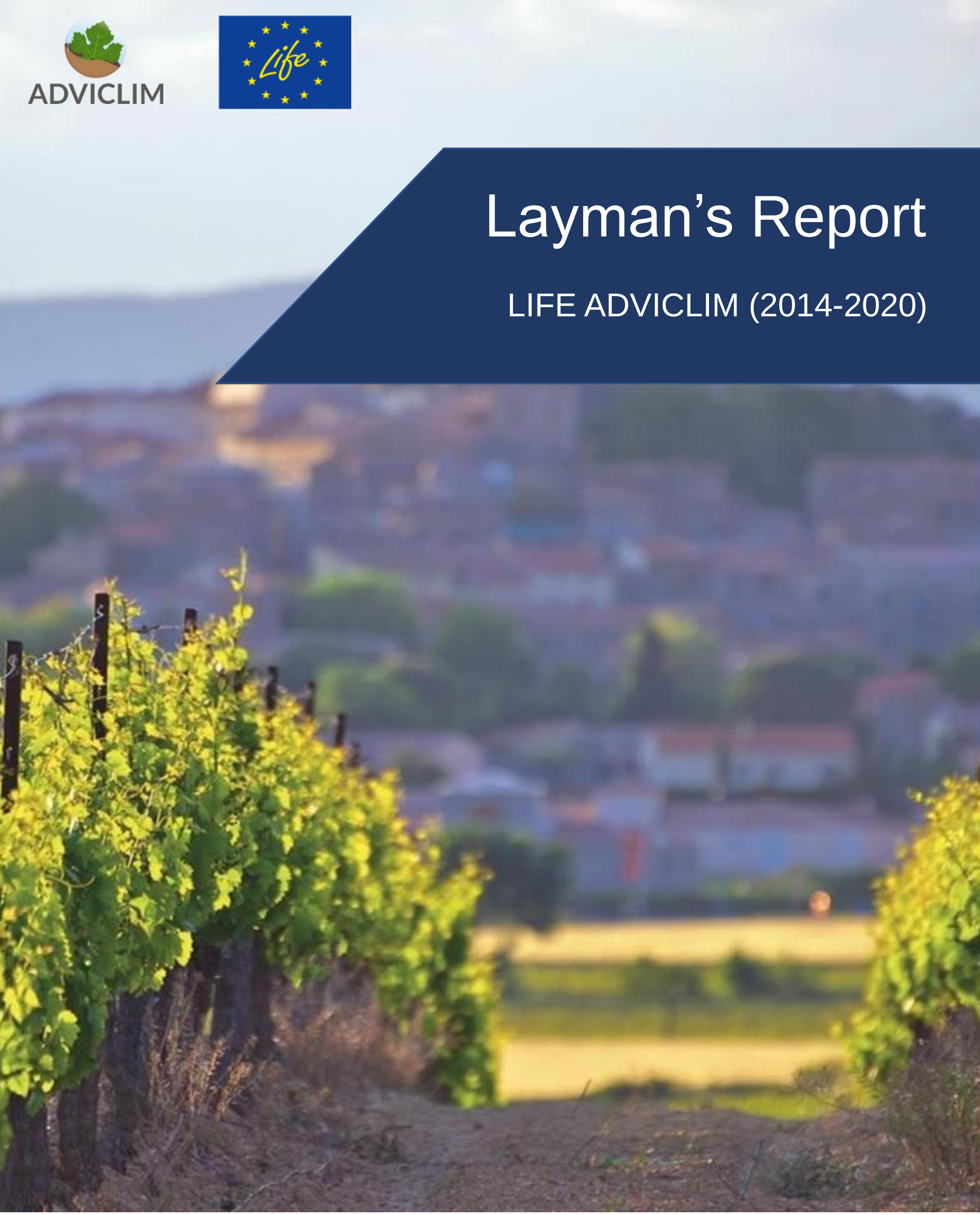


Layman's Report

LIFE ADVICLIM (2014-2020)

Basic project information

Project Name: LIFE ADVICLIM, LIFE13 ENV/FR/001512

ADaptation of Viticulture to Climate change : High resolution observations of adaptation scenarii for viticulture

Duration: July 2014 – June 2020

Coordinating Beneficiary:

- University of Rennes2, France

Associated Beneficiaries:

- CNRS, France
- Institut Français de la Vigne et du Vin, France
- INRA, France
- Bordeaux Sciences Agro, France
- Plumpton College, United Kingdom
- Hochschule Geisenheim University, Germany
- University of Agricultural Sciences and Veterinary Medicine Iasi, Romania
- ECOCLIMASOL, France
- Public University of Navarre, Spain

Project Budget: €2,852,388

EU financial contribution: €1,426,193 (50%) co-financed by the EU LIFE+ Funding Programme

Partners' contribution: €1,426,193 (50%)

The LIFE programme is the EU's funding instrument for the environment and climate action. The general objective of LIFE is to contribute to the implementation, updating and development of EU environmental and climate policy and legislation by co-financing projects with European added value.

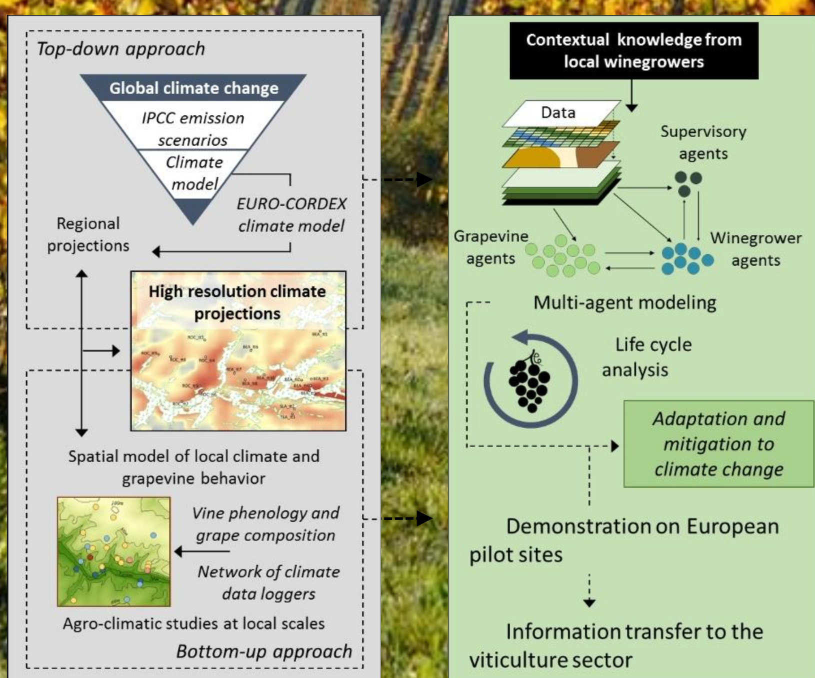
Partners participating in the project

University of Rennes2, France	https://www.univ-rennes2.fr/
CNRS, France UMR6554 LETG	https://letg.cnrs.fr/
INRAE, France UMR1287 EGFV	https://www.isvv.u-bordeaux.fr/en/egfv.html
BSA, France	https://www.agro-bordeaux.fr/
IFV, France	https://www.vignevin.com/
HGU, Germany Department of Viticulture	https://www.hs-geisenheim.de/en/
Plumpton College, United Kingdom Department of Wine	https://www.plumpton.ac.uk/
USAMV, Romania Faculty of Horticulture	http://www.uaiasi.ro/horticultura/
ECOCLIMASOL, France	https://www.ecoclimasol.com/en/
UPNA, Spain Department of Agricultural Production	http://www.unavarra.es/departamento-agronomia-biotecnologia-alimentacion

Background of the LIFE ADVICLIM project

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 winegrowing regions by 2100. These studies, based specifically on climate simulation, propose fairly radical methods to adapt to climate change, such as the relocation of wine-growing regions. Existing studies on the impact of climate change cover large wine-growing regions, without taking into account the spatial variability of climate at 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 winemakers manage their estate and adapt to the climate at the plot scale, notably by agricultural practices (tillage, work on the vine, etc.). The spatial variability of climate (mainly temperature et bioclimatic indices based on sum of degree days) at local scale should therefore be taken into account when defining a rational climate change adaptation policy.

In the LIFE-ADVICLIM programme, 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 the development of 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 aims 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 to oceanic to continental climates.



- **Agroclimatic measurements at vineyard scale**
- **Spatial modelling of temperature, vine development and grape composition**
- **Climate change projections (2050 and 2100) at vineyard scale under different scenarios (RCP4.5 and RCP8.5)**
- **Definition of adaptation scenarios with assessment of carbon footprints**
- **Information transfer to winegrowers (e.g. stakeholders, workshop, web platform, ...)**

PILOT SITES

Pomerol/Saint Emilion (France)

The Saint-Emilion, Pomerol and their satellites appellations are located in the north eastern part of the Bordeaux area, on the right bank of the Dordogne, close to the city of Libourne. This area principally produces red wine, including some of Bordeaux' most prestigious estates, such as château Cheval-Blanc, Pétrus and château Ausone. The main varieties grown in the Saint-Emilion and Pomerol area are Merlot (70%), Cabernet franc (25%) and Cabernet-Sauvignon (5%).

Loire Valley (France)

The wine producing areas of the AOP-Coteaux du Layon and AOP-Saumur Champigny are located in the Loire Valley region. These two areas, producing respectively dry or sweet white wines and red or rosé wines, are representative of the contrasting landscape and geo-pedological features of the Loire Valley. The grappe varieties allowed by the Appellation regulations are Chenin in the Coteaux du Layon area and Cabernet Franc, with a permitted addition of up to 15 % of Cabernet Sauvignon or Pineau d'Aunis in Saumur Champigny area.

Sussex (United Kingdom)

Rock Lodge Vineyard was established over 50 years ago, and is located in the Southeast of England in the county of Sussex. Rock Lodge vineyard has a total area of 7.3 ha. The vineyard is very representative of cool climate viticulture, hosting a range of grape varieties for the production of sparkling, white, rosé and red wines like Pinot noir, Chardonnay, Pinot Meunier, and Bacchus.

PILOT SITES

Rheingau (Germany)

The Rheingau wine-growing region is located at the 50th degree latitude north and is famous for their well-known Riesling wines. Due to the gradient within such steep slope vineyards as well as management practices meso-climate varies and impacts on wine quality. The Riesling is with 78 % of the growing area the most important grapevine variety, followed by Pinot Noir (12 %), Pinot Blanc (1.6 %) and Müller-Thurgau (1 %).

Cotnari (Romania)

The Cotnari wine-growing region represents the viticulture of the temperate continental climate zone. This vineyard is located in the north-eastern part of Romania and produces white wines. The fame of the Cotnari wine growing region was given by the sweet wines of the local variety Grasa de Cotnari.

The main varieties grown in the Cotnari area are Grasa de Cotnari (approximately 25%), Feteasca albă (approximately 25%), Frâncușă (approximately 25%) and Tămâioasă românească (approximately 15%).

La Rioja (Spain)

The Rioja wine-growing region represents the viticulture of the Mediterrenean climate. The vineyard is located in Ausejo in the Rioja Baja sub-zone at an altitude of 450m. The “Finca los Almendros” vineyard has a total area of 300 ha. The topography of the site and the diversity of soil types results in a complexity of terroirs, which allows to produce a range of styles of wines. Most of the acreage is planted with red varieties, with Tempranillo and Grenache being the most cultivated.

From Agroclimatic Observation to Modelisation at the Vineyard Scale

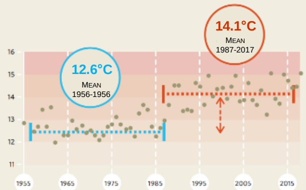
In order to characterize temperature variability over each pilot site and the link with vine development and grape composition, networks of temperature sensors, phenological observation plots and plots for monitoring maturity, were set up. Using this measurement and observation network, the study of the link between climate at a local scale and grapevine development becomes possible. The spatial distribution of temperature was analyzed, 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.

This experimental approach made enabled:

- to analyse the spatial variability of temperature during the vine's growing season
- to create maps of temperatures and agroclimatic indices through spatial modeling
- to assess the impact of temperature on vine development and grape composition at ripeness by means of a phenological model
- to create maps of the occurrence of phenological stages

Temperature trends in Bordeaux (1956-2017)

Mean annual temperature increased by 1.5°C from 1956-1986 to 1987-2017



The Bordeaux wine-growing climate has moved from "temperate" to "warm temperate" according to Huglin's classification.

	Huglin Index (Degree. Day)	Climate classification
1956 1986	1814	Temperate
1987 2017	2125	Temperate Warm

+ 311°C.Days

Huglin Index : $\Sigma\,[((Tm-10)+(Tx-10))/2]*k$ - from 1st April to 30th September
Tm = Mean daily temperature   *Tx = Maximum daily temperature*
k = Coefficient of day length
***Objective**: Compare wine climates*
(Huglin index Classification detailed on the next page)

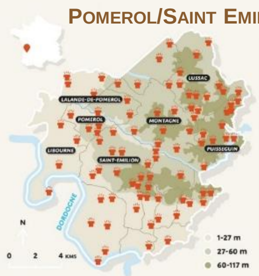
Temperature trends in each pilot site (1956-2017)

Mean annual temperature increased by 0.7°C to 1.5°C from 1956-1986 to 1987-2017

	Bordeaux	Loire Valley	Cotnari	Rheingau	Sussex	Rioja	
Mean annual temperature	+1.5°C	+1.1°C	+1.5°C	+0.7°C	+1°C	+0.8°C	+1.1°C
Huglin Index (Degree. Day)	+311°C.D	+277°C.D	+236°C.D	+157°C.D	+188°C.D	+270°C.D	+240°C.D

Huglin Index increased by 157°C.Days to 311°C.Days from 1956-1986 to 1987-2017

Location of temperature sensors in Pomerol/Saint Emilion pilot site

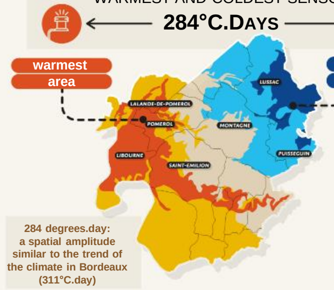


90 temperature sensors installed in Merlot plots

Spatial variability of the Huglin index (average 2012-2018)

Difference between the warmest and coldest sensor

284°C.Days



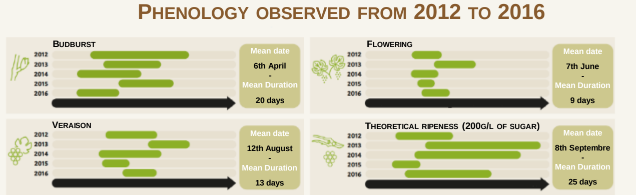
284 degrees.day: a spatial amplitude similar to the trend of the climate in Bordeaux (311°C.day)

The south-facing slopes of Saint-Emilion and the region of Libourne and Pomerol have the strongest Huglin index. The northeast of the study site is the area with the lowest index values.

Local factors (e.g. slope, exposure, type of soil, distance from the sea, etc.) cause climate variations that can be greater than climate variability on a larger scale or the increase in temperature over several decades.

Precise knowledge of temperature distribution at high spatial resolution allows growers to optimize viticultural practices and selection of plant material according to the local conditions. This issue becomes even more strategic in a context of global warming, where growers need to adapt to spatial temperature variability and evolution over time*.

Phenology observed from 2012 to 2016



High amplitude for bud-break and theoretical maturity in relation to the interannual variability of temperatures at the pilot site. Strong vintage effect with warm years like 2015 which have more advanced phenological stages than a cooler year like 2013.

* Rességuier L., Mary S., Le Roux R., Petitjean T., Quénol H. and van Leeuwen C., 2020: Temperature variability at local scale in the Bordeaux area. Relations with environmental factors and impact on vine phenology. *Frontiers Plant Science*, 11, 515.

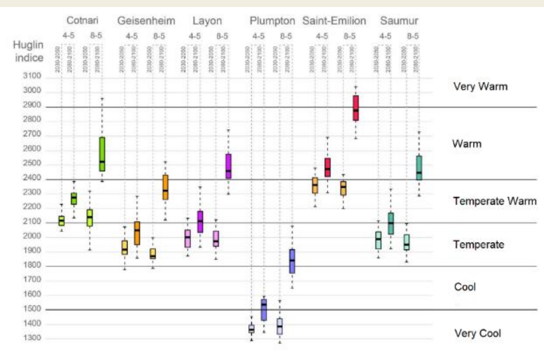
Modelling of climate change effects at the vineyard scale

To integrate the local temperature variability at vineyard scale, daily fine scale temperature maps were produced using a downscaling method. Then bioclimatic indices (e.g. Huglin and Winkler indices) and phenologic models (e.g. Grapevine Flowering Veraison) were mapped at the vineyard scale with RCP 4.5 (optimistic) et 8.5 (pessimistic) scenarios for the period 1986-2005, and future periods (2031-2050 and 2081-2100).

Modelling of bioclimatic indices demonstrated, in accordance with the regional scale approach, an increase in the growing degree-days over the investigated period. The integration of local scale in climate change projections gave more details and highlighted a great temperature range within each studied site.

Combined with regional climate scenarios, analyzing the spatial variability of local climate (bioclimatic index and phenologic modelling) makes it possible to refine the models' spatial resolution and to propose rational adaptation methods at the vineyard scale rather than at the level of major wine regions.

Future Huglin index in each Adviclim pilot site



Huglin index classes

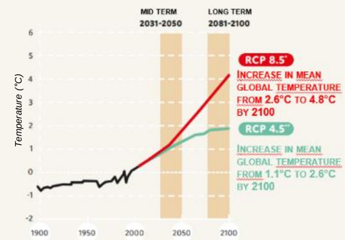
Climate class	Values (°C.Day)
Very cool	≤ 1500
Cool	1500 - 1800
Temperate	1800 - 2100
Temperate Warm	2100 - 2400
Warm	2400 - 2900
Very Warm	> 2900

The Huglin Index refers to the concept of growing degree-days, which is calculated as the sum of daily mean and maximum temperature above 10°C from April to September in the Northern Hemisphere. The base temperature of 10°C refers to the minimum temperature necessary for grapevine physiological activity. The interest in using the Huglin Index is that the cumulated heat is strongly correlated with grapevine phenology and is strongly correlated with berry composition at harvest (Huglin, 1978).

Huglin index modelling shows a spatial and temporal evolution of different climate classes. All the sites will move upwards into warmer climatic classes or to the upper level of their present class. By 2100, the increase in degree-days compared to the current period will be amplified and should reach between 500 and 1000 units depending on the site. As a result, according to the RCP8.5 scenario, all ADVICLIM wine regions will probably reach the "warm" and "very warm" classes; except "Sussex", the northernmost pilot site, which will probably reach the "temperate" climate class (comparable to the current climate of Bordeaux).

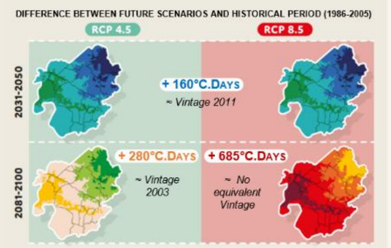
Future Huglin index Variability at local scale in Pomerol/saint Emilion pilot site

Evolution of the mean temperature on the surface of the earth



Change in global annual mean temperature relative to the period 1986-2005
*RCP 8.5 = Continued increase in greenhouse gas emissions by 2100
**RCP 4.5 = Stabilization of greenhouse gas emissions by 2040, then strong decrease from 2060 to 2100
Source: IPCC, 2013

Climate Change Projection (Huglin index)



The warmest and coolest areas remain the same as in the historical period (1986-2005)

From climate change scenarios (EURO-CORDEX), temperatures were extracted at the study site with 10km resolution. A downscaling was then applied using a geostatistical model in order to adapt the climate change projections to the scale of the pilot site.

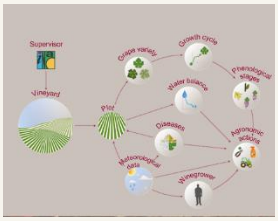
The spatial variability of climate within the pilot sites is similar to, if not higher than the rise in temperature (sums of degree/day) between the current period and future periods (2050 and 2100). Considering the mid term, i.e. by 2050, the trend in the Huglin index is similar whatever the scenario (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 units depending on the region compared to the reference period (1986-2005) while there is an increase of 100 to 300 units 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. By2081-2100, the Huglin index sharp increase i.e. between 300 and 500 units and between 600 and 1000 units for RCP4.5 and RCP8.5 respectively, would lead to a spectacular shift by 2 or 3 climate classes in all pilot sites.

The integration of local climate variability 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. The 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.

Adaptation of cultural practices to climate change

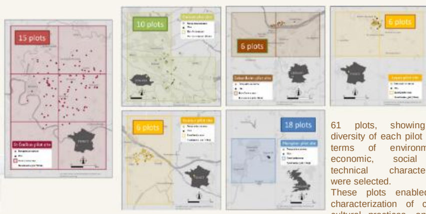
In order to define an adaptation strategy at the plot scale, the SEVE model - *Simulating Environmental impacts on Viticultural Ecosystems*” - was developed to assess the effect of climate change, and associated increased climate variability, on grapevine growth and on vineyard management practices. The objective of this model is to define climate change adaptation scenarios, based on climatic spatial variability and vinegrowing practices. The SEVE model was applied to several plots representative of different types of viticulture (e.g. conventional, integrated, organic, ...) in each pilot site. By integrating local environmental and related conditions (vine phenology, water balance and water stress, business structure, end-product objectives, etc.) the SEVE model provides spatial and temporal information about numerous control parameters (phenology, agronomic actions, adaptation tools, water balance, etc.).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).

The Multi-agent model SEVE



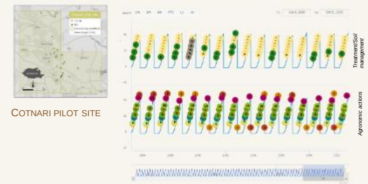
The SEVE model present a generic modeling environment for simulating grapevine growth and berry ripening under different conditions and constraints (slope, aspect, soil type, climate variability...) as well as production strategies and adaptation rules according to climate change scenarios. Each activity is represented by an autonomous agent able to react and adapt its reaction to the variability of environmental constraints. Agents are distinguished according to their objectives: "Supervisors" Agent plays an overseeing role in the model, "Winegrower" Agents aim to grow grapes and produce wine that meets precise specifications according to their end-product goals and "Vine" Agents are grape production entities. The relationships between these three types of agents determine the production strategies adopted by the winegrowers.

Experimental plots in each pilot site



61 plots, showing the diversity of each pilot site in terms of environmental, economic, social and technical characteristics, were selected. These plots enabled the characterization of current cultural practices, and the modelling of their evolution according to different climate change scenarios.

Modeling agronomic action at plot scale



Cotnari pilot site

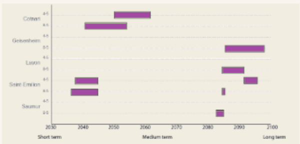
SEVE model reproduce the dynamics of vine growing and agronomic choices and practices according to climate spatial variability. The agronomic itineraries are determined for each vineyard plot according to the climatic profile of the year (current and future) and the winegrower's production strategies.

- based on grapevine management methods
- depending on the business structure
- depending on the sensitivity of vine growers to climate change

Adaptation strategies: Vine variety change

		4.5		8.5	
	name	date of replacement	New grape variety	date of replacement	New grape variety
2030-2050	Plot 1	2040	Cabernet franc	2039	Cabernet-Sauvignon
	Plot 15	2044	Cabernet franc	2044	Cabernet franc
	Plot 55	2044	Cabernet franc	2044	Cabernet franc
	Plot 552	2044	Cabernet franc	2044	Cabernet franc
	Plot 78	2039	Cabernet franc	2041	Cabernet-Sauvignon
	Plot 90	2044	Cabernet franc	2044	Cabernet franc
	Plot 83	2039	Cabernet franc	2040	Cabernet-Sauvignon
	Plot 9	2039	Cabernet franc	2040	Cabernet-Sauvignon
	Plot 242	2039	Cabernet franc	2040	Cabernet-Sauvignon
	Plot 232	2039	Cabernet franc	2040	Cabernet-Sauvignon
	Plot 70	2037	Cabernet franc	2036	Cabernet-Sauvignon
	Plot 14	2037	Cabernet franc	2035	Cabernet franc
	Plot 102	2044	Cabernet franc	2044	Cabernet franc
	Plot 32	2044	Cabernet franc	2044	Cabernet franc
	Plot 106	2044	Cabernet franc	2044	Cabernet franc
	name	date of replacement	New grape variety	date of replacement	New grape variety
2080-2100	Plot 1	2092	Petit verdot	2084	Carmenère
	Plot 15	2093	Cabernet-Sauvignon	2084	Carmenère
	Plot 55	2093	Cabernet-Sauvignon	2084	Carmenère
	Plot 552	2093	Cabernet-Sauvignon	2084	Carmenère
	Plot 78	2096	Petit verdot	2084	Carmenère
	Plot 90	2093	Cabernet-Sauvignon	2084	Carmenère
	Plot 83	2096	Petit verdot	2084	Carmenère
	Plot 9	2096	Petit verdot	2084	Carmenère
	Plot 242	2096	Petit verdot	2084	Carmenère
	Plot 232	2096	Petit verdot	2084	Carmenère
	Plot 70	2090	Petit verdot	2084	Carmenère
	Plot 14	2090	Petit verdot	2084	Carmenère
	Plot 102	2093	Cabernet-Sauvignon	2084	Carmenère
	Plot 32	2096	Cabernet-Sauvignon	2084	Carmenère
	Plot 106	2096	Cabernet-Sauvignon	2084	Carmenère

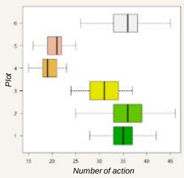
Pomerol/Saint Emilion pilot site



ADVICLIM pilot sites

- Adaptation strategies must consider the changing of grapevine variety from 2031-2050 (for Pomerol/Saint Emilion, Cotnari and Plumpton) and from 2081-2100 for all pilot sites. In Cotnari and Plumpton, this change provides new opportunities such as the switch to quality red wine production;
- At the plot scale, taking into account local climate variability allows a reasoned strategy for changing vine varieties to be implemented. The winegrower will spread out the planting of new grape varieties over time;
- Need to define adaptation strategies by changing the variety of grape varieties according to the types of viticulture and wine. The ability to adapt is more important for blended wines (e.g. Pomerol/Saint Emilion) than for single grape variety wines (e.g. Riesling in Rheingau or Chenin in the Coteaux du Layon).

Adaptation strategies: Agronomic action



Coteau du Layon pilot site (2080-2100)

period	gid	name	production_profile	agronomic action min	agronomic action mean	agronomic action max	fungicide treatment min	fungicide treatment mean	fungicide treatment max	soil management min	soil management mean	soil management max
2030-2050	1	0005	organic	25	35	46	15	22	29	1	2	6
	1	0005	organic	28	36	42	15	23	27	1	2	4
	2	0335	organic	25	35	46	14	22	29	1	3	6
	2	0335	organic	31	37	44	16	23	27	1	3	5
	3	0566	organic	24	30	37	12	17	23	1	2	4
	3	0566	organic	27	32	37	13	18	23	1	3	5
	4	1007	integrated	15	19	22	5	7	9	1	2	5
	4	1007	integrated	16	20	23	5	7	9	1	3	4
	5	0119	conventional	16	20	25	5	7	10	1	3	5
	5	0119	conventional	18	22	25	6	8	9	1	3	5
	6	0219	organic	26	35	45	14	22	29	1	2	5
	6	0219	organic	26	36	42	14	23	28	1	2	4
2080-2100	1	0005	organic	25	35	41	15	22	29	1	3	5
	1	0005	organic	29	36	43	15	21	29	3	4	5
	2	0335	organic	28	35	43	16	22	29	1	3	7
	2	0335	organic	29	36	43	13	21	30	2	4	7
	3	0566	organic	24	30	36	12	17	23	1	2	6
	3	0566	organic	25	32	36	13	17	22	2	4	5
	4	1007	integrated	16	19	22	5	6	9	1	2	4
	4	1007	integrated	18	21	24	5	7	9	2	4	5
	5	0119	conventional	17	21	24	5	7	10	1	3	5
	5	0119	conventional	18	22	25	5	7	9	3	4	5
	6	0219	organic	28	35	43	16	22	30	1	3	5
	6	0219	organic	28	36	42	13	21	30	2	4	6

- Very few changes in agronomic actions during the first period (2031-2050) for all pilot site;
- Varying changes according to pilot sites and types of viticulture during the second period (2081-2100): In Pomerol/Saint Emilion and Sussex, there will be a need for an increase in the number of phytosanitary treatments for 80% of the representative plots (e.g. more important for organic plots in Pomerol/Saint Emilion). Very few changes for Cotnari and Loire Valley areas (except a little decrease in fungicide treatments and especially on organic plots in Loire Valley) and for Rheingau. The increase in phytosanitary treatments reflected a potential future increase in disease pressure. This trend is due to the increase in temperature and precipitation resulting from the output of regionalized climate models (Cordex);
- The water deficit values generated by the WALIS model do not reach a level which justifies the implementation of irrigation. But, in Rheingau, the results showed that steep slope part in the west of the area is susceptible for the occurrence of drought stress.

According to RCP4.5 and RCP8.5, several prospective simulation have been implemented to compare adaptation strategies on a European scale. Through different experiments in ADVICLIM pilot site, SEVE model provided potential adaptation strategies tendencies from short-term to long-term adjustment. Simulation results underline that small scale variability is strongly linked with vine phenology stages and ripeness potential. Over the next century, winegrowers will likely be confronted by increasing temperatures and changing rainfall patterns that will have important impacts on agronomic practices (increase/decrease of fungicide treatments or soil management practices depending on site and scenario) and adaptation strategies (management of frost risk or heat waves, plant material adaptation, change in vine training system…).

Tools developed to adapt and contribute to mitigation

Adapting plant material

Adapting rootstocks and grape varieties to climate change scenarios using the temperature zoning maps produced in this study.

Changing viticultural practices

Adapt management systems according to the earliness of the vineyard plots: leaf thinning, leaf/fruit ratio, grapevine trunk height, soil maintenance, pruning date, etc.

Anticipating extreme weather events

Use the minimum temperature maps of frost events produced in this project to improve the location of protection systems.

Use the maps of extreme maximum temperatures (>35°C) to set up adapted practices on the areas most sensitive to heat waves.

Reducing Greenhouse Emissions

Adapt the power of the machines and the number of passes through the plot of land.

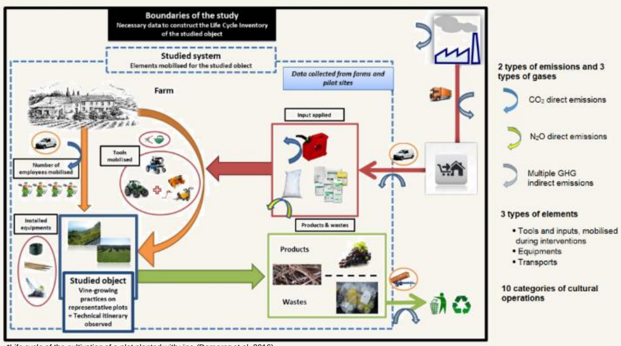
Adaptation can't go without mitigation

Adaptation can mean new actions, new equipments, new tools. But what are the consequences of those changes on the carbon footprint ? How to minimise the impact of the wine sector on climate change ? Viticulture is not the stage of wine production with the highest carbon footprint. Bottling and transport cause more carbon emissions than vineyard work.

It was essential to ensure that the climate change adaptation scenarios presented in AVDICLIM do not generate more emissions responsible for climate change than the current situation.

- Identify the main processes responsible for greenhouse gases (GHG) emissions today;
- Identify the proportion of indirect emissions against the proportion of direct emissions from the plot;
- Compare GHG emissions of observed practices against the practices modelled in scenarios with SEVE model.

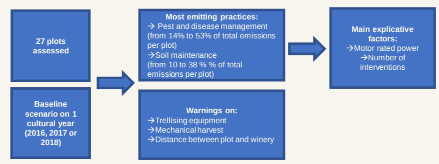
A diagnosis tool of greenhouse gases emissions



*Life cycle of the cultivation of a plot planted with vine (Demarez et al, 2016)

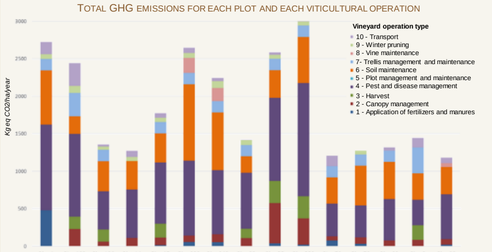
The carbon footprint is an environmental assessment method based on life cycle approach, accounting for Green House Gases (GHG) emissions from cradle to grave. It is first a diagnosis tool, useful for analyzing the hotspots of an activity in terms of GHG emissions. The originality was to get deep inside 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).

A prospective tool to make adaptation consistent

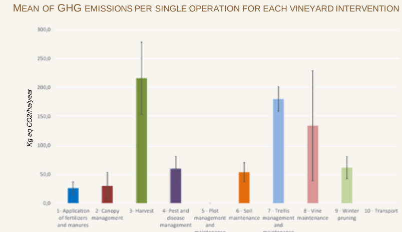


The aim is to make sure that adaptation actions to climate change don't generate more emissions responsible of climate change than the current practices. Some of adaptation actions are likely not to have impact on GHG emissions (vine variety changes, early pruning for frost risk, canopy management practices for heat waves,...) as it does not implies 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.

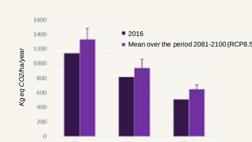
Total GHG emissions for each plot and each viticultural operation



Mean of GHG emissions per single operation for each vineyard intervention



Adaptation scenarios assessment integrating pest and disease management actions changes



Pomerol/Saint Emilion pilot site

High variability in GHG emissions between every plots. 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.

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.

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,...)

Most emitting practices

Disease management : Between **20** and **40%** of total emissions per plot

Soil maintenance : Between **14** and **34%** of total emissions per plot

Main emission factors

Motor power

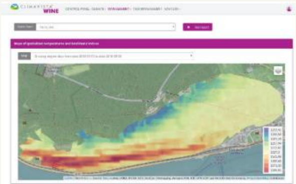
Number of interventions

INFORMATION TRANSFER TO THE WINE SECTOR

The major purpose of LIFE-ADVICLIM is to be useful to the professionals of the wine sector, ensuring that the results of research and development work are applicable, meet the demands of the wine industry and reach the winegrowers. 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*). The VIDAC platform aims at providing to the project researchers and stakeholders a large set of project data. These data are helpful for research as well as for responding to the needs of the actors (winemakers, public organizations, political ...) in order to easily release information to the viticultural sector and raise their awareness of climate change. A Story Map (interactive mapping tool) was also built in order to illustrate all phases of the project. The Story Map is an. This pedagogical tool has been used during meetings with winegrowers and stakeholders.

THE VIDAC PLATFORM

VISUALIZATION OF THE DAILY TEMPERATURE



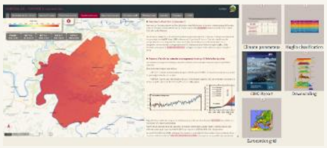
MAP OF THE GROWING DEGREE DAYS INDEX IN 2016 OVER RHEINGAU PILOT SITE

The VIDAC platform has a user-friendly interface allowing to visualize the collected field data and information relevant to ongoing decision making. Future climate scenarios at plot scale and carbon footprint calculations are included to promote awareness of climate change issues. Winegrowers can access the data corresponding to their plot (e.g. hourly temperatures recorded by sensors, phenological stage, …) and the results through a web-based data-archiving center and visualization platform.

- Access for the wine growers participating to the project: 95 in Pomerol/Saint Emilion; 3 in Cotnari, 15 in Loire Valley and 1 in Sussex;
- Visualization and download of temperature data (sensors) and other data from public weather stations;
- The sensor networks of the two French pilot sites of ADVICLIM are connected to an automatic data recovery system on the VIDAC platform;
- Visualization and download of climate and phenological data modelling (current and future period);
- Displaying the result of "adaptation strategies" and "carbon footprint assessment" at plot scale.

AUTOMATIC DATA RECOVERY IN COTEAU DU LAYON PILOT SITE

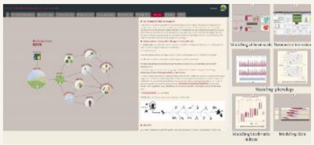
STORY MAP



FUTURE TEMPERATURE MODELING AT LOCAL SCALE

The implementation of a story map during the ADVICLIM project aimed to describe the main objectives of the project and to facilitate the communication of the results produced by the different actions. A story map is a dynamic tool that allows end users to explore a subject through various communication tools (images, videos, interactive maps, data, figures, and text). The ADVICLIM Story Map is used to communicate with professionals in the wine industry (managers, cooperatives, winegrowers). The interactive document can be viewed at the following address: *https://www.adviclim.eu/storymap*

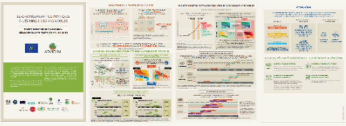
FUTURE PHENOLOGICAL MODELING AT LOCAL SCALE



CONSTRUCTION OF CLIMATE CHANGE ADAPTATION SCENARIOS.

GUIDANCE MANUAL, VIDEOS AND LEAFLETS TO SUPPORT WINEGROWERS DECISION-MAKING

GUIDANCE MANUALS FOR WINE SECTOR



SYNTHESIS LEAFLET FOR LOIRE VALLEY PILOT SITE

VIDEO DOCUMENTARY

By providing better understanding of actual and future agro-climatic potentials, the information transfer documents aim to assist winegrowers in building adaptation strategies to ensure the maintenance of wine quality and sustainable production. These tools aim therefore to inform on climate change and adaptation in viticulture, as well as to describe the modelling framework and process applied in this scientific project to address this issue. Indeed, while there are many management tools and solutions that hold great potential, there is little guidance on how viticultural practices should be undertaken at different temporal (short to long term) and spatial scales (local to regional level) in response to a changing climate.

- Guidance manuals to support winegrower's decision-making;
- Guidelines for professionals, scientific experts, and local authorities;
- Video report describing each Action of the project;
- Video documentary entitled "*The challenge of climate change for European viticulture: Adaptation tools*";
- Synthesis leaflet for each pilot site.

WORKSHOPS, TECHNICAL DAYS AND MEETINGS

Several workshops and meetings were held during the project. The aim of these events was to show the progress of the project but also to present the tools and results to wine professionals and stakeholders. Workshops with the winegrowers of the pilot sites were also organized in order to build our models and to validate our results. These meetings with winegrowers were very important, particularly for developing climate change adaptation scenarios. The LIFE-ADVICLIM project team also participated in the organization of scientific symposia and the final meeting that took place in Pamplona (Spain) from 28 to 30 January 2020. During this event, a technical day took place on 30 January 2020 at the *Estación de Viticultura y Enología of Navarra*. 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.

LIFE-ADVICLIM FINAL MEETING IN PAMPLONA (SPAIN)

TECHNICAL DAY WITH WINEGROWERS AND STAKEHOLDERS IN NAVARRA

DISSEMINATION OF THE PROJECT

Communication and dissemination Actions	Achieved results
Web site: Number of visitors Link to partners and stakeholder's websites	 More than 10 000 32
Leaflets	10
Project presentation at international level	Project presentation in English
Newsletters	7
Notice Boards	15
Social network: Twitter	1 083 followers/165,5K impressions
Video report	8
Networking (participation in workshops with other LIFE projects)	4
Annual meetings, National workshops and professional days on pilot sites	9
Organisation of International conference	2
Dissemination toward scientific community Publications (scientific journal, book, …) Conferences Colloquia and seminars (with seminar papers) Scientific workshops	 26 62 39 8
Media TV/Radio report Documentary Internet National and international magazine Local, regional and national newspaper	 10 2 10 10 22
Story Map	All pilot sites

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Layman’s Report

LIFE ADVICLIM (2014-2020)