100 + dissemination actions
	<b>Expected results</b>	
	<i>Minimum of 10 articles published in local newspapers</i> Objective: 10	22
	<i>Project leaflet</i> Objective: in 4 languages	achieved
	<i>Newsletters</i> Objectives: 10 newsletters and 2 000 readers	The 6 <sup>th</sup> newsletter was launched in April 2020. 220 people received it
	<i>Project presentation in English (power point format)</i> Objective: to have this project presentation available	Available on the private area of the ADVICLIM web site
	<i>Facebook and twitter profiles</i> Objective: 1000 followers on Twitter- Likes on Facebook	1075 followers
	<i>EU conference proceeding</i> Objectives: program, invitation, notes, photos	18 conferences realized
	<i>National workshops</i> Objectives: 5 national workshops with 120 attendees in total	4 workshops, 450 attendees
	<i>Participation of Partners to international and national conferences in order to disseminate project activities and results.</i>	38 conferences in total

	<b>Deliverables</b>	
	<i>Dissemination plan - 30/09/14</i>	achieved
	<i>Guidelines for professionals, scientific experts, and local authorities - 31/12/17</i>	Realized – May 2020
	<i>Dissemination report -15/07/19</i>	Realized – May 2020
<b>Action D.4 Notice Boards</b>	<b>Indicators of progress</b>	
	<i>Number of launched notice boards</i> Objective: 16	15
	<i>Notice board's model shaped</i> Objective: 2014, September the 31 <sup>st</sup>	achieved
	<i>Notice Board implemented in pilot sites</i> Objective: 2014, November the 30 <sup>th</sup>	achieved
	<b>Expected results</b>	
	<i>Creation of two different types of notice boards (one type for pilot sites focusing on demonstration activities and one type for strategic places)</i>	achieved
	<i>At least 1 notice board per pilot sites(6 in total ) and one notice board in strategic place per partner (9 in total) : 15 notice boards</i>	achieved
	<b>Deliverables</b>	
	<i>Notice board - 28/11/14</i>	achieved

The table below shows what have been achieved concerning the main expected results.

Expected results	Achieved	Indicators
Web site created in January 2015	Created 10 months late	100 %
Web site: 50 000 visitors	10 000 visitors	20 %
Web site: 15 links to partners and stakeholders websites	More than 30 links	100 %
10 articles in local newspapers	22	100 %
Leaflet in 5 languages	4 languages	100 %
10 newsletters – 2 000 readers	7 newsletters – 220 readers	70 % - 11 %
Project presentation in English (PPT format)	Available	100 %
FB and Twitter profile – 1 000 followers	1 075 followers	100 %
5 national workshops – 120 attendees (total)	4 workshops - 450 attendees	80 % - 100 %
Notice Boards	15/15	100 %

#### 5.2.2 Dissemination: overview per activity

##### **Action D.1: Project website**

The website has been created, according to the graphic guidelines of the project (Annex D1).

The project has been validated by all the partners during the progress meeting of June 2015 at Plumpton College. Then, IFV, with the support of the partners, realized the contents. The English version has been validated by all the partners in September 2015. Then, French, Romanian and German partners worked on the translations into their languages.

The English version of the website was launched the 1<sup>st</sup> October of 2015. The French was launched the 23<sup>th</sup> October of 2015. The Romanian version was launched on October the 28<sup>th</sup>. The German was launched at the beginning of 2016 (January).

The website contains a section dedicated to News and Events that is regularly updated. The information is also relayed via social networks (Facebook and Twitter). By the end of the

project it was decided to implement the site with a photo library in order to provide images of the different pilot sites as well as the meetings that occurred.

The website also contains a private area, designed to help partners to exchange documents and to find all necessary information and documents for the project management. Each partner has a private access. Access to the web site: [www.adviclim.eu](http://www.adviclim.eu).

The tables below summarize some data on website visits.

Website data	From the 01/10/2015 to the 26/01/2020	
Number of sessions	12 717	
Number of users	8 166	
Average time spent on the site	00:03:02	
Total number of page seen	42 272	
Average of page seen during one session	3,32	
Percent of new visitors	85,6 %	

Geographical origin of the ten top users (by number of session)	France	5 226
	United Kingdom	1 007
	United states	969
	Romania	542
	Germany	446
	Spain	446
	Russia	443
	Italy	392
	Unknown	386
	New Zealand	341

The graphic below shows the number of viewed pages since the site is online.



## Action D.2: Communication and dissemination activities

### D.2.1. Partners roles

A dissemination team has been defined and presented to the partners during the progress meeting of June 2015 at Plumpton College. This dissemination team is composed by IFV (Sophie Penavayre, Joël Rochard and the trainee in charge of communication) and UR2 (Marlène Meslay and Hervé Quénot). The dissemination team contact for the partners is Sophie Penavayre (and the trainee).

First actions of the dissemination team have been the creation of the valorisation plan (then validated by partners) (Annex D2) and the communication and moderation rules. Six moderation rules have been presented and validated by the partners at the progress meeting of June 2015, and are available on the private area of the project web site (Annex D3). The rules

have been presented one more time during the progress meeting of April 2016. During summer 2016, a trainee worked with IFV. She established a more precise and updated dissemination plan which is now used by IFV team to lead and manage the actions D. (Cf. Annex D2bis).

## D.2.2. Dissemination tools and material

### D.2.2.1. Logos

IFV realized the graphic guidelines of the project in January 2015, in order to give to the project a visual identity, and to harmonize the dissemination supports. From this graphic guideline, the logo of the project has been created (Annex D1). A presentation support model (.ppt) and a report model have also been designed.

### D.2.2.2. Social network profiles

A Facebook and a Twitter profiles, on the name of ADVICLIM, have been created. These accounts “like” and “follow” the stakeholders identified through the stakeholder’s matrix in order to create a relevant network on those social media. Posts and Tweets are published according to the different news, publications, about the project. The ADVICLIM’S Facebook ceased being up to date since it didn’t reach the expected audience.

Even though the ADVICLIM’s Facebook has been dropped the Twitter is almost daily updated and counts 1067 followers.

### D.2.2.3. Newsletters and leaflet

#### D.2.2.3.1. Newsletters

The first newsletter has been sent in December, 2015. The second one has been sent in September 2016. The third one will be sent in June, 2017.

The sending will go through the users’ subscriptions on the website and the email address present in the stakeholder’s matrix.

<b>N° Newsletter – Release date</b>	<b>Recipients – En/Fr/De/Ro</b>
<b>1 – Dec. 2015</b>	124 – EN/FR/DE/RO
<b>2 – Sep. 2016</b>	134 – EN/FR/RO
<b>3 – Nov. 2017</b>	136 – EN/FR
<b>4 – Jan. 2019</b>	240 – EN/FR
<b>5 – July. 2019</b>	220 – EN/FR
<b>6 – April 2020</b>	220 – EN/FR
<b>7 – Sept. 2020</b>	220 – EN/FR

A 7<sup>th</sup> newsletter is scheduled on September 2020 in order to disseminate all the deliverables et announce the follow-up of the project. After the second newsletter it was decided to release the next ones only in French and English due to necessary time for translation (Newsletters not translated in Romanian and German).

#### D.2.2.3.2. Leaflet

Two types of leaflet are produced:

- Presentation of the LIFE-ADVICLIM project

A leaflet has been created by IFV in order to present the project and its objectives. It has been created in the different languages of the project and is available on the project web site. Each partner was in charge of print it and distribute it (Annex D4).

- Synthesis leaflet for each pilot site

The overall results of the project (including adaptation scenarios with carbon footprint calculations) are disseminated through information leaflets. Two types of leaflet are produced: specific documents for each pilot site, and a general leaflet at European level. The leaflet for

each pilot site has been created (available in **Annex T1**). The specific summary leaflet for European viticulture will be published before the end of 2020 (delay due to the COVID19 crisis).

#### D2.2.4. Videos

During the final meeting at Pamplona, the communication team interviewed each action leaders, asking them their role in the Adviclim project, the main results obtained in each actions and in which way it will benefit the vine workers. It results on five videos posted on Twitter and hosted on the french wine institute Youtube channel VignevinFrance ([https://www.youtube.com/playlist?list=PL1dRoyJUp7dy7iEnijSN5u0uuvn\\_1kUFA](https://www.youtube.com/playlist?list=PL1dRoyJUp7dy7iEnijSN5u0uuvn_1kUFA)). The videos have been seen 123 times.

During the final meeting, a video documentary entitled “*The challenge of climate change for European viticulture: Adaptation tools*” highlighted the LIFE-ADVICLIM project and the various recommendations for winegrowers on adaptation to climate change. This video documentary made by the “UPNA” partner (in Spanish, French and English) will be distributed via the LIFE-ADVICLIM website, Twitter and the web platform of the Spanish wine industry (www.vitivin.pro).

#### D.2.3. Dissemination activities at EU and international level

##### D2.3.1. Project presentations at EU / international level

Several communication actions have been realized since the beginning of the project. A reporting system, completed by all the partners has been created in order to list the actions realized. From the beginning of the project and until the end of April 2017, 75 communication actions have been realized by the partners. The nature of these actions, their numbers, their partners and the audience for which they were intended are summarized in the tables below.

Type of activity	
Project presentation	26
Article	22
Poster presentation	4
Television/Radio report	10
Video interview	1

Scientific publications	
Peer reviewed journals	14
Books and books chapters	5
Seminar papers	25
Seminar presentations	10

Type of partner	
CNRS	12
IASI	2
IFV	6
INRA	10
NAVARRA	1
PLUMPTON	4
UGM	1
UR2	1

Type of audience	
Researchers and academics	33

Wine professionals	18
General public	9

The reporting is available on the private area of the project web site.

The ADVICLIM project took an important part in the organization and realization of the ClimWine Congress which took place in April 2016 in Bordeaux. *ClimWine 2016* is a symposium dedicated to the research about climate change effects on vine and wine. 180 people, from 20 countries, participated to the symposium. The participants visited the pilot site of Pomerol/Saint-Emilion, equipped with temperature sensors in the framework of ADVICLIM project.

The final meeting of the LIFE-ADVICLIM was held from 28 January to 30 January 2020 at the Department of Agronomy of the *Public University of Navarre* in Pamplona gathering the different action leaders, some researchers involved in the project, some members of the Advisory Board as well as a European Union Commissioner for LIFE projects.

On 29 January 2020 was dedicated to a networking meeting hosted by the Department for Rural Development and Environment of the government of Navarra in Pamplona. Various LIFE projects, including ongoing and/or finished projects, conventional or integrated projects related to adaptation of viticulture to climate change were presented.

A technical day took place on 30 January 2020 at the Estación de Viticultura y Enología of Navarra (EVENA). The workshop gathered 100 winegrowers and stakeholders, which shows the interest of local actors in the research findings and the importance of the dissemination action. The research topic transferred to winegrowers included adaptation tools (on vineyard management, plant material and cultivation practices - canopy management and irrigation). The day ended with a round table with local winegrowers and discussions on the importance to combine adaptation and sustainability. The video report entitled “*The challenge of climate change for European viticulture: Adaptation tools*” was made during this meeting.

#### D2.3.2. Dissemination toward scientific community:

From the beginning of the project many actions toward scientific community have been realized:

- Publications: 16 papers in scientific journals; 10 books and books chapters
- Conferences: 36 presentations at national and international conferences; 26 project presentations
- Colloquia and seminars (with seminar papers); 25 seminar papers and 10 seminar presentations
- Scientific workshops: organization and participation in 8 workshops in Europe, Argentina and New Zealand

#### D2.3.3. Dissemination via training

ADVICLIM partners gave courses to oenologists and agricultural engineers:

- Courses entitled “New technologies for the study of terroirs” were given to a total of 240 French second year DNO (oenologist academics French formation) students.
- A course entitled “Bordeaux terroir – Climate” was given to a class of 33 agricultural engineers from Bordeaux SciencesAgro.

In addition to these courses, two field visits have been conducted on the Pomerol/Saint-Emilion pilot site for an audience consisting of oenologist engineers and wine and vineyard master degree students.

#### D2.3.4. Development of EU network of experts



In order to develop an EU network of experts, the dissemination team first realized a stakeholder's matrix. The stakeholder's matrix is an excel file where all the partners indicate the relevant information about the stakeholders they are aware of. Information as: their name, their specific interest in the project, their social media accounts, the contact person in the organization, an email address. This is available on the private area of the project web site.

Thanks to networking activities, ADVICLIM appeared in the newsletter n°6 of the LIFE project Vineyard4heat ([www.vineyards4heat.eu](http://www.vineyards4heat.eu)). This project also appeared in the newsletter n°2 of the ADVICLIM project. Thanks to these exchanges, a meeting has been organized in January between IFV Beaujolais and a delegation from Vilafranca del Penedes, Spain (leader of the Vineyard4heat project) ([see article](#)). Several collaborations between the 2 vineyards have been defined for the future.

A page is dedicated to Networking on [adviclim.eu](http://adviclim.eu) and teases other projects from the LIFE program such as NADAPTA and ADMICLIM. It contains abstracts and links to the corresponding online sites (if available).

#### D2.3.5. Production of a guideline

The guideline is the deliverable D2: Guideline for professionals, scientific experts and local authorities.

#### D2.4. Dissemination activities at pilot sites and local level

##### D2.4.1 Project stakeholder dissemination events

A first workshop has been realized in the pilot site of Cotnari (RO) the 23th May of 2015. 40 people participated to the workshop.

A workshop has been realized in the pilot site of Saint-Emilion (FR) the 12<sup>th</sup> November of 2018. 200 people participated to the workshop. A second workshop has been realized in Fronsac (FR) the 20<sup>th</sup> March of 2019.

A workshop has been realized in the pilot site of Val de Loire (FR) in March 2019. 100 people participated to the workshop.

A final workshop has been realized in the pilot site of Rioja (SP) on 2020. More than 100 people participated to the workshop.

##### D2.4.2 Media publicity

23 articles have been published since the beginning of the project. Also, 6 television reports have been released.

#### **Action D.3: Layman's report**

This report has been realized at the end of the project. A dissemination plan has been defined in order to disseminate via all the communication tools : web site <https://www.adviclim.eu/>, twitter, newsletter # 7.

#### **Action D.4 Notice Boards**

IFV realized, with the support of the partners, the notice boards they have to implement on their pilot sites and strategic places.

Bordeaux Sciences Agro and INRA Bordeaux. Two notice boards have been created: an on-site notice board (pilot site of Bordeaux) and a strategic one. They have been printed implemented in November.

INRA Angers. Two on-site notice boards (pilot site of Val de Loire) have been created by IFV. They have been printed and implemented by INRA Angers.

University of Agricultural Sciences and Veterinary Medicine. Two on-site notice boards (pilot site of Cotnari), have been created, printed and implemented.

Plumpton College. Two notice board have been created: an on-site notice board (pilot site of the Sussex) and a strategic one. They have been printed and implemented.

Institut Français de la Vigne et du Vin. IFV had to implement a notice board on a strategic place. It was difficult to identify a strategic place. So it has been decided, with the Dissemination team, to create a poster which could be used during several communication actions (available in Annex D5). The poster has been created, printed and used for the 1<sup>st</sup> time in November 2015, during a conference by Joël Rochard during the Winery Congress in South Africa.

Université Rennes 2. As for IFV, it has been decided not to implement a notice board on a strategic place but to create a “kakemono”, communication tool which will be used in the different communication actions of the project. The kakemono has been printed and is available.

Centre de Recherche Nationale et Scientifique: A poster has been created instead of a notice board.

Ecoclimasol: a poster has been created instead of a notice board.

Hochschule Geisenheim University: the on-site notice board (pilot site of Rheingau) and the strategic notice board have been created, printed and implemented. All the notice boards, posters and kakemono are available on the private area of the Project web site.

### 5.3 Evaluation of Project Implementation

In this section you should evaluate the following aspects of the project:

- Methodology applied: discuss the success and failures of the methodology applied, results of actions conducted and the cost-efficiency of actions

**Action A1:** Application of existing methodologies developed in previous different projects and the duplication and innovative combination of them in this project were a success. Methods (climatic and agronomic analysis) and agroclimatic models were improved during the project. The climate and phenological models developed permitted the downscaling of climate change modelling to a local scale. The local-scale agro-climatic modelling, integrating climate change scenarios, was completed for each pilot site.

The main failures concern the installation of the data transmission system. The transmission system was installed only on the Loire Valley and Pomerol/Saint Emilion pilot sites. Numerous additional developments were necessary, in particular for the acquisition of climate data and their integration into the VIDAC platform. However, except these problems, the temperature data could be acquired automatically from the sensor to the VIDAC platform.

**Action B1:** A multi-agent model (SEVE) was developed to assess the effect of climate change, and associated increased climate variability, on grapevine growth and on vineyard management practices. The objective of this model was to define climate change adaptation scenarios, based on climatic spatial variability and vinegrowing practices. The SEVE model has been applied to several test plots in each pilot site. These simulations made it possible to identify several climate change adaptation scenarios, based on the spatial variability of the local climate at different temporal scales (short, medium and long term).

This action was a great success. The results are very innovative. Compared to its initial description in 2014, the action B1 has been modified by the proposal of providing two deliverables on adapting viticulture to climate change, instead of one. As mentioned before, these two deliverables are complementary, as the first enable the communication on general

aspects of climate change and adaptation in viticulture, whereas, the second allows to provide more detailed results at global and local scale. The second deliverable is therefore more effective as winegrowers have been already informed on the current and expected issues of climate change and the necessity to adapt their management practices and decision-making. Technical difficulties led to delays in the construction of the SEVE model and in the acquisition of the information required for modeling at each pilot site. We had also underestimated the developments required for this action. It should be noted that these changes did not entail any modification in the budget plan.

**Action B2:** The objective of Action B2 was to calculate pilot site carbon footprints according to the different climate change adaptation scenarios identified in Action B1. Carbon footprints has been calculated, according to the winegrower's cultivation practices, on representative test plots for each pilot site. This approach provided a detailed diagnosis that allowed to emit recommendations for climate change mitigation (decrease the number of interventions, use of low power rate motors, ...). A split in the results between direct and indirect emissions was also done in order to make winegrowers aware of the life cycle approach, and the impact of manufacturing of their inputs and equipment's. The methodology (Life Cycle approach) and the results were presented during technical workshops with the winegrowers. This approach was highly appreciated by winegrowers and stakeholders because the carbon footprint assessments were carried out at the scale of the vineyard. This carbon footprint assessment tool is currently being applied by the IFV in other projects.

The main failures involved significant delays. Difficulties for some partner pilot sites in providing the data required for the carbon footprint calculation. Technical problems related to the construction of climate change adaptation scenarios (Action B1) led to delays for Action B2. Compared to the initial project (2014), action B2 has been modified: The carbon footprint analyses focused specifically on winegrowers' practices in order to be connected to the adaptation scenarios resulting from Action B1. This tool is compatible with the carbon assessments carried out on all the activities of the vine and wine sector in each wine-producing region (e.g. Cahier technique CIVB, 2018<sup>1</sup>).

**Action B3:** Action B3's objective was to recommend effective adaptation techniques with GHG assessment to each pilot site, thus generating knowledge and promoting communication between policy-makers and decision-takers. This was delivered in several formats: (1) specific deliverable per pilot site, (2) the VIDAC web platform, (3) published material (in the form of pilot site-specific leaflets), (4) a Story Map (a pedagogical tool presenting each action of the project in the form of interactive map), (5) "Guidance manuals to support winegrower's decision-making", (6) "Workshops, technical days and meetings".

Théo Petitjean (INRA Bordeaux) coordinated the production of the deliverables for each pilot site in order to follow the same approach. The success of this action is demonstrated by the production of the synthesis leaflets for each pilot site. These materials are currently being promoted through the website, the Twitter account and various meetings with stakeholders and winegrowers. The "Layman Report" and the "After Life report" will be disseminated as a continuation of the LIFE-ADVICLIM project.

**Action B4:** The ClimaVista® Wine platform, developed by ECOCLIMASOL, has been adapted to meet the objectives of the ADVICLIM project through the VIDAC (VID Data

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<sup>1</sup> CIVB, 2018 : « Plan Climat 2020 des vins de Bordeaux », Les cahiers techniques du CIVB, n°64, Avril 2018, 12p

Archive Center and Visualization) platform. The VIDAC platform aims to provide researchers and project stakeholders with a large set of data (weather stations, satellite data, model outputs, carbon footprint results, etc.). The VIDAC platform offers useful functionalities with a good ergonomics which was very much appreciated by the winegrowers of the Pomerol/Saint Emilion and Loire Valley pilot site. This platform is a success, particularly with the acquisition of temperature data and access to climate change modeling at the plot scale. Thanks to the ADVICLIM results, Ecoclimasol launched the commercialization stage of the platform ClimaVista Wine. The main failure was the low number of accounts created in the other pilot sites. However, Ecoclimasol has regularly solicited the partners of all the pilot sites.

**Action C1:** Action C1 project plan was restructured and adapted to the general progress of ADVICLIM. We defined environmental indicators and describe this indicators regarding their particular meaning in the different pilot sites in detail. The methodology was based on a literature review, available data and discussions with qualified specialists. This approach consisted in estimating the environmental impact of the project findings in two steps: a general environmental assessment for each site, followed by a specific environmental assessment based on the adaptation scenarios from Action B1. Environmental assessments on a regional scale have made it possible to define the most relevant environmental indicators impacted: water quality, water management, water treatment, soil characteristics, biodiversity. The specific environmental assessment based on adaptation scenarios was more complicated. The results showed the expected impacts but it was difficult to quantitatively assess the environmental impact of the evolution of cultural practices or changes in grape varieties. The main failure has been the difficulty to set up a methodology in line with the objectives of the LIFE-ADVICLIM project. The environmental assessment of climate change adaptation scenarios at the plot scale would require further development.

**Action C2:** As for Action C1, Action C2 project plan was restructured and adapted to the general progress of ADVICLIM. The main objective of action C2 was to monitor the impact of the project actions based on a socio-economic and financial assessment. Action C2 consisted in estimating the costs of the different viticultural practices used on each pilot site, both for the current period and for different future scenarios, as calculated in Action B1. The methodology was defined on the basis of bibliographical references and meetings with experts in each pilot site. Action C2 made it possible to estimate the cost of cultural practices at the plot level. This type of approach was of great interest to winegrowers because the results showed a very high variability of costs according to local characteristics. A "cost" function should probably be added to the SEVE model (Action B1) and to the VIDAC platform.

**Action D:** A dissemination team was defined at the beginning of the project (UR2 + CNRS + IFV). This team defined the dissemination strategy and created the tools (graphic charter, website, billboards, brochures, social networks...). The other partners (Action leader and pilot site manager) contributed to provide the information for dissemination via newsletters, website, Twitter etc... All the objectives have been achieved (except for the number of connections to the website and the number of newsletters) and the "After Life Plan" will continue to disseminate the results to stakeholders. However, the level of dissemination of results varied among partners. This explains the lack of regular updating of the website.

○ Compare the results achieved against the objectives

Task	Foreseen in the revised	Achieved	Evaluation
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	proposal		
A1	Observation and validation of future climate simulations at terroirs scales.	<ul style="list-style-type: none"> <li>- Climatic and agronomic observations at fine scale</li> <li>- Climate and phenological Modeling at fine scale</li> <li>- To integrate climate change scenarios in climate models adapted at fine scales</li> </ul>	This action has been successfully except problems related to the installation of the data transmission system.
B1	<p>Formalization of a multi-scale framework in order to simulate grapevine phenology and agronomic practices at plot scales and homogeneous agroclimatic zones</p> <p>Compilation of cultural practices adapted to climate</p>	<p>Achieved</p> <p>Achieved</p>	<p>Despite the delay, this action has been successfully with the implementation of the SEVE model.</p> <p>The action B1 has two deliverables that are focused on assisting the winegrowers to adapting viticulture to climate change. The deliverable “<i>Guidance manuals to support winegrower's decision-making</i>” was very much appreciated by winegrowers and stakeholders.</p>
B2	<p>Winery carbon footprint budgets and the detailed emission entries</p> <p>Classification of the carbon footprints identifying the universal, winery-profile and winery specific emission entries</p> <p>Potential evolution of the carbon footprints in a context of climate change (impact of climate on winery practices)</p>	<p>Achieved</p> <p>Carbon footprint assessment realised for all the 27 plots over the five pilot sites, for one cultural campaign.</p> <p>Achieved</p> <p>Generic and specific conclusions presented in the deliverable <i>Greenhouse gases emissions assessment of viticulture technical itineraries: method and results</i>.</p> <p>Action modified, due to the adaptation scenarios developed by Action B1</p>	<p>The objectives of Action B2 have been achieved.</p> <p>Evaluation of the greenhouse gas emissions of the viticultural technical itineraries for each pilot site.</p> <p>Identification of the cultural practices that emit the most GHGs.</p> <p>Need to complete GHG assessment on adaptation equipment for extreme scenarios (e.g. irrigation, solar shading system in vine...).</p>
B3	To demonstrate the feasibility of the adaptation and mitigation strategies developed in B1 and B2	Achieved	Application of the same methodological approach to analyze and model the impact of climate change at the scale of the different pilot sites of the ADVICLIM project.
B4	Data Archive Center and Data	Achieved	Creation of Data Archive

	Visualization Platform  Specific section for information transfer to wine professionals		Centre and Data Visualization Platform (VIDAC) VIDAC Web platform with every experimental vineyards Link with climate data (data loggers' networks) Creation of accounts (manager of pilot sites and winegrowers) Forms online (for actions B1 and B2) Maps of spatialized temperatures and bioclimatic indices (past, real-time and future) Displaying the result of B1 and B2 actions at plot scale
C1	Technical Assessment and evaluation of demonstration activities on each pilot site	Achieved but with modifications from the original plan.	A general environmental assessment for the most relevant environmental indicators in each pilot site  A specific environmental assessment based on the adaptation scenarios defined by actions B1.
C2	Socio-economic assessment of demonstration activities on each pilot site	Achieved but with modifications from the original plan.	Estimation of the costs of different viticultural practices at the scale of the test plots on each pilot site (for the current period and for different future scenarios).
D	A detailed table shows in part 5.2 the objectives foreseen in the proposal and the achievement for every indicator of progress, expected results and deliverables.	Achieved	

○Indicate which project results have been immediately visible and which results will only become apparent after a certain time period.

#### **Action A1:**

- Data collection on pilot site for every growing season: (1) Climate data from temperature sensor network; (2) Agronomic data (phenology, grape composition, vine nitrogen and water status)
- Climate modelling at vineyard scale in climate change context (RCP4.5/8.5 2031-2050/2081-2100)
- Grapevine Phenology modelling at vineyard scale in climate change context (RCP4.5/8.5 2031-2050/2081-2100)

The integration of local climate variability (bioclimatic indices and phenological modelling) into regionalized climate change simulations provides an assessment of the impacts of climate change for European viticulture at the vineyard scale. The knowledge gained using this methodology is the increasing horizontal resolution that better suits the winegrowers concerns. Overall conclusion highlights the fact that thermal differences within each site is

similar to the thermal differences simulated by the climate model. Hence, these results give the local winegrowers/stakeholders information necessary to understand the current functioning as well as historical and future viticulture trends at the scale of their site that may facilitate decisions about future strategies.

#### **Action B1:**

Through the development of this modelling approach, the impact of climate variability on grapevine performance and winegrowers' production strategies was specifically targeted, both over time and space. The results obtained highlighted that SEVE model is able to reproduce the dynamics of vine growing and agronomic choices and practices according to climate variability. In the context of climate change, such a dynamic and complex model will help to better assess potential impacts on viticulture and to frame adaptation solutions at different temporal and spatial scales. Thanks to this approach, simulation outputs illustrate some potential agronomic strategies among a set of potential strategies.

However, even if we used bias-corrected climate data, there is uncertainty in the data included in SEVE and the model at different scales propagates this uncertainty. Many improvements are needed to reduce these biases. Many perspectives are currently underway.

Improvements are currently being made to improve the quality of modelling, particularly for (1) for the calculation of water balances necessary to simulate the use of irrigation; (2) for tillage practices and their impact on temperatures. Results will become apparent soon.

#### **Action B2:**

The main visible results of Action B2 were (1) the identification of the main processes responsible for greenhouse gas (GHG) emissions; (2) the identification of the proportion of indirect emissions compared to the proportion of direct emissions from the plot; (3) The calculation of GHG emissions of the cultural practices resulting from the SEVE modelling.

These 3 issues GHG allowed emission screening of a range of climate change adaptations strategies. The improvements necessary for Action B1 will also make it possible to improve the quality of the results of Action B2. Some adaptation measures (e.g. more equipment such as shading or irrigation systems, etc.) that can produce significant GHG emissions require improved modelling to reduce uncertainties in adaptation scenarios.

#### **Action B3:**

All the results from Actions A1, B1 and B2 were immediately visible during the period of the project. The results of observations and agroclimatic modeling were presented to winemakers and stakeholders at the end of each growing season. The "After life plan" provides for the dissemination of the results of Action B3.

#### **Action B4:**

The results were immediately visible according to the implementation of the different services in the ClimaVista Wine platform:

- Creation of Data Archive Centre and Data Visualization Platform (VIDAC)
- VIDAC Web platform with every experimental vineyards
- Link with climate data (data loggers' networks)
- Creation of accounts (manager of pilot sites and winegrowers)
- Forms online (for actions B1 and B2)
- Maps of spatialized temperatures and bioclimatic indices (past, real-time and future)
- Displaying the result of B1 and B2 actions at plot scale

#### **Actions C1 et C2:**



Actions C1 and C2 required the results of the other actions. The results were not immediately visible. Moreover, we had to modify these two actions compared to the initial project.

#### **Action D:**

The results were visible during the ADVICLIM project. At the beginning, the objectives of the project were presented with the notice boards installed on the pilot sites, the leaflets, the website, the first newsletters, and dissemination actions (articles, conferences, TV and radio reports...). During the project, the results were presented with the same means of dissemination as well as workshops with winemakers and stakeholders. Several conferences and meetings with other LIFE projects have made it possible to disseminate our results. After the ADVICLIM project, the Layman report and the "After LIFE" plan will allow further dissemination of the project results.

- Indicate effectiveness of the dissemination and comment on any major drawbacks

Please, see the Table in “5.2 Dissemination actions” part. This table summarizes the indicators of effectiveness of the dissemination. No major drawbacks, even if the accumulated delay has also caused delays in dissemination actions. An important dissemination work has been planned in the framework of the “After Life Plan”.

### **5.4 Analysis of long-term benefits**

The main objective of ADVICLIM is to demonstrate that adaptation to climate change in wine production will be implemented through reasoned agricultural practices. Reasoned agricultural practices based on “High resolution study of viticultural adaptation scenarios” will also reduce greenhouse gases (mitigation). Indeed, many activities involving climate change models predict relocations of wine growing regions. This will lead to significant releases of greenhouse gas effects. By proposing reasoned adaptation methods, we enable to limit greenhouse gases in the future. We work about this issue in collaboration with national and regional wine organizations from European countries.

1. Environmental benefits
  - a. Direct / quantitative environmental benefits:

Environmental benefits of the ADVICLIM project are numerous and include adaptation and mitigation of climate change. Most studies have addressed the issue of the impact of climate change on viticulture in wine regions worldwide at large scale by computing bioclimatic indices to assess the ability to continue viticulture in the well-established wine-producing regions of the world. Models of the evolution of agroclimatic indices show that climate change will allow the development of new winegrowing regions in areas which have been considered until now being too cool for ripening wine grapes, while winegrowing in warmer regions will become challenging. The simple translocation of winegrowing regions to higher latitudes and/or higher altitudes will have high financial, social and environmental costs. In winegrowing regions in southern Europe, where winegrowing is challenged by climate change, no alternative crops can be considered when vines disappear. Hence, translocation of wine growing regions implies a major risk of desertification of large parts of Europe. Development of vineyards in areas not yet cultivated by vines can have a major financial and

ecological impact, because of the threatening of wild life habitats (Hannah et al., 2013<sup>2</sup>). Moreover, translocation of vineyards would involve high greenhouse gas emissions. The ADVICLIM project, by studying possibilities of mitigation and adaptation, allows to avoid or limit these potential greenhouse gas emissions.

In the ADVICLIM project, the adaptation and the mitigation issue needs to be tackled at local scale in close interaction with winegrowers. Indeed, we showed that wine growers adapt their practices to the spatial variability of climate over very short distances. These practices partly determine the characteristics and uniqueness of their wines (the so-called terroir effect, which includes not only environmental factors like soil and climate, but also plant material and practices, van Leeuwen et al. 2019<sup>3</sup>; *Deliverable\_B1*). Considering that spatial differences in climate are much larger than temperature changes in the future and that winegrowers already adapt their practices to this spatial variability, a large range of adaptation practices to future changes that can be learned from fine scale differences in viticultural practices and implementation of site specific plant material (root stocks, grapevine varieties and clones). Conserving, as much as possible, vineyards in their current locations by the adaptation of plant material and practices will indirectly and considerably limit greenhouse gas emission compared to a scenario where wine growing regions would be translocated to higher latitude or altitude.

In the Life ADVICLIM Actions B1 and B2, a multi-criteria environmental impact assessment focusing on GHG emissions analysis has been carried out on various European viticultural pilot sites. The results highlighted the best possible adaptation and mitigation cultural practices in order to reduce directly and indirectly the impacts on the environment. This approach applied at the scale of the vineyard give the local winegrowers information necessary to understand the current functioning as well as historical and future viticulture trends at the scale of their site that may facilitate decisions about future strategies.

By 2050, whatever the climate change scenario, the suggested adaptation methods are based on the use of plant material and viticultural management strategies. Although these methods have low greenhouse gas emissions, multi-criteria environmental analysis has made it possible to optimize the number of interventions and practices in relation to the local characteristics of the plots and the winegrowers' strategies. The most effective mitigation actions are in agronomic and technological innovations (e.g. practices that reduces the need of an intervention, ...). The optimization of these actions therefore has direct environmental benefits. By 2100, By 2081-2100 under the RCP8.5 scenarios, the thermal increase is greater and involve other adaptation methods such as changing grape varieties. Knowledge of local climate variability makes it possible to optimise adaptation scenarios according to the specific characteristics of the vineyard by proposing a reasoned adaptation strategy. This approach also offers a direct environmental benefit because the winegrower will be able to define his strategy for planting new grape varieties according to local climate variability. This will avoid the translocation of winegrowing area. The environmental benefit is also important on carbon

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<sup>2</sup> Hannah, L., Roehrdanz, P.R., Ikegami, M., Shepard, A.V., Shaw, M.R., Tabor, G., Zhi, L., Marquet, P.A. and Hijmans, R.J., 2013. Climate change, wine, and conservation. *Proc. Natl. Acad. Sci. USA*, [www.pnas.org/cgi/doi/10.1073/pnas.1210127110](http://www.pnas.org/cgi/doi/10.1073/pnas.1210127110).

<sup>3</sup> van Leeuwen, C., Destrac-Irvine, A., Dubernet, M., Duchêne, E., Gowdy, M., Marguerit, E., ... & Ollat, N. (2019). An update on the impact of climate change in viticulture and potential adaptations. *Agronomy*, 9(9), 514.

foot print even if it is necessary to complete the GHG assessment on adaptation equipment for extreme scenarios (e.g. irrigation, solar protection systems in vineyards, etc.).

In the context of a regional environmental assessment (Action C1), this multi-criteria environmental approach at the plot scale provides a significant environmental benefit on the main environmental indicators (e.g.: water management, soil characteristics, waste treatments, ...). For example, optimizing the number of interventions and practices in relation to the local characteristics of the plots and the winegrowers' strategies can reduce the impacts on water quality and management.

- b. Relevance for environmentally significant issues or policy areas (e.g. industries/sectors with significant environmental impact, consistency with 6<sup>th</sup> or 7<sup>th</sup> (as applicable) EU Environment Action Programme and/or important environmental principles, relevance to the EU legislative framework (directives, policy development, etc.)

The results of the Life ADVICLIM project have a real impact on environmental issues in the wine producing sector at the European and international level. It has to be noticed that in spite of different environmental and socio-economic backgrounds, the issues viticulture is facing in the context of climate change, but also the role of the sector in GES emissions, are similar in all countries and therefore best addressed at EU level.

ADVICLIM makes the census of good operational practices at local and national levels, to enable sharing and dissemination of scientific knowledge and professional know-how, in order to confront different technical and scientific point of views in Europe. They were assembled so as to develop the very best intervention method to be applied in field conditions. It is by sharing practices emerging from various contexts that we will best address the common issue that viticulture is facing in the context of climate change. By creating a network of experts and stakeholders, ADVICLIM is link local efforts and make them applicable at EU level.

Furthermore, our project develops methodologies and tools based upon climate change observations, climate change modelling and grapevine monitoring, with the aim to transfer scientific expertise to the wine producing sector and to consult professionals through their winegrower's associations.

In Bordeaux (Pomerol/Saint Emilion pilot site), the Life ADVICLIM project is carried out in collaboration and sometime with the financial support of the wine inter-profession (example: "Conseil Interprofessionnel des Vins de Bordeaux"), wine trade unions ("Conseil des Vins de Saint-Emilion", "Syndicat de Pomerol"... ) and some wine cellars ("Vigneron de Puisseguin, Montagne, Saint-Emilion") but also group of defence against pests ("GDON du Libournais"). All these actors are interested in our results and ask us regularly to come to present project. The tools, the results, the climatic maps, the indicators... which are carry out in this project help them to sensitize vine-growers to climate change and to propose solutions of adaptation and mitigation. This project concretely supports the inter-profession in its policy of reducing environmental impacts and adapting to climate change. A concrete example is the collaboration with the "GDON du Libournais". This organization work in particular on Eudemis, an insect that is responsible of damage on clusters. The temperature sensors in Bordeaux were established close to Eudemis traps, to relate the temperature to the development of this insect, in order to better adapt and reduce phytosanitary treatments. This approach is also applied to other wine appellations (e.g. Entre deux Mers) within the

framework of the AVVENIR project funded by the "Conseil Interprofessionnel des Vins de Bordeaux". In the Loire Valley (pilot sites of Coteaux du Layon and Saumur Champigny), the Life ADVICLIM project has also been carried out in collaboration with the wine industry (Inter-Loire) and wine cooperatives. In Navarra, the involvement of the regional public authorities and the wine inter-profession has produced important results in terms of environmental impact and reasoned strategies for adaptation to climate change. At the final meeting of the LIFE-ADVICLIM project, a day was dedicated to a networking meeting hosted by the Department for Rural Development and Environment of the government of Navarra in Pamplona. Various LIFE projects, including ongoing and/or finished projects, conventional or integrated projects related to adaptation of viticulture to climate change were presented. Keeping in mind that the final objective of LIFE projects is research transfer to help policies making, feedback on the various experience was shared between different LIFE projects leaders and researchers involved in various Interreg and LIFE projects carried out in Navarra and Spain. It led in interesting discussions on how the different projects can contribute to policy making at different scales levels and how to encourage winegrowers to be part of the processes of policy making.

In the methodology developed in the Life ADVICLIM project, technologies are developed and tested in various bioclimatic situations, in vineyards using different cultural practices by growers with different environmental backgrounds and then transferred to the International/European level. The ADVICLIM project objectives are achieved by means of transnational cooperation.

At the initiative of the LIFE-ADVICLIM project, a survey entitled "*Understanding Winegrowers' Perceptions and Adaptation Attitudes to Climate Change*" was carried out among the stakeholders and winegrowers of each partner country in the project. The objective of this study is to explore the current and future state of the wine sector in an ever-changing climatic environment, in order to assess the perception and adaptive capacities of the winegrowers and stakeholders involved. As the main international viticultural organisations were interested in this study, we decided to carry it out in the world's main wine-producing countries. The survey was therefore carried out in 27 wine-producing countries and yielded more than 3750 responses, 1825 of which were obtained in the partner countries of the LIFE-ADVICLIM project. The results of this survey will help in the realisation of the directives of the international resolutions (OIV) for the adaptation of viticulture to climate change (please, see, below).

At the international level, the results of the Life ADVICLIM project are used for the resolutions of the "*Organisation Internationale de la Vigne et du Vin*" (OIV). The OIV is an intergovernmental organisation of a scientific and technical nature of recognised competence for its works concerning vines, wine, wine-based beverages, table grapes, raisins and other vine-based products. OIV resolutions are official texts adopted by consensus by the General Assembly of Member States and available in the five languages of the Organization. OIV resolutions are often used as references to set European Union regulations. Several members of the Life ADVICLIM project are OIV experts (Hervé Quénot, Etienne Neethling, Kees van Leeuwen, Sophie Penavayre) involved in several OIV resolution. Results from the Life ADVICLIM project are a valuable resource for OIV resolutions on climate change adaptation and mitigation. The partners of the LIFE-ADVICLIM project are very involved in the international draft resolution entitled "*Strategies for adaptation of the viticultural sector to climate change*" (CI-ENVIRO 2020-10 9.IV.1). The results of the survey carried out in 27 wine-producing countries are a basis for the OIV's strategic plan. In the continuity of the LIFE-ADVICLIM project, Etienne Neethling (INRA Angers partner) was awarded an OIV grant to carry out a study on improving the resilience of wine-growing systems in Europe.

The LIFE-ADVICLIM project partners are also very involved in the international draft resolution entitled "VITI-ENVIRO 18-640 *“Multi-criteria assessment of environmental impact in vitivinicultural sector - life-cycle assessment (LCA): general principles for conduction and communication of results”*" (VITI-ENVIRO 18-640). The LCA methodology developed and applied by ADVICLIM partners (IFV/ESA/INRA) is used for this resolution.

## 2. Long-term benefits and sustainability

### a. Long-term / qualitative environmental benefits

Adaptation of plant material and cultural practices in order to preserve wine production in the current winegrowing areas will be of major environmental benefit. A better understanding on the impact of climate on vine physiology, grape ripening and diseases will also limit the use of inputs like herbicides, spraying products and fertilizers.

The adaptation scenarios resulting from the SEVE model will have long-term environmental benefits. Based on the evolution of winegrowers' practices, these scenarios make it possible to propose reasoned adaptation methods that avoid “brutal” changes (e.g. vineyards translocation) that could lead to significant environmental damage (e.g. biodiversity, land clearance, etc.). Adaptation scenarios with GHG assessment at vineyard/plot scale enable an individualised adaptation strategy to be established. This makes it possible to implicate the winegrower in the positive and negative impacts on the environment. The main environmental indicators have been identified for each pilot region of the LIFE-ADVICLIM project (Action C1). These indicators are considered in the reasoned adaptation strategies in order to limit the long-term impacts on the environment (e.g. optimising the number of treatments, ...).

### b. Long-term / qualitative economic benefits (e.g. long-term cost savings and/or business opportunities with new technology etc., regional development, cost reductions or revenues in other sectors)

The limitation of vineyard translocations to higher latitudes and altitudes will have major economic benefit in the long term. The vine is a long living species and vines only come into production 3 or 4 years after plantation. Development of new vineyards cost over 20 000€/ha (Roby et al., 2008<sup>4</sup>), not including the clearance and preparation of the land. If vineyards can be contained in their current production areas, these expenses can be saved. The Life Adviclim project by studying the climate at local scale and by downscaling the climate change scenario is a tool for better adaptation of plant material, viticultural practices and at the end allows to preserve the current vine production areas. Improved adaptation of wine production to climate change preserves wine quality and marketability of the produced wines. Tourism, which is an important economic benefit in many wine growing regions, will be preserved. In the frame of the Life ADVICLIM project, information panels have been set up in the pilot sites to inform local growers and visitors about the objectives of the Life ADVICLIM project. The results are disseminated together with the various communication documents (e.g. brochures, social medias, TV and radio reports, etc.). The transfer of information via stakeholders is also very important for local and regional development.

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<sup>4</sup> Roby J.-P., van Leeuwen C. et Marguerit E., 2008. *Références Vigne. Références technico-économiques de systèmes de conduite de la vigne*. 2<sup>e</sup> édition. Ed. *Synthèse Agricole - Lavoisier*, Paris. ISBN 978-910340-50-6, 269p.

Another important point on the economic level is the transfer of the techniques developed during this project, in particular in terms of environmental (e.g. network of temperature sensors, climate variability, improving the accuracy of climate change models), agronomic (e.g. phenological models, maturity levels) and practice diagnostics (GHG, costs of cultural practices). These tools and results could be taken over by wine producing professionals, leading to economic activity and employment. The workshops organised with winegrowers and stakeholders have shown that the professional bodies are very interested.

- c. Long-term / qualitative social benefits (e.g. positive effects on employment, health, ethnic integration, equality and other socio-economic impact etc.)

Maintenance of wine growing areas in their current locations will have major impact on local employment. This is particularly important, because wine producing areas which are threatened by climate change are mainly located in southern Europe where unemployment rate is already very high. Moreover, when vines disappear in these areas, no other crop can be developed. The emergence of new wine-growing regions can also have a positive economic effect (e.g. Brittany in France, UK, Denmark, Holland, ...). It is particularly important to establish new vineyards taking into account sound adaptation and mitigation strategies.

- d. Continuation of the project actions by the beneficiary or by other stakeholders.

Numerous actions developed in the Life ADVICLIM project will be extended beyond the project duration as they have long-term implementation and scope: Actions B3 "*Demonstration on European pilot sites and Information transfer to the viticultural sector*", B4 "*Information transfer to the wine industry sector (VIDAC platform)*" and D1 to D4 "*Communication and dissemination activities*".

The aim of the after-LIFE communication plan was to list the different communication tools that will be used after the end of the LIFE-ADVICLIM project. Communication tools developed in the ADVICLIM project that will be improved and continued include:

- VIDAC Web Portal presenting data and information tailored toward the end user;
- Guidelines on best cultural practices for climate change adaptation at the vineyard scale. These guidelines allow for a reasoned adaptation strategy to be implemented, thus limiting fairly "brutal" methods such as relocating wine-growing regions;
- Guidelines on best cultural practices to reduce greenhouse gases (GHG). Identify the main processes responsible for GHG emissions to ensure that climate change adaptation scenarios will not generate more emissions;
- Guidelines for professionals, scientific experts and local authorities. These guidelines include description and information on the various techniques and methods developed during the project;
- Interactive tools (e.g. Story Map, videos) to train winegrowers, stakeholders, agricultural advisers and students (e.g. agricultural schools) in in guidelines applications in their vineyards;
- Summary booklets presenting the main guidelines in each wine-growing region. These synthesis documents are disseminated via wine cooperatives and regional structures, and also at national and international level with wine organizations (e.g. International Organization of Vine and Wine);

- Technical days to demonstrate to winegrowers how to apply these guidelines in their vineyard.

The ADVICLIM partners are leading institutions in viticulture and climate and agree to inform about the results of the project during 5 years after the end of the project. As part of their usual activities, they will also participate in conferences and provide information to stakeholders and to the public. Thanks to the strong connections created with wine producers, they will ensure that they will continue to initiate adaptation and mitigation actions. All the beneficiaries will communicate project experiences at various national and European fora.

The communication carried out around this project to our partners, wines inter-professions, wines trade unions and cooperatives has already had positive repercussions and has shown the interest of our partner for this project. For example, the tools developed in this project were transferred to the cooperative of Irouleguy, located at the foothills of the Pyrenees (France, see next paragraph).

In May 2017, Ecoclimasol participated in a Delegation led by the French Ambassador in Argentina in Mendoza. During the meetings organized with the Authorities of the Mendoza Province and Mendoza city as well as with different vineyards, Ecoclimasol presented the ADVICLIM Project, its advances and the web platform ClimaVista Wine, described as a scientific-based web platform for operational decision-making. Thanks to the ADVICLIM results, Ecoclimasol launched the commercialization stage of the platform ClimaVista Wine. A cooperative in the South of France is currently in a trial mode of the platform, a famous international vineyard used it in China, and the platform together with the ADVICLIM project results is currently promoted in Mendoza, Argentina.

3. Replicability, demonstration, transferability, cooperation: Potential for technical and commercial application (transferability reproducibility, economic feasibility, limiting factors) including cost-effectiveness compared to other solutions, benefits for stakeholders, drivers and obstacles for transfer, if relevant: market conditions, pressure from the public, potential degree of geographical dispersion, specific target group information, high project visibility (eye-catchers), possibility in same and other sectors on local and EU level, etc.

The objective of the ADVICLIM project is to adapt the winegrowers' cultivation practices while mitigating the effects on climate change. The results of this project help guide winegrowers in managing their vineyards, particularly in terms of the choice of plant material (rootstock, grape variety), management systems and harvest dates. To achieve these results, the SEVE multi-criteria model was built and applied on the different European pilot sites of the project. The structure of the SEVE model has the advantage of being upgradeable and replicable on other sites. The different modules of the model are regularly improved. For example, the phenology model was improved during the ADVICLIM project by adding a grape maturity model. The WALIS model (water balance calculation) was also improved during the project. These different evolutions of the SEVE model reduce the bias and thus improve the quality of the results.

This approach developed in the LIFE-ADVICLIM project is applied on other sites with new collaborations and within the framework of new projects.

- Other pilot sites:** during the LIFE-ADVICLIM project, several fine-scale temperature measurement networks were installed in other wine growing regions to better

understand this key parameter of terroir: AOP Chignin-Bergeron (Savoie), Clos Cristal vineyard (Loire Valley), Ausejo vineyard (Rioja in Spain), AO Vale in Bento Gonçalves (Brazil), .... These study sites have been equipped with temperature data loggers, indicating that the extension of the LIFE-ADVICLIM methodology is already taking place in other wine regions in the World;

- ***An example that already reflects visibility and interest of the results of the ADVICLIM project*** is the transfer of our specific methodology in the territory of Irouleguy in collaboration with the VITINNOV trans-research and development company. A study of the temperature variability was undertaken in this mountain vineyard in cooperation with the local cooperative cellar. A network of 31 temperature sensors has been set up inside the region at the beginning of 2016. To assess the impact of the different terroir parameters, eco-physiology measurements were carried out on 104 plots located near the temperature sensors. The spatial distribution of the temperature, related to other variables, like soil parameters and relief will allow to classify the influence of these parameters on vine behavior and grape quality potential. The final objective for the cooperative cellar is to better adapt plant material, vineyard management practices and harvest dates to each parcel for improving quality, which is of particular importance in a context of climate change. This project was co-funded by the Nouvelle Aquitaine region, the LABEX COTE, and the cooperative cellar of Irouleguy who showed major interest in the results of the Life ADVICLIM project;
- ***Complementary and replicable projects have started during LIFE-ADVICLIM:***
  - ***The AVVENIR project (2018-2021)*** funded by the “Comité Interprofessionnel du Vin de Bordeaux” (CIVB) aims to improve the study of fine-scale climate using less dense networks and satellite imagery, as well as climate models developed within the framework of Life. In the long term this would allow to study the climate variability at local scale in many wine growing regions and to improve the precision of model outputs on climate change at reduced cost. The tools developed in the LIFE-ADVICLIM and AVVENIR projects are applied in the Entre-Deux-Mers wine appellation.
  - ***ACCAF-LACCAVE 2.21 (2018-2022) " Towards integrated systems to reduce the vulnerability of the wine industry to climate change "*** funded by INRA aims to define adaptation strategies for French viticulture. Several cooperative events (e.g. organization of colloquiums, workshops, meetings with stakeholders and winegrowers, etc.) have taken place with the LIFE-ADVICLIM project.
  - ***COFECYT/COVIAR (2019-2021) "Instalacion de parcelas pilotos para la definición de estrategias de adaptabilidad de los viñedos al cambio climático "*** funded by COVIAR (Argentina) University of Cuyo (Argentina). The objective is to replicate the agroclimatic measures tools in Argentinean vineyards in the Mendoza region;
  - ***CSIC (2018-2020) " Evaluación del meso-clima en viticultura para la adaptación de medidas de manejo sustentables en la zona este del país "*** was funded by Uruguayan research and Uruguayan wineries and in collaboration with Univ. de la Republica, Montevideo. This project aimed to assess the impact of climate change on Uruguayan viticulture and to define adaptation methods in relation to winegrowers' practices;
- ***The successful replicability of the LIFE-ADVICLIM project is the creation of the VINADAPT international laboratory (2019-2023) with New Zealand.*** The IRP-



VINADAPT “*High-resolution scenarios for adapting agrosystems to climate change: application to viticulture*” aims to develop climate change adaptation scenarios at the vineyard scale by combining simulations of the future climate at fine scales with vine growth models, as well as integrating the cultivation practices of wine growers. These scenarios will be constructed and applied in French and New Zealand wine-growing regions. The different models developed in LIFE-ADVICLIM are applied and improved in this international laboratory project. This "wall-less" laboratory structure will make it possible to set up new international projects in the continuity of the LIFE-ADVICLIM project. <https://cnrssingapore.cnrs.fr/project/irp-vinadapt/>

- **Several international and national projects (replicability, demonstration, transferability, cooperation) have been submitted to calls for proposals:**

- ***CliAmWine “High-resolution scenarios for vineyard adaptation to climate change: application to Argentinean and Uruguayan viticulture” project*** has been submitted to the “*Regional Program CLIMAT-AmSud 2020 Project Proposal (Research – Innovation)*”. The objective is to use the approach developed in LIFE-ADVICLIM for South American viticulture (Argentina and Uruguay). In particular, this project will improve the SEVE model by developing an irrigation module;
- ***PEI3 “Transition et durabilité des systèmes de productions végétales face aux changements climatiques (adaptation et atténuation)” of « Pays de Loire/Bretagne » regions*** has been submitted in September 2020. The aim is to apply the adaptation and mitigation scenarios defined on the Val de Loire pilot site (Coteau du Layon and Saumur Champigny) but also on new winegrowing operations in the Val de Loire and Brittany. Several pilot wineries have been selected. The adaptation strategies defined by the SEVE model will be applied by the winegrowers. The aim of this 4-year project is to validate and improve the results of the LIFE-ADVICLIM project.

#### •NEXT...

- The very rich collaboration with the partners of the Public University of Navarre in the LIFE-ADVICLIM project will continue with the setting up of new projects. The networking day organized during the final meeting provided an opportunity to meet other LIFE project leaders (LIFE-NAdapta, LIFE-PRIORAT-MONSANT, ...). We plan to set up a European project (probably LIFE).

Overall, the LIFE-ADVICLIM project will has shown the interest of adaptation scenarios at vineyard scale and GHG emission assessment to winegrowers. These results are very useful for winegrowers to adapt to their local terroir conditions and to climate change. This approach can be transferred to professional structures (e.g. extension services, private companies) that can use the expertise developed in the Life ADVICLIM project. In particular, the Institut Français de la Vigne et du Vin (IFV) winegrowers to realized GHG emission assessment in their plots in order to include environmental consideration in their management.

4. Best Practice lessons: briefly describe the best practice measures used and if any changes in the followed strategy could lead to possible adjustment of the best practices

The aim of this project was to set up a reasoned adaptation strategy to guide winegrowers in the management of their vineyards with a better choice of plant material (rootstock, grape variety), management systems and harvest dates.

In terms of adaptation, the measurement of fine-scale climatic variability and improvement of the accuracy of climate change modelling are essential for a better understanding of terroir characteristics and effects of climate change at local scales.

In terms of mitigation, the measurement of the environmental and economic impacts of differences in technical management at plot scales allowed to determine “Best Practice lessons”.

These two aspects have been compiled in the SEVE multi-criteria model in order to define the best possible adaptation strategies related to greenhouse gas emissions. Best practice measures have been described in the deliverables of Actions B1, B2 and B3 for each pilot site representative of European viticulture.

5. Innovation and demonstration value: Describe the level of innovation, demonstration value added by EU funding at national and international level (including technology, processes, methods & tools, organisational & co-operational aspects);

- Automation of temperature measurement networks with a radio connection system using *LoRa* technology. It is a real technological advance that enables winegrowers to visualize climate data in real time. However, improvements are needed to reduce data transmission problems.
- Creation of high-precision climate models that produce accurate temperature maps and downscaled climate projections.
- Creation of a multi-agent model synthesizing all the data on adaptation and mitigation with the aim of providing adaptation responses to winegrowers.
- Propose to winegrowers and stakeholders a reasoned climate change adaptation strategy based on knowledge of local climates.
- Creation of the VIDAC platform to make all information and results accessible to winegrowers and the wine industry.
- Assessment of greenhouse gas emissions at vineyard plot scales.

6. Long term indicators of the project success: describe the quantifiable indicators to be used in future assessments of the project success, e.g. the conservation status of the habitats / species.

Indicators:

- Number of winegrowers' accounts created on the ClimaVista Wine platform (<https://wine.climavista.com/>);
- Number of companies that use the methodologies developed in ADVICLIM;
- Number of regions installing the fine-scale climate networks;
- Evolution of adaptation in terms of grapevine displacement, change in cultural practices, adjustment of plant material;
- Trends in the quantities of CO<sub>2</sub> emitted by winegrowers.

## 6. Comments on the financial report

### 6.1. Summary of Costs Incurred

PROJECT COSTS INCURRED			
Cost category	Budget according to the grant agreement*	Costs incurred within the project duration	% **
1. Personnel	2 116 913,00 €	2 237 144,11 €	106%
2. Travel	139 189,00 €	69 844,77 €	50%
3. External assistance	229 940,00 €	189 016,44 €	83%
4. Durables: total <u>non-depreciated</u> cost			
- <i>Infrastructure sub-tot.</i>			
- <i>Equipment sub-tot.</i>	32 914,00 €	8 409,40 €	26%
- <i>Prototypes sub-tot.</i>			
5. Consumables	20 930,00 €	11 669,51 €	56%
6. Other costs	125 900,00 €	42 248,79 €	34%
7. Overheads	186 602,00 €	176 983,31 €	95%
<b>TOTAL</b>	<b>2 852 388,00 €</b>	<b>2 735 316,33 €</b>	<b>96%</b>

\*) If the Commission has officially approved a budget modification indicate the breakdown of the revised budget. Otherwise this should be the budget in the original grant agreement.

\*\*) Calculate the percentages by budget lines: e.g. the % of the budgeted personnel costs that were actually incurred

A detailed version of the budget (provisional and actual) is attached in Annex F14.

#### **Personnel costs:**

The personnel costs budget was exceeded by 6%. This is due to several factors:

- Technical and administrative difficulties were faced throughout the project and led to delays in the implementation of actions B1 and B2, which were more time consuming than foreseen.
- With the 2<sup>nd</sup> amendment to the Grant Agreement, the project was extended by 8 months, and this required additional personnel resources (for the additional tasks and the overall running of the project). This overconsumption was anticipated in the 2<sup>nd</sup> amendment request.
- The daily rate of several team members were underestimated at the proposal stage. Therefore, even when respecting the involvement foreseen in the budget (in terms of person days), the personnel costs were higher than expected, as identified by the European Commission in the letter following the submission of the Mid-term Report. Below are explanations for the reported hourly rates which appeared to the

EC to be excessive, both in relation to budgeted rates and in relation to hourly rates for similar positions in other UK/French LIFE projects, as explained in the letter from the EC dated 30/08/2017.

**BSA:**

- Laure de Rességuier (BSA): her daily rate budgeted was 170€, which is lower than a usual engineer's salary. Her actual daily rate (347€ in 2020) is equivalent to the other engineers and researchers declared on the project (as shown in the financial statements of the other French partners UR2, CNRS, IFV, INRA PDL)
- Kees Van Leeuwen (BSA): the daily rate foreseen in the budget was also underestimated and not in line with his position of senior expert.

**IFV:**

- Joël Rochard: Mr Rochard's hourly rate is actually lower than the budgeted rate, for most years. The daily rate indicated in the budget is 560€. Over the period 2014-2018, his average actual daily rate is 540,79€. This amount is consistent with his level of expertise (senior expert).
- Régis Cailleau: his average actual daily rate for the whole project period is 456.25€, which is close to the budgeted daily rate (453€).

**Plumpton College:**

- Chris Foss, Alistair Nesbitt and Ross Morley: the high hourly rates reported at the mid-term report stage were actually due to a calculation mistake. The final declarations are coherent with the hourly rates budgeted in the grant agreement. However, the daily rate of Alistair Nesbitt is still higher than anticipated (206.48€ on average, instead of 175€ in the budget). 175€ was a low prediction for a lecturer ("expert" status).
- Matteo Marengon, Javier Urrecho: Matteo Marangon took over as Expert when Alistair Nesbitt stopped working at Plumpton, and Javier Urrecho took over from Matteo briefly when Matteo left. Their daily rates are indeed well above the rate budgeted for Alistair Nesbitt (367.45€ on average for Matteo Marengon, and 344€ for Javier Urrecho). Once again, this can be explain by their expert status. Their salary rates are similar to those of other staff in similar positions in the project.

At the consortium level, the difference between the Grant Agreement budget and the personnel costs incurred remain below the 10% flexibility margin. However, there are significant discrepancies between the beneficiaries regarding the use of the personnel costs budget. For example, BSA's budget was largely exceeded, not only because of the higher cost of person days, but also because of an increasing involvement. Indeed, BSA was in charge of centralising the analyses of the ADVICLIM pilot sites to complete the B3 deliverable added with the 2<sup>nd</sup> amendment to the grant agreement. Théo Petitjean visited the pilot sites and worked with action leaders to this end. On the other hand, some beneficiaries have used fewer staff resources than initially foreseen. For example, Plumpton College used 71% of its allocated personnel costs budget to carry out the tasks planned.

Additional remark: Mr Chris Foss from Plumpton College was initially an internal staff member of the organisation. After his retirement in June 2019, he was employed as a consultant in Plumpton College to finish his tasks on the project. His involvement as an

internal employee and then as an external expert in the year 2019 was claimed in two separate lines in Plumpton's personnel costs statement.

For more details, please see in Annex F1 a document describing the hourly rate calculation method for every staff member involved in the project.

### **Travel costs:**

Travel and subsistence costs remain at a low average (50%). The monitoring activities on the pilot sites, the dissemination activities and the project meetings were conducted but were less expensive than originally planned. For example, in USAMV's budget, the trips to monitor the pilot site were estimated at 50€ per round trip, while the actual cost was around 12€ per trip.

Also, some large expenditure items were unused, such as the 5 return trips to Argentina for Jean-Philippe Boulanger (ECS), which were budgeted at 15 000€. We were told that these expenses were not eligible since ECS Argentina is not a beneficiary, therefore the costs of these travels were not reported in the ECS' Financial statement. Similarly, the IFV had a budget of 11500€ to travel to the different pilot sites, which was eventually done during project meetings. This envelope was therefore not used.

Other travel expenses could not be claimed, for example Plumpton College did not declare the cost of attending the Pameplune meeting because Chris Foss was reimbursed by his organisation after the end date of the project.

### **External assistance costs:**

As foreseen in the grant agreement budget, most of the external assistance expenses charged to the project were used for the monitoring of the demonstration site and the dissemination or communication activities. However, the 10 000€ invoiced by the Public university of Navarra were not budgeted in the grant agreement. These costs are linked to the organisation of the ADVICLIM Final conference, which took place in Navarre on January 2020. Organising such an event (over three days with different locations) would have been complicated from distance and it was preferable to delegate this task to Public University of Navarra (UPNA), ADVICLIM external partners in Pamplona, Navarre. UPNA is a longtime collaborator of the ADVICLIM project, they implemented a pilot site in Navarre, participated in the project meetings and co-signed scientific publications. Université Rennes 2 participated in the preparation of the final conference, UPNA contacted and paid the service providers, and submitted an expenses report after the end of the event (limited to a maximum amount set beforehand).

Overall the External assistance costs consumption is below the initial forecast (83%).

### **Equipment:**

The equipment expenditure is far below the grant agreement budget for this category (26%). Costs for the installation of weather stations and data networks in the pilot sites were foreseen in the Grant agreement. However, these equipment installation costs were finally borne by ORBIWISE, the company that implemented the data transmission to the platform.

A videoconference equipment was purchased by UR2, to ensure the monthly steering committees and one-to-one meetings with members of the consortium. This purchase was also used on a weekly basis for the communication between the project coordinator Hervé Quérol and the project manager, since Hervé Quérol has been living in New-Zealand since September 2016.

### **Consumables:**

Expenditure on consumables reached 56% of the planned budget. The consumable needs for action B3 were lower than anticipated. In this case too, some of the planned expenses (data transmission system, installation of cable systems, etc.) were covered by ORBIWISE.

### **Other costs:**

Other costs expenses for actions E1, D4, D2 and C2 were less important than expected, and 34% of the budget was used.

The items were actually purchased but at a lower price. For example, USAMV had 3000€ available for flyer printing, but in reality it cost less than 50€. The creation of notice boards was also less expensive than expected (e.g. 1000€ instead of 6000€ for UGM).

Finally, as explained above, the cost related to the organisation of the final meeting were eventually moved to the *External assistance* category.

### **Overheads:**

ECS' external assistance costs have been removed from the overheads calculation. Indeed, ECS subcontracted tasks to their Argentinean component (Ecoclimasol Argentina). They explained the choice of this subcontractor in specific letters provided with the Mid-term report. However, to guarantee no profit is generated by this operation, they excluded these costs from the overheads formula.

This is why there is a slight discrepancy between the percentage of total costs (96%) and the percentage of overheads (95%).

## 6.2. Accounting system

Each beneficiary has an individual accounting system, with different methods of expenditure monitoring.

- BSA: given that the expenses incurred by BSA on the project only concern the salary of the contract worker Théo Petitjean (apart from the salary of the permanent staff who declare time on the project, Laure de Résseguier and Kees Van Leuwen), an analytical code has not been put in place.
- CNRS: Expenses are incurred, received, recorded and certified by the laboratories on GESLAB and then paid via BFC.
  - The central financial and accounting system of the CNRS is BFC (Budget Finances Comptabilité) which is a type of SAP ERP software with full analytical functionalities.
  - GESLAB is a financial management software that has been implemented to meet the needs of research unit management. Currently, all CNRS units, delegations and central services use GESLAB. It enables the stakeholders to manage on the one hand all the credits whatever their origin and on the other hand all their expenses (purchases, missions) according to internal particularities.

The GESLAB application is interfaced with the financial and accounting management of the CNRS BFC. The interface must ensure consistency between the two systems.

Contracts requiring an individualised follow-up of the expenses are followed up in analytical modeling via an OTP (Organigramme Technique de Projet) in BFC.

For the ADVICLIM contract the number 53101 has been created.

- ECS: The accounting follow-up is carried out by ECS manager Jean-Philippe Boulanger, using the excel Financial Statement file (LIFE format). No particular procedure has been set up.
- IFV: IFV has set up a cost accounting system. ADVICLIM's expenses are monitored with the software GARP. The follow-up number assigned to AVDVICLIM is 506.
- INRA Bordeaux and INRA PDL: INRA applies the rules of budgetary and accounting management of research contracts described in the document in Annex F2. The reference of the ADVICLIM contract in the accounts is 22000840.
- Plumpton College: a cost center was set up for Adviclim, all the expenses were coded to that cost centre. In Annex F3 is the transaction reports from the Adviclim cost centre from 1<sup>st</sup> August 2015. Please note that the costs of existing staff at the college (Chris Foss, Ross Morley etc) were not transferred into the Adviclim cost centre, they are shown in full within the cost centre for the department that they work in, even though some of their time was spend working on Adviclim.
- UGM: the accounting is performed through SAP software. The internal project number is 5321 5103 (Life-ADVICLIM-EU). The accounting ledger is attached in Annex F3bis.
- UR2: the university has implemented a cost accounting system. All expenses relating to the LIFE-ADVICLIM contract are tracked under code 14SU-EA02. The files provided in Annex F4 and Annex F4bis trace all the operations of the financial center R930EA to which the ADVICLIM expenses are charged.
- USAMV: the Adviclim expenses are registered in a separate cost center in USAMV's accounting system. Please fin the project ledger in annex F5.

On a three monthly basis, associated beneficiaries send their updated financial statement to the coordinating beneficiary, with the documentation supporting the expenses (invoices and timesheets). The project manager then reviews the financial reports, verifying the following:

- The financial tables are completed correctly (the cost items are claimed in the appropriate cost categories, there is no missing information or blank cells, the correct exchange rate is used, etc)
- The costs claimed are clearly linked to the ADVICLIM activities
- The supporting documents bear the mention “LIFE13 ENV/FR/001512” (stamped on the invoices)
- The amounts declared in the Financial statement are consistent with the supporting documents provided

The time spent on the project is recorded using monthly timesheets showing the daily hours dedicated to ADVICLIM and to the other activities of the staff members. Most of the beneficiaries use the Model LIFE timesheets as presented in the “Standard statement of expenditure” document. CNRS and INRA PDL use their own time registration systems, which also provide the level of information requested in the LIFE Guidelines. The timesheets are signed every month by the staff member and their manager.

Specific issues regarding financial and administrative matters raised by the EC throughout the project are answered in Annex F0.

#### 6.4. Auditor's report/declaration

Please refer to the audit report available in Annex F15.



## 6.5 Summary of costs per action

Action no.	Port name of action	1. Personnel	2. Travel and subsistence	3. External assistance	4.b Equipment	6. Consumables	7. Other costs	TOTAL
A1	Observation and spatial conceptualisation at vineyard scale	126 031 €		10 000	0	0	0	136 031 €
B1	Adaptation of cultural practices to climate change	212 559 €		0	0	0	0	212 559 €
B2	Cultural practices GES mitigation according to climate change scenarios	301 562 €		2 150	0	0	0	303 712 €
B3	Demonstration on European pilot sites	551 917 €	14 158,2	114 754,9	25 12,33	11 669,21	4 142,64	699 154 €
B4	Information transfer to viticultural sector	413 828 €		12 798	0		0	426 626 €
C1	Territorial analysis of adaptation to climate change and mitigation of GIS emission measures impact	58 379 €		0	0	0	0	58 379 €
C2	Socio-economic and financial assessment	45 863 €		0	0	0	0	45 863 €
D1	Project website	36 492 €		6 695,6	0	0	300	43 487 €
D2	Communication and dissemination activities	164 709 €	8 052,38	9 718,38	0	0	14 733,93	197 214 €
D3	Layman's report	9 065,53		0	0	0		9 066 €
D4	Notice Boards	11 693 €		0	0	0	5 000	16 693 €
E1	Project management	253 991 €	47 634,19	25 000	58 97,07	0	18 072,22	350 594 €
E2	Final Audit			7 900	0			7 900 €
E3	After-life communication plan (without associated costs)			0	0	0		0 €
E4	Networking with other European projects	37 749 €		0	0	0	0	37 749 €
E5	Monitoring of project progress	13 305 €		0	0	0		13 305 €
	Overheads	156 600 €	4 889 €	11 131 €	589 €	817 €	2 957 €	176 983 €
	Total	2 393 744 €	74 734 €	200 148 €	20 129 €	21 484 €	57 692 €	2 735 316 €

Overall, the distribution of costs per share is in line with the table set out in the grant agreement (form R2). Regarding the cost category breakdown, more personnel costs than expected were spent on actions B1, B2 and B3. As explained above, technical obstacles (problem with the integration of climate change scenarios into the model) required additional developments and test periods, which explains the overspent on the personnel cost budget on these actions

## 7. Annexes

### 7.1 Administrative and financial annexes

The administrative and financial annexes are gathered in the attached folder *Finacial annexes*.

- Annex F0. Responses to issues raised in EC letters.pdf
- Annex F1. Personnel costs calculation.pdf
- Annex F10. Master thesis A Henry - Vulnerabilite et adaptabilite des viticulteurs au changement climatique.pdf
- Annex F11. Letter.of.assignment\_F.Gautier.pdf
- Annex F12. ECS\_Subcontract.ECS.Argentina.zip
- Annex F13. Co-financing CIVB.zip
- Annex F14. Consortium final expenditure.xlsx
- Annex F2. Note\_Technique\_09-2008.pdf
- Annex F3. Adviclim cost centre transactions.xlsx
- Annex F3bis. UGM\_SAP\_53215103.pdf
- Annex F4. 14RSU-EA02 Bilan financier 2014-2016.xlsx
- Annex F4bis. 14RSU-EA02 Bilan financier 2017-2020.xlsx
- Annex F5. USAMV Project analytical ledger 2018\_2019\_2020(1).PDF
- Annex F6. Plumpton Certificate for exempt education supplies.pdf
- Annex F7. ECS ledger file.pdf
- Annex F8. USAMV - Personnel costs explanations.zip
- Annex F9. Personnel costs supporting documentation.zip
- Annex F15. Rapport d'audit externe.pdf
- Annex F15bis. Translation of the audit report.pdf

### 7.2 Technical annexes

#### 7.2.1 List of keywords and abbreviations used:

- **AB** : Advisory Board
- **BSA** : Bordeaux Sciences Agro
- **CNRS** : National Centre for Scientific Research
- **IFVV** : Institut Français de la Vigne et du Vin

- **INRA** : National Institute for Agricultural Research
- **SC** : Steering Committee
- **UR2** : University Rennes 2
- **UGM** : Gesenheim University
- **USAMV** : Université des sciences agricoles et de la médecine vétérinaire *Ion Ionescu de la Brad*

### 7.2.2 Deliverables

The deliverable listed below are available in annex, in the folder *Technical annexes > Deliverables*

- **A1:** *Observation and spatial conceptualisation at vineyard scale: Maps of climate change modelling for each pilot site.*
- **B1:** *Adapting viticulture to climate change: Guidance manual to support winegrowers' decision-making.*
- **B1:** *Adaptation of cultural practices to climate change: Results synthesis*
- **B2:** Greenhouse gases emissions assessment of viticulture technical itineraries: method and results
- **B3:** Technical report for each pilot site (x 5)
- **B3-B4:** Story map report
- **B4:** Information transfer to the viticultural sector
- **C1:** Environmental assessment of the project
- **C2:** A socio-economic assessment of the effects of climate change and the recommendations resulting from the LIFE-ADVICLIM Project
- **D2:** Guidelines for professionals
- **D2:** Dissemination report
- **D3:** Layman report
- **E3:** After Life communication plan
- **E5:** Final evaluation report

### 7.2.3 Technical Action annexes

- Annex T1. B2 - Rapport méthodologique.pdf
- Annex T2. B2 - Cahier des charges - Développement plateforme web.pdf
- Annex T3 - leaflets for each pilot site.zip

### 7.3. Dissemination annexes

Please find below the list of annexes related to the dissemination activities, available in the folder *Dissemination annexes*:

- Annex D1. Life\_ADVICLIM\_D\_GRAPHIC GUIDELINES\_2015-10-01.pdf
- Annex D2. ADVICLIM\_D2\_Vvalorisation plan\_v20150716.pdf
- Annex D2bis. Life\_ADVICLIM\_D\_Dissemination Plan\_2\_2016\_07\_06.pdf

- Annex D3. Life\_ADVICLIM\_Communication & moderation rules.pdf
- Annex D4. LIFE\_ADVICLIM\_presentation leaflet English.pdf
- Annex D4. LIFE\_ADVICLIM\_presentation leaflet French.pdf
- Annex D4. LIFE\_ADVICLIM\_Presentation leaflet\_German.pdf
- Annex D5.\_Life\_ADVICLIM\_D\_Poster\_IFV\_vecto\_fr.pdf

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## 8. Financial report and annexes

- "Standard Payment Request and Beneficiary's Certificate" – signed by the legal representative of the coordinating beneficiary (Olivier David – President of University Rennes 2)
  - Path to the document: *Financial statements > Signed > 1. Standard payment request.pdf*
- "Consolidated Cost Statement for the Project" - signed by the legal representative of the coordinating beneficiary
  - Path to the document: *Financial statements > Signed > 2. Consolidated cost statement for the project.pdf*
- "Financial Statement of the Individual Beneficiary" completed for each project beneficiary (available in excel format and in pdf format for the signed versions)
  - Excel format: folder *Financial statements*
  - Signed versions: folder *Financial statements > Signed*
- Supporting documents, and further information or clarifications, requested in previous letters from the Commission (e.g. in the letter announcing mid-term pre-financing payment, in the feed-back letter following project visits, etc.), and not already submitted.
  - Please refer to the document *Annex F0. Responses to issues raised in EC letters* (folder *Financial annexes*)
- Auditor's report using the standard reporting format
  - The auditor's report is attached in Annex F15 (folder *Financial annexes*), with the English translation in Annex F15bis