Long term Adaptation to Climate ChAnge in Viticulture and Enology LACCAVE

Metaprogramme AAFCC

Final report: results from 2012 to 2016

English version

July / 2016

Remarques générales sur le rapport

Ce rapport servira de base à l'évaluation du projet ;

Le rapport est constitué d'un résumé pour décideurs (deux pages) et d'une synthèse scientifique destinée aux acteurs et gestionnaires concernés par le projet de recherche et à l'évaluation du projet (10 pages maximum, hors annexes) ;

Ce document a pour but d'être téléchargé et mis à disposition des différents comités du métaprogramme ACCAF (comité scientifique international, comité des porteurs d'enjeux, cellule de coordination) ;

Les contenus devront donc être rédigés de façon à ce qu'ils soient facilement compris par un lecteur non spécialiste, notamment ceux du résumé, et pourront être complétés par des illustrations (photos, graphiques, schémas, etc.);

Le résumé et la synthèse devront être rédigés en français et en anglais (dans deux documents distincts).

La répétition de certains éléments a pour but de permettre une réutilisation facile des contenus de chacune des parties ;

Une version éditable de toutes les informations devra être fournie jusqu'à approbation par la cellule de coordination du métaprogramme ;

En complément de ce rapport, les équipes devront fournir deux diapositives reprenant les faits et conclusions essentiels du projet ;

Une mention particulière devra être ajoutée au cas où des données ou informations confidentielles seraient inclues dans le rapport ;

Le comité scientifique international sera chargé de cette évaluation. Une attention particulière doit donc être donnée aux remarques formulées par le comité lors de la présentation des projets ;

Veillez, de plus, à apporter des éléments autour des 5 points suivants :

- Science en amont des processus clés.
- Meilleure évaluation des incertitudes pour les projections de réponses et d'impacts.
- Développement d'un ensemble d'options d'adaptation.
- Evaluation des moteurs et des freins socio-économiques.
- Contribution à l'innovation.

Ce rapport doit être complété dans un délai de 4 mois maximum après la fin du projet.

INDEX

General presentation of the project

Title: LACCAVE

Dates and duration: 2012 (march)-2016(april) : 49 months

AAFCC budget: 412000 euros (400 000 + 5000 (Special issue of JISVV) + 3600 (Supplemental support of consumer study) + 3000 (ClimWine2016 support)

Head of the project

Name: Nathalie Ollat / Jean Marc Touzard

Unit and Division: UMR1287 EGFV, Bordeaux, BAP / UMR0951 Innovation, Montpellier, SAD

Contacts: ollat@bordeaux.inra.fr / touzard@montpellier.inra.fr

Overview of the consortium

Divisions involved: EA, SAE2, MIA, CEPIA, SPE, (+ SAD, BAP)

Other units involved:

INRA :

Avignon : US1116 Agroclim

Angers : UE1117 UVV

Bordeaux : UMR1065 SAVE, USC1320 GAIA , UE1086 Viticulture, (+EGFV)

Colmar : UMR1131 SVQV

Montpellier : UMR1110 MOISA, UMR1083 SPO, UMR1230 SYSTEM, UMR0759 LEPSE, UMR1334 AGAP, UE0999 Pech Rouge, UE1057 Vassal, UMR1221 LISAH, UMR0729 MISTEA, (+ Innovation)

Paris : UMR1048 SADAPT, UMR1330 ALISS

non INRA :

UMR6042 Geolab (Limoges), UMR6554 Costel (Rennes), Univ. Bourgogne (Dijon) UR œnologie (Bordeaux)

Size of the team and staff involved: 96

- Permanent Staff : 67

Senior researchers	1 (Innovation), 2 (Lepse), 2 (SPO), 1 (Lisah), 3 (EGFV), 1 (SADAPT), 2 (Uni Bourgogne), 1 (SAVE), 2 (UVV), 1 (Moisa), 1 (System), 6 (Oeno Bord), 1 (Mistea), 3 (AGAP), 1 (Costel), 1 (Aliss), 1 (Gaia)= **30**
Junior researchers	1 (Innovation), 1 (Lepse), 1(Agroclim), 1 (SPO), 1 (Lisah), 3 (EGFV), 1 (SVQV), 2 (UVV), 1 (System), 3 (Pech Rouge), 1 (Oeno Bordaux), 1 (UEV), 2 (Moisa), 1 (Mistea), 1 (AGAP), 1 (Vassal), 1 (Gaia) = **23**
Technicians	1 (Innovation), 2 (Lepse), 1 (SPO), 3 (EGFV), 1 (SVQV, 2 (UVV), 1 (Pech Rouge), 1 (Oeno Bordeaux), 1 (UEV), 1 (Mistea)= **14**

- Non-permanent Staff: **29**

Fixed-term contracts	2 (Innovation), 1 (Lepse), 1 (SPO), 1 (SVQV), 1 (Pech Rouge), 1 (Mistea)= **7**
PhD	1 (Lepse), 1 (EGFV)= **2**
Postdoctoral fellows	1 (Innovation), 1 (Lepse), 1 (EGFV), 1 (Uni Limoges), 1 (UVV/Costel), 1 (Aliss/Oeno Bordeaux), 1 (Mistea), 1 (SPO) = **8**
Master students	2 (Innovation), 1 (Lepse), 3 (Lisah), 1(SVQV), 2 (UVV), 1 (Pech Rouge), 2 (Mistea) = **12**

Person/month equivalent for the duration of the project : **798**

- Permanent Staff : **434**

Senior researchers	20 (Innovation), 36 (Lepse), 13 (SPO), 6 (Lisah), 20 (EGFV), 24 (Sadapt), 7 (Uni Bourgogne), 3 (SAVE), 6 (UVV), 3 (Moisa), 6 (System), 24 (Oeno Bordeaux), 6 (Mistea), 6 (AGAP)= **180**
Junior researchers	2 (Innovation), 24 (Lepse), 8 (Agroclim), 13 (SPO), 4 (Lisah), 30 (EGFV), 12 (SVQV), 4 (UVV), 6 (System), 6 (Pech Rouge), 8 (Oeno Bordeaux), 4 (UEV), 6 (Moisa), 12 (Mistea), 2 (AGAP): **141**
Technicians	3 (Innovation), 48 (Lepse), 12 (SPO), 12 (EGFV), 12 (SVQV), 8 (UVV), 2 (Oeno Bordeaux), 2 (Pech Rouge), 8 (UEV), 6 (Mistea): **113**

- Non-permanent Staff: **364**

Fixed-term contracts	4 (Innovation), 18 (Lepse), 18 (SPO), 6 (SVQV), 1 (Pech Rouge), 6 (Mistea): **53**
PhD	12 (Lepse), 12 (EGFV) **: 24**
Postdoctoral fellows	36 (Innovation) 36 (Lepse), 36 (EGFV), 8 (Uni Limoges), 36 (UVV/Costel), 36 (Aliss/Oeno Bordeaux), 18 (SPO), 18 (Mistea): **224**
Master students	12 (Innovation), 6 (Lepse), 18 (Lisah), 9 (UVV), 6 (Pech Rouge), 12 (Mistea)**: 63**

Trainees (master, PhD, post-doc fellows):

Post doc fellows

Rami Albasha (LEPSE 2015-2016)

Junqi Zhu (EGFV 2015-2016)

PhD

PhD fully involved in the project

James Boyer (Economie, EDEG Montpellier, 2012-15)

Aude Coupel-Ledru (Génétique, ED Montpellier, 2012-15)

Etienne Delay (Géographie, ED Limoges, 2012- 2015)

Alejandro Fuentes (Economie, ACCAF/Région Aquitaine, 2012-16)

Etienne Neethling (Agronomie, SAD/PaysdeLoire, 2013-16)

Landry Rossdeutsch (Biologie, INRA-EA/Région Aquitaine, 2012-2015)

PhD with ponctual participation to the project

Valentin Tilloy (Microbiologie, Inra/Lallemand, 2010-2013)

Aunur Muljarto (Informatique, ED Montpellier/Supagro/ MIA)

Masters

Aude Coupel-Ledru (Supagro, 2012), ecophysiologie, Lepse

Mathieu Bourmaud (ESA Angers, 2012), sciences du sol, Lisah.

Julia Juan (Agrocampus Ouest, 2014), Economie, UMR Innovation

Mélanie Brucciamachie (AgroSup Dijon, 2014), Economie, UMR Innovation

Ana Gonzalez Arnaiz (Univ polytec Madrid ,2015). *land use, Lisah*.

Francois Xavier Weber (CNAM, ESGT, 2015). *Analyse paysage, lisah*

Hélène Logel (Agrosup Dijon, 2014), agronomie.

Santiago Alvarez Gei (ESA Angers), agronomie

Alexandre Mairin (Master, informatique Mistea)

Julio Ruiz (Master, mathématique Mistea)

Partners of the project (with logos):

Projects :

ANR Duravitis, programme UE Innovine, programme Life-Adviclim, INRA-Perpheclim, Région Aquitaine AVA2C, ARIMNET-Almira, CSA booster KIC Climat

Academic partners :

Montpellier SupAgro, Bordeaux Sciences Agro, UR GRAPPE (ESA Angers), Swedish University of Agricultural Sciences (Department of Economics, Uppsala),

Members of the international scientific committee : G. Jones (Oregon U., USA), V. Bonnardot (Stellenbosh U. South Africa), J. Tonietto (Embrapa, Brazil), H. Schultz (Geisenheim R.C., Germany), F. Zamora (Tarragone U., Spain).

Non academic partners :

FranceAgrimer (P. Aigrain, F. Brugière), et INAO (J Gautier), prospective (WP7)

BRGM Montpellier (C. Hérivaux, JD Rinaudo), Association climatique de l'Hérault, IFV

Syndicat des vignerons de Quart de Chaume (49), Syndicat des vignerons de Saumur Champigny (49), ODG Bordeaux-Bordeaux supérieur (33), Conseil des vins de Saint-Emilion (33), AOC Savennières (49), AOC Alsace (67), GDA et coopérative Banyuls (66)

Société Lallemand (thèse Valentin Tilloy).

LACCAVE

Metaprogramme "Adaptation of Agriculture and Forests to Climate Change" (AAFCC)

SYNTHESIS

Name of the project leaders: Nathalie Ollat / Jean Marc Touzard

Other scientific partners (non Inra)

Bordeaux Sciences Agro, Montpellier SupAgro, Université de Bordeaux, Université de Dijon, Université de Limoges, CNRS-Rennes, France AgriMer, INAO

GENERAL CONTEXT

In France, the vine and wine industry is a major economic sector associated with cultural importance. With a surplus over 10 billion euros in 2015, wines and spirits are ranking just after aeronautics for the national exportation value. Grape growing contributes to more than 15% of the agricultural production in value with only 3% of cultivated farmland. The sector generates more than 500,000 direct and indirect jobs. Through its historical and cultural roots, it plays also a key role in the conservation of landscapes and tourist attraction.

Like all agricultural crops, grapevine is sensitive to climate, with marked effects on yields and composition of grapes. It is a perennial crop whose production is harvested annually in late summer, but productivity depends on the climate of two developmental cycles. For a given grapevine variety, climate and geographical origin are factors of differentiation of the types of wine produced. The vine is also subject to significant pest pressure which depends on climatic conditions. It is an excellent marker of past climate, and harvest dates were used to reconstruct the climate since the thirteenth century.

Besides the climate, the development of wine production in France is closely linked to its local provenance since 59% of surfaces are classified “Designation of origin” and 26% under “Protected Geographical Indication”. Wine prices depend on these rankings that guarantee the quality according to the origin, allowing synergies with oenotourism.

These biological and economic factors make the vine and wine industry very vulnerable to climate change, to the point that some alarmist simulations predict a reduction of 50% of the surfaces suitable for the production of quality wines in France in 2050. Adaptation is therefore a major challenge, and the characteristics of this production and its development define specific conditions for adaptation. It is a perennial plant with annual harvest, which allows the combination of strategies at short and long terms. Its ties to the geographical space and highly regulated practices are the bases of “Appellations of Origin”. It has major consequences on the possibilities of innovation and geographic mobility, both important dimensions of climate change adaptation. Moreover, the industry is organized in France around regional vineyards that are / will be affected differently by climate change and have / will have varying capacities to accommodate, with major economic consequences on their competitiveness. Taken together these parameters make the French vine and wine industry a "model system" to conduct a multidisciplinary scientific approach on adaptation to Climate Change in Agriculture.

Aware of the vulnerability of the sector, some of its stakeholders (professionals or scientists) started to consider climate change issues since the mid-2000s. Research has been initiated by several French teams to identify the impacts of climate change on the grape growing conditions of grapevine. These studies were conducted in a disciplinary way, roughly coordinated, with no special focus on adaptation strategies. Similar developments were observed in the major wine-producing countries. It turned out that it was a necessity to better coordinate the researches undertaken in France on this issue in order to respond more effectively to the concerns of the sector. It was also important to strengthen and structure the dynamics of scientific knowledge at the international level.

GENERAL OBJECTIVES

The general objectives of the LACCAVE project are to further characterize the long-term impacts (2050) of climate change on the grapevine growing and wine production, particularly at regional

scales, and to elaborate additional knowledge on innovations and possible adaptation strategies for the sector. The purpose is not to propose technical solutions ready to use. The goal is to improve our understanding of the effects of climate change, and then to explore various levers and their combinations to define adaptation strategies at the local or regional level. It is also important to assess the economic, sociological and environmental consequences of these strategies. Finally it aims at coordinating the French research on these issues, at communicating the results at the national and international levels, in order to better meet the demand of the industry and society.

More specific objectives are i) to build a multidisciplinary scientific network, ii) to develop a shared vision and a collective questioning on the issue, iii) to develop methods and analysis tools, iv) to coordinate responses to other funding calls. The project has the ambition to support a set of targeted or integrative studies and achieve a prospective study on adaptation strategies. To prepare a more operational phase, the objective is also to share information and initiate actions with stakeholders.

METHODOLOGICAL ELEMENTS (AND POSSIBLE DIFFICULTIES)

The LACCAVE project supported the development of a national multidisciplinary scientific network and a combination of more disciplinary research operations. The methods are therefore organized at both levels.

The first step was to build a consortium with a group of scientists with very diverse skills, bringing together all the INRA laboratories already involved in climate change studies and covering a diversity of regional situations. The network was established while preparing the application and was extended to three non-INRA teams (major teams on the subject with complementary approaches). It involved also the establishment of an international scientific committee and the recruitment of 8 students (including one co-funded by ACCAF). The development of this scientific community has been supported by bi-annual meetings of Work Packages leaders (WP), the organization of regular seminars and conferences (4), the construction of a common analytical framework, the development of internal communication tools and the writing of collective publications.

The project combined WP transversal activities and more specific studies by disciplinary groups:

- To assume the coordination and transversal activities, WP0 managed the network and organised seminars. It was in charge of internal and external communication and collective publications. WP1 provided the simulation of the climatic scenario, synthetize the knowledge on the impacts of climate change and analyse the perceptions. WP7 organized joint discussions on adaptation and the role of science, particularly through a foresight exercise.

- The more specific scientific activities usually brought together related disciplines. They were organized in five WPs, integrating each time one or two Ph-ds. WP2 was dedicated to analyse the genetic and physiological bases of grapevine adaptation (drought, temperature) (2 Ph-Ds); WP3 aimed at analysing the possible innovations, focusing on varieties, irrigation and oenology (1 Ph-D); WP4 studied the evolution of practices and strategies at a small regional scale (case studies in Anjou, Bordeaux, Languedoc) (2 Ph-Ds); WP5 addressed the economics of adaptation, from the point of view of producers and consumers (1 Ph-D); WP6 offered data analysis methodologies and the development of information systems (1 Ph-D).

In each WP, the methods were specific and covered globally the following categories: modelling, experiments, field observations, agronomic, economic or sociological surveys, bibliometric analyses, methodologies for action research or foresight exercise. Exchanges between participants around these methods highlighted common questions related to climatic scenarios, the concept of adaptation and the need to better contextualize and integrate the knowledge produced. Therefore 8 internal seminars (interWP) were organized, becoming an important component (not originally scheduled) to build a multidisciplinary approach. These seminars were :

Ecophysiological modeling (Pech Rouge)

Multi-agent systems (Montpellier)

Methodologies to analyse the variability at the scale of a regional level (Angers, Roujan)

Impact analysis and innovations in a witness vineyard (Banyuls)

Analysis of innovation and adaptation strategies (Montpellier)

Database management (Montpellier)

Genetic of Adaptation (Paris)

Methods for social science surveys on viticulture and climate change (Bordeaux)

Furthermore the development of relations with stakeholders (technical journals, conferences, seminars) and willingness to contribute to the public debates on climate change (Agricultural Fair, CSA symposia, UNESCO, COP21, media interviews ...) were included as an important component of the overall approach of the project LACCAVE

The construction of this scientific network and the development of more specific searches were conducted in a very satisfactory manner, concluded by the International Congress Climwine2016 (see results and impacts) Difficulties to reach the ambitious objectives were related to the limited financial resources in view of the scale of operations undertaken, the time required for the coordination of such a network nationwide (sometimes against regional or institutional dynamics), the inertia of the collective functioning of groups ... This mainly limited the development of a website, the effective implementation of international collaborations (mounting international projects) or the development of more operational partnerships with local players.

OVERVIEW OF THE RESULTS

1- The construction of a national scientific network (WP0)

First of all, the LACCAVE project brought together all the French teams working on the theme "vine, wine and climate change": 96 researchers and students, 20 INRA units and 3 non INRA units. The project improved the visibility of their works at national and international scale. This community has exchanged very actively on the theme, taking into account the multidisciplinary dimension of the issue. Existing or new collaborations have been developed (leading in many cases to new formal projects). The Laccave members have shared a systemic vision and an analysis framework of adaptation (combination of adaptation levers at several scales, taking into account the perception by stakeholders and consumers). This network dynamic has developed thanks to the success of the general meetings in Bordeaux (2012), Angers (2015) and Montpellier (2014, www.supagro.fr/web/ihev/pages/?idl=19&page=1768&id_page=4132), leading to the international congress Climwine2016 (https://colloque.inra.fr/climwine2016),

bringing together 200 scientists from 20 countries. The network was supported by the establishment of collaborative tools (mailing list, Silverpeas space), a permanent animation work based on the WP leaders (7 WP leaders meetings), the organization of 8 thematic seminars, a collective strategy for scientific and public communication (at national and international scale), and finally the prospective study on the French wine industry in the context of climate change.

2. The improvement of climate simulations at local level (WP1)

The project provided the framework for improving knowledge on climate variability and climate evolution at the local level. Climatologists and modelling specialists have worked on climate scenarios across 8km x 8km developed by MétéoFrance and available on the DRIAS platform (http://www.drias-climat.fr/), in order i) to obtain useful information for the development of adaptation strategies in different French wine regions, and ii) to disseminate these outputs to stakeholders (Montpellier midterm meeting, CIAG Montpellier, "La Recherche" journal, Climwine2016 Proceedings). Furthermore, temperature variability at local level has been studied in a modeling perspective in the Loire Valley (thesis of E. Neethling) and the region of St Emilion. This work has highly contributed to launch the Life-Adviclim European project (http://www.adviclim.eu/fr/). The results of this work were presented at the COP21 symposium (Unesco) and at Climwine2016. They highlight that within a small wine region, the variability of temperature can be equivalent to i) that observed on average between two wine regions, and ii) the increase in average temperature expected for 2050, offering flexibillity/opportunity for adaptation at the local level (Bonefoy et al, 2014 ; Neethling et al, 2016).

3. Overview of Climate Change Impacts on vine and wine (WP1)

The LACCAVE project also quickly provided an overview of the impacts of climate change on vine and wine, and updated it regularly. This synthesis has benefited from the collective ability to bring together results from a wide range of existing works, such as historical observations, experiments and simulations (in different disciplines). The advancement of phenological stages was confirmed and clarified (Bois et al , 2014; Fraga et al, 2016) ; the accentuation of water stress for the vines in the Mediterranean area has been clearly shown (Ojeda et al, 2014) ; bibliographic reviews have better established the possible impacts of climate change on grapes component (sugar, acids, aroma precursors, anthocyanins ...) and the wine quality (Escudier et al, 2015; Darriet and van Leeuwen, 2016), providing an illustration of how climate change can influence the quality of food, and thus its markets and regulations (Ollat et al, 2016). Two points have been less considered: the consequences of the (possible) increasing climate variability (and extreme events); the indirect impacts linked to the evolution of pathogens and ecosystems (Caubel et al., 2014). However, a survey has been launched at the international level, in order to better assess the correlations between disease incidence and climatic data, and to improve pest risk simulations. These overviews on various dimensions of climate change impacts have been published in scientific journals and were necessary for a clear communication to the general public (Escudier et al, 2016). They have mostly been a common basis to start working on adaptation, defined as a set of actions to respond these impacts (Viguier et al., 2014).

4- Advanced knowledge on the genetic basis of adaptation (WP2)

Several studies were conducted as part of LACCAVE, or in connection with the associated projects, to better understand the genetic determinants of vine response to water stress (thesis

of A. Coupel Ledru and L. Rossdeutsch) and to high temperatures (in link with Duravitis project). Work on phenology (methods, genetic variability analysis, modeling) were made with the ACCAF-Perpheclim project. Genetic variability was studied in clonal populations, intraspecific vinifera or between rootstock genotypes. The results highlight the importance of hydraulic conductivity and night transpiration as genetically controlled characters involved in the management of water losses of the vine (Coupel-Ledru et al., 2014 and forthcoming). Furthermore, the metabolism of ABA and the molecular determinants of the transport of water in the plant have varying characteristics depending on the genetic origin of rootstocks, and could be associated with adaptation to drought (Rossdeutsch et al., 2016A and b). Interactions between rootstock and scion play also a key role in the response of plants. The effect of high temperatures on i) the vegetative growth of the vine, ii) the berries and iii) the composition of the grapes has been studied by several LACCAVE participants. Variable and complex responses have been demonstrated according to the organ or molecule, and to the phenological stage impacted by the stress (Torregrosa et al, 2016,.. Duchêne et al, 2016, Proceedings Climwine2016). Studies carried out in the context of joint projects revealed significant interaction between the effects of CO2, temperature and UVB (Martinez-Luscher et al., 2015). A major concerted effort was made on ecophysiological modeling in order to identify gaps and to better integrate the various existing models (modeling workshop; Vivin et al, 2016, Proceedings Climwine2016.). Two postdoctoral students have been working in the KBBE-Innovine project on this topic.

5- Characterization of adaptation practices in the vineyards (WP 3, 4, 6)

Enological and viticultural practices, but also the potential of vine varieties (scion and rootstock) have been investigated as possible solutions for adaptation:

In winemaking, yeast strains producing less alcohol yield have been selected in Montpellier and Bordeaux (Tilloy et al, 2014 ; Daquin et al, 2016 ; Proceedings Climwine2016). Promising results allow to launch this innovation into the market (partnership with Lallemand firm). Other technologies such as desalcoholisation or acidification have also been experimented in the context of industrial partnerships, and presented/discussed in the LACCAVE project. The better understanding of "how to manage the aromatic potential of wine in a context of climate change" has also been exposed, analyzed and debated within LACCAVE (Pons et al, 2016. Darriet et al, 2016.), with inputs from IT colleagues (Muljarto et al, 2015) and useful information for experimental economics studies (see point 7).

As far as vine management is concerned, a wide range of practices has been assessed (Barbeau et al., 2014), including irrigation (Pelegrino, Ojeda, 2015). Research on highly innovative processes have also been initiated and supported by various partners : The re-use of recycled water for irrigation (Project IrriAlt'eau) ; coupling wine production with the production of electricity by photovoltaic coverage (project Sun'Agri 2B). The results are still preliminary and studies should continue beyond the Laccave project.

The diversity of plant material (varieties and rootstocks) has been studied in different vineyards, using pre-existing devices (Vitadapt, UEVassal) in collaboration with the Accaf PERPHECLIM project. A similar device for rootstock assessment in various (real) climate conditions has been implemented (Idéogreffe project supported by the CIVB). These devices have raised a significant amount of data on the phenology of many varieties, but also on their agronomic and biochemical characteristics. The data has been analyzed through an ontology (WP6) organizing information for potential new varieties cultivation in different regions in the context climate change, especially in Bordeaux.

An overview of possible changes of practices at different scales of space and time was conducted (Barbeau et al., 2013) and can be used as a decision making tool. Several surveys were also carried out among wine producers in different regions in order to assess their perceptions of both climate change and new practices (Thesis E. Neethling ; Teil et al, 2016.). Sociological surveys show how the changes in practices for the climate challenge are influenced by those related to environmental and quality issues (Teil, 2016). The thesis of E. Neethling combined several approaches: climate modeling at the local level, assessment of impacts on grape growing, analysis of practices and perceptions of wine growers. This work draws the methodological basis for exploring the best practices of adaptation at the local level.

6. Land use management and modeling of landscapes evolution (WP4)

The need of coordinating adaptation solutions at the local scale stands as another scientific contribution of the project. All works are converging to show that the local level is a key issue adaptation (Quenol, 2015), leading to reconsider the organization / location of the vineyard plots according to the variability of climate impacts (see point 2) and the management of local public goods (soil, water, landscape, biodiversity ...). This issue is beginning to pull the development of new projects, for example by wine growers associations (Quenol et al, 2015. Ugaglia et al, 2016). To support these local strategies several methods have been explored by members of the LACCAVE project, combining scenario building, exploration of coordination problems and co-construction of strategies with stakeholders. We focused on multi-agent model connected with cartographic representations (on climate, land use) and models integrating hydrological and ecological processes (Delay et al., 2015). The thesis of E Delay in Banyuls (Pyrénees Orientales), the works carried out in Roujan (Hérault) and in the Loire Valley were used as empirical basis for such research (Vinatier, 2015). The organization of internal seminars enabled the creation of a simulation model (prototype) taking into account the plot geometry in hilly landscapes, and opening new perspective for the modeling of viticulture under climatic constraints at local level (Vinatier, Gonzalez Arnaiz, submitted). In Banyuls, the simulations of future landscapes have linked climate change, land management and possible evolution of the wine quality (which depends on the location of the plots). The outputs have been elaborated and discussed with the grape growers of the local cooperative in order to explore new collective rules for vine plantation and grape payment (Delay, 2015; Delay, Becu, 2016).

7. Economic analysis of conditions for adaptation to climate change (WP5)

Economic conditions of adaptation were studied at the producer level and, more original, at the consumer level.

Beyond the first syntheses on the economic dimensions of adaptation in the wine industry (Viguier et al., 2014), surveys have been carried out in the Bordeaux region, linking the perceptions of climate change by the wine producers with their expected strategies, and their potential costs at the farm level (Ugaglia Peres, submitted). In this regional context, producers are above all considering the risks of climate variability (Ugaglia et al., 2016), following different strategies according to their resources and their (inherited/projected) trajectory. Studies in other regions (presented during the Bordeaux LACCAVE seminar in 2015) confirmed that risk management is crucial, combined with different local issues (drought in Languedoc, diseases in Champagne). Economic decisions (investment) result from uncertain cost/benefice calculations, taking into account the wine value, the expected costs and a scope of options allowed by each quality label (Boyer et al., submitted).

The analysis of consumer's willingness to pay for wines affected by climate change is a new contribution of LACCAVE. Methods of experimental economics were developed (thesis of A. Fuentes Espinoza) to show that consumer's behavior is also a lever for adaptation. We organized wine tasting sessions with large consumers panels in order to assess their judgment and willingness to pay for both wines (still) impacted by climate change (more alcohol, less acidity, changes in aroma and color) and the acceptance of oenological innovations to correct the wine quality. The influences of climate change on different sensory characteristics of the wines have been demonstrated, suggesting influences on the (future) wines markets (Fuentes Espinoza et al. 2016). Above all, this work is an important empirical verification of the instability of consumer's preferences according to its duration of exposure to a product (Giraud- Heraud et al., 2016): the "wines of climate change" have been more appreciated in the first tasting session, then progressively depreciated (in comparison to current wines) when the consumer repeats the tasting along a week (important result in the field of experimental economics). Finally the results show that consumers have differentiated valuations (partly related to age and gender) of the oenological processes aiming to correct the effects of climate change on quality (desalcoholisation and acidification).

8. The role of innovations and research for adaptation (WP 3, 7)

Another contribution of the LACCAVE project was to question the role of agricultural research on the development and dissemination of innovations that contribute to adaptation strategies (new varieties, agronomic practices, wine-making technology…) (J. Boyer thesis). The first national survey, coupled with a bibliometric study of scientific publications on "vine and wine", showed the importance of ongoing research (around the two poles of Montpellier and Bordeaux) but without clear relations with the regional vineyards where the research centers are located (Boyer, Touzard, 2016). A double survey was thus carried out in 3 vineyards (Champagne, Bordeaux, Languedoc) with hundred wine producers and 80 researchers in order to understand the links between i) the perception of the climate challenge, ii) the implemented/expected actions coping with this challenge (in research or adoption of innovation) and iii) the advice networks built for these actions. If various wine producers profiles (according to their position on innovations and climate change) is shared between the regions, their willingness to innovate largely depends on each "regional innovation system" (Boyer et al., Submitted) and the role that can play wine interprofessional organization, able to build a real "demand for research and innovation" (Boyer, 2016). These results call for developping multidisciplinary and participatory research, including the wine interprofessional partners (Ollat et al., 2016). They show that the organization of links between research and wineproducers is also a lever for adaptation.

9. The construction of adaptation scenarios for the vine and wine sector (WP7)

One of the important operations in LACCAVE was to realize a foresight exercise in order to explore adaptation strategies in the French wine industry, in the context of climate change. The exercice was led by an animation group including twelve LACCAVE researchers (covering all WPs) and experts from the INAO and FranceAgriMer. A new method has been tested to describe the roads leading to the implementation of different adaptation strategies (Aigrain and al.- climwine proceedings). Starting from a "median" climate scenario for 2050, 4 major adaptation strategies have been defined: "conservative" integrating marginal changes in the current vineyards; "Innovate to stay" opening the vineyards to radical innovations in order to maintain their current locations ; "Nomads vineyards" highlighting the consequences of potential vineyards relocation; "Liberal" testing a situation where "everything is possible everywhere."

The group has collected, selected and combined a wide range of assumptions that could be related to these 4 strategies (influence-dependency matrix between 70 assumptions). The information comes from researchers, previous prospective and the survey of “wine actors” in 3 wine regions. Four roads were finally described by linking micro-scenarios (outputs of the matrix analysis), providing possible stories that lead to the 4 adaptation strategies in 2050 (FranceAgrimer forthcoming). Work on the construction of roads is a contribution to research on prospective methods. The results will also help to initiate a new phase of co-construction of "climate strategies" at regional scales (see perspectives).

IMPACT OF RESEARCH: PRACTICAL IMPLICATIONS, RECOMMENDATIONS, PRACTICAL OUTPUTS, EXPLOITATION AND DISSEMINATION

- Practical implications:

1. Establishment of a scientific community, development of scientific expertise, response to funding calls, collective publication, participation to major events related to climate change (COP21) and response to media requests (see output section) .

2. Significant contributions to the analysis of the issue and perception of adaptation to climate change in the vine and wine sector for each wine region, with consequences on the development of "climate strategies" in several wine organizations (Bordeaux, Languedoc, Champagne ...).

3. Development of a "political message" in 5-points echoed by several media intended for policy makers (eg Ollat Touzard, Parliamentary Review, 2015):
- Adaptation strategies depend first on the level of mitigation and could be reasonably implemented in all French vineyards if global warming stays below 2°C (more latitude to adapt using local climatic variability, less instability);
- There is no single solution, but different combinations of technical innovations, spatial strategies and institutional changes.
- The integration of these solutions must be elaborated considering the value chain, including the changing of consumer preferences, which is crucial for wine;
- These adaptation strategies must be coordinated at local and regional levels where climate impacts are specific and where the use of resources can be optimized;
- Taking into account the large uncertainties, the best way to adapt is based on the collaborative capacity between researchers and stakeholders, even at regional level

4. Publication of adaptation scenarios (FranceAgrimer, forthcoming) to launch in November 2016 with several meetings with stakeholders in different wine-growing regions, in order to contribute to the co-construction of regional climate strategies.

5. Knowledge to be used for the development of new techniques: targets for drought adapted grapevine varieties, new yeasts with a lower alcohol yield (in partnership with Lallemand), comparative evaluation of viticultural practices.

6. Methodological contributions for future research and operational applications: analysis of adaptation frameworks prototype multi-agent systems, methods of investigation,

7. Contribution to the transfer of innovations at INRA (Pech Rouge, partnership Fruition Science ...) and the European Climate Smart Agriculture project of the Climate KIC.

- Recommendations and possible limits:

The project had two ambitious goals in seeking to develop visions and methods of integrating adaptation (at the scientific, operational and societal levels) and contributing to the development of more targeted solutions. The impacts are significant in both areas, but it is clear that i) the review work should be extended, deepened, and ii) that important levers of adaptation were not taken into account and should be further analysed (see perspectives). Moreover activities at regional scales should be better structured, formalized, for an optimal impact to the industry stakeholders. Finally a bottom-up approach, taking into account the experiences, the modification of practices and the initiative undertaken by the players themselves appears to be necessary. It should provide a critical outlook of the academic knowledge about the involved processes and allow to take into account the large variability of situations in French vineyards.

- Practical outputs, exploitation and dissemination:

LACCAVE resulted in many scientific developments and was also involved in educational activities, knowledge transfer to the stakeholders and to the civil society:

Scientific Impacts: Participants published 62 scientific articles in relation with the project, including 20 ones from co-authorship from several WPs. If the majority of the articles refer to specific disciplines (agronomy, biology, microbiology, economics, geography ...), 23 relate to strategic multidisciplinary journals for the vine and wine sector (JWE, JISVV, AJEV, AJVWR) and 7 are targeted to climate and climate change journals. Journals with high impact factors have been reached (in particular two articles in PNAS). In addition, 190 scientific presentations at conferences (oral or poster) have been identified, of which 30% are collective and multidisciplinary. Communications have been mainly presented in conferences related to the vine and wine sector, especially in Climwine2016 congress organized as the final event of the project (27 papers and 26 posters, half of Congress communications). The most important collective written communications are the response published in PNAS (2013), the special issue JISVV (2014), the book coordinated by Hervé Quénol (2014). Major collective papers were presented at the UNESCO convention / COP21 (poster), the Congress of the South African society for viticulture and oenology (2014), in Oenology Congress in 2015 in Bordeaux, and GIESCO meetings (Porto and Narbonne). The major scientific event is the organization of Climwine2016 Congress and the upcoming edition of the book of Proceedings (end of 2016).

Impact in terms of training: The project contributed to the training of students, mainly doctoral fellows. MP AAFCC co-funded a doctoral fellowship and 6 PhD other students were integrated into the project (Funded by INRA divisions, universities or regional councils), a Ph-d was undertaken as internal training and 2 others contributed partly to the project. An important place was given to the work of Ph-d students in seminars and Climwine2016 Congress (attribution of a young researcher award). Ten students in Master 2 (or last year engineer curricula) also conducted their internship within LACCAVE. Research results and reviews also supplied training modules (generally Master level) especially in viticulture and oenology (Bordeaux and Montpellier) and will contribute to a MOOC developed by the University of Reading (UK) on agriculture facing climate change, as part of a European project of the climate KIC.

Operational impacts (the wine sector actors): since its launching, the project has been presented to the major regional wine trade organizations (BNIC, CIVB, CIVC, InterRhône, Interloire,

national IFV, IFV Southwest, Loire Valley Appellation Languedoc, Vignerons de Banyuls ...) and during the general meetings of the two major national federations (CNAOC IGP in 2014 and France in 2016), each advertised with numerous press articles. Researchers were also strongly involved in the events organized by INRA for this area: meetings organised by the vine and wine sector in Montpellier and Bordeaux, Carrefour Innovation Agronomique, Innovine, Agricultural fair show (2015 and 2016 editions), conferences for the international exhibition SITEVI 2015, press document from INRA about research on the vine and wine ... Finally, many articles were written collectively by LACCAVE participants and published in technical journals, including all the well-known professional journals (la Vigne, Réussir Vigne, La revue des Oenologues, La revue française d'Oenologie French magazine, PAV, Vitisphère ...). In total 73 oral presentations and 70 technical publications were identified, involving a major impact of the project to the actors of the wine sector.

Civil society impact: LACCAVE has ensured a high visibility to the research performed in France, especially at INRA. Media coverage began in early 2013, peaking with the response to the publication by Hannah et al. (2013) in PNAS. Another wave of media coverage took place in 2015 during the COP21 in Paris, and continued until the spring of 2016. Overall at least 300 communications in the media were listed for the main TV channels (TF1, Arte, France 2, 3, 5, BFM, iTV ...), radios (5 broadcasts on France Inter, 2 of RFI, 2 on France Culture ... interview on Europe1, France Info ....), major national newspapers (Le Monde, Les Echos, Le Figaro, Paris Match ...), recognized blogs (Mediapart, Huffingtonpost ...) and science magazines (La Recherche, Pour la Science, Science et Vie ...). Coverage included also foreign media (TV Japanese, Dutch, Austrian, German, Danish, AFP and Reuters headlines; HuffPost US, American Scientific, Buzzfeed ...), with LACCAVE cited in more than a hundred international media sites. Contributions to several scientific documentaries should be highlighted, particularly for the program: Xenius for Arte (28mn), Life Sciences channel (Paris Sciences winning film festival 2015) and in 2016 making a documentary for France 5 ("le vin en ébullition") organized around the research performed in LACCAVE. Finally, the project has provided a collective contribution of INRA to the COP21, with a continuous presence in the Great Hall (booth research institutes), culminating with the presentation of Laccave to the Secretary of State for research and higher education and interacting with different media. During the second half of 2015, LACCAVE was ranking at the top of media impact for INRA (inrapresse study).

PERSPECTIVES

1. To maintain the scientific network with annual meetings, workshops, project development, website Laccave development, funding applications... To implement participative science initiatives around local projects and socio-professional sector partners: observations of impacts of climate change and shared analysis of solutions implemented locally.

2. To formalize an international process of collaboration initiated through the scientific committee of the project or Climwine2016.

3. To continue with the communication of results. A review could be published in an international journal, the France5/TV5 monde documentary film will be released at end of 2016

4. To develop new research topics: analysis of local climate scenarios incorporating especially rainfall and evaporative demand; improved studies about the strategies to face climate variability and risk management; investigation about the contribution of soil and soil management practices; studies of multi-stress effects; integration of mitigation constraints;

exploration of innovative systems taking into account other major issues, as the reduction of pesticides and inputs;

The implementation modalities of these perspectives remain open. The possibility to apply to AAFCC for Laccave II project is under consideration.

PARTNERSHIPS

LACCAVE was a good opportunity to initiate and strengthen several types of partnerships.

The network and the collaboration between the teams at the national level, associated with three external teams, allowed the completion of the project objectives. The coordination activities, thematic workshops and general meetings, including ClimWine2016 Congress participated to strengthen the network. The maintenance of the network will improve the efficiency and visibility of the research conducted in France on this important issue.

The major internal partnerships resulting from LACCAVE include 1- cooperation between Oenologists (Bordeaux and Montpellier) and Economists (Aliss) on experimental economics and the willingness to pay of consumers. This collaboration resulted in the creation of a new team in Bordeaux; 2- collaboration between Climatologists in Rennes, Dijon and Bordeaux biologists, which led to the successful application Life-ADVICLIM; 3- collaboration of teams participating in Perpheclim project which was highly beneficial for LACCAVE; 4- prospective work which involved teams of LACCAVE but also external organizations; 5- synergy development between scientists from Bordeaux and Montpellier in Oenology and Ecophysiology, but also between Social Sciences (SAD SAE2) and Biology (EGFV). ; 6- work involving Informatic and Data processing team (WP6).

LACCAVE participated to the development of partnerships between organizations across the country and among regions. At the national level, the collaboration with INAO and FranceAgrimer was crucial for the foresight study and is an important step to extend the results to the industry. The project also strengthened the links between INRA, the Engineering Schools (Bordeaux Sciences Agro, Montpellier SupAgro) and the Universities working on the climate change issue. In each region, more specific partnerships were established with the local industry representatives (Interprofessions), other organizations involved in initiatives on climate (BRGM, Climate Association of Herault ...) or political bodies (CR Aquitaine). These partnerships will facilitate the transmission of the LACCAVE results to the end users. For the future, more local approaches are required, for which these partnerships are very important.

LACCAVE contributed to forge links between national and international projects on climate change. It tried to ensure that the results of these projects could be brought to the attention of the entire LACCAVE network, and could be included in the global approach. The following projects must be cited: AAFCC-PERPHECLIM, ANR-DURAVITIS KBBE-Innovine, TERVICLIM, TERADCLIM, ADVICLIM, Bordeaux-Adelaide-Geisenheim collaborative HEATBERRY.

LACCAVE has set up an international scientific council whose members were able to follow the project's progress and were invited to participate to at least one scientific event (kick-off meeting, mid-term meeting or Climwine2016). A draft for an international network had been unsuccessfully submitted to AAFCC in 2012. The participation of the members of the International Scientific Council and other foreign colleagues to the activities of LACCAVE strengthened the scientific visibility and highlighted the multidisciplinary approach.

MORE INFORMATION (SOME REFERENCES)

MAJOR COLLECTIVE PRESENTATIONS AND REWIEWS ABOUT THE PROJECT

Ollat N., Touzard J.-M., Van Leeuwen C. 2016. Climate Change Impacts and Adaptations: New Challenges for the Wine Industry. Journal of Wine Economics, 11:139-149.

Ollat N, Garcia de Cortazar-Atauri, Touzard J. Climwine2016. Proceedings of the international symposium – Bordeaux – 10-13 april 2016

Ollat N, Touzard J. 2014. Long-term adaptation to climate change in viticulture and enology: the LACCAVE project. Journal International des Sciences de la Vigne et du Vin Spécial Laccave.

Quénol H. et al., 2014. Changement climatique et terroirs viticoles. Ed. Lavoisier, coll. Tech. & Doc. 444p.

Barbeau G., Neethling E., Ollat N., Quénol H., Touzard JM. 2015. Adapting to climate change in grapevine agronomy. Agronomie Environnement & Sociétés, 5 (1): 9-16.

Van Leeuwen C., Schultz H., Garcia De Cortazar Atauri I., Duchêne E., Ollat N., Pieri P., Bois B., Goutouly J.-P., Quénol H., Touzard J.-M., Malheiro A. C., Bavaresco L., Delrot S. 2013. Why climate change will not dramatically decrease viticultural suitability in main wine-producing areas by 2050. PNAS Proceedings of the National Academy of Science of the USA, 110 (33), E3051-E3052.

PUBLICATIONS BY LACCAVE Ph-D FELLOWS

Boyer J. 2016. Analyse de l'implication des acteurs de la recherche dans l'adaptation au changement climatique: l'exemple des régions viticoles française. Innovations: Revue d'Economie et de Management de l'Innovation, n°52. In press

Coupel-Ledru A., Lebon E., Christophe A., Gallo A., Gago P., Pantin F., Doligez A., Simonneau T. 2016. Reduced night-time transpiration is a relevant breeding target for high water-use efficiency in grapevine. PNAS In press.

Delay, E., Piou C., Quenol H. 2015. The Mountain Environment, a Driver for Adaptation to Climate Change. Land Use Policy 48: 51–62. doi:10.1016/j.landusepol.2015.05.008.

Neethling E., Petitjean T., Quénol H., Barbeau G. 2016. Assessing local climate vulnerability and winegrowers' adaptive processes in the context of climate change. Mitig Adapt Strateg Glob Change. DOI 10.1007/s11027-015-9698-0

Giraud-Héraud, E., Fuentes Espinoza, A, Pérès, S, Pons, A., Tempère, S., Darriet, P. 2016, Le réchauffement climatique est-il souhaité par les consommateurs de vin ? Approches croisées d'économie expérimentale et d'analyse sensorielle Actes du colloque OENO 2015.

Rossdeutsch L, Edwards E, Cookson SJ, Barrieu F, Gambetta GA, Delrot S, Ollat N. 2016. ABA-mediated responses to water deficit separate grapevine genotypes by their genetic background. BMC Plant Biology. 16: 91-106

Tilloy V., Cadière A., Ehsani M., Dequin S., 2015. Reducing alcohol levels in wines through rational and evolutionary engineering of Saccharomyces cerevisiae. International Journal of Food Microbiology, 213: 49-58.

EXECUTIVE SUMMARY

TITLE OF THE PROJECT

LACCAVE

SHORT SUMMARY

LACCAVE aimed to study the impacts and adaptations to climate change of the French vine and wine industry. A network of 23 laboratories was established and led a multidisciplinary approach to consider adaptation strategies at the local level by combining technical levers, organizational and relocation in space. Important communication activities were developed during the 4 years of the project at the scientific, technical and media levels.

EXTENDED SUMMARY

Context:

Considering the socio-economic importance of the French vine and wine industry, the sensitivity to climate of the production and the quality of wines, the specific links to geographical space and the conditions for the integration of innovations, this sector was considered as a scientific model to study the major challenges faced for the adaptation to climate change.

Objectives:

The project aims at collecting and generating knowledge required for the improvement of assessing the long-term impacts of climate change and to consider adaptation strategies. It was dedicated to specific studies on some key issues related to adaptation and to multidisciplinary research activities using different approaches, including a prospective study. Finally it aims at improving the coordination of research on this issue at the national level.

Methodology:

Methodologies have been adapted to the different project objectives. They combined modelling, experiments, field observations, agronomic, economic or sociological surveys, bibliometric analyses, methods of action research or foresight exercise. An important work of coordination and communication was implemented.

Main results:

The LACCAVE project has been closely associated with 7 Ph-D. The main results of the project are :

1. Construction of a national research network. Development of multidisciplinary knowledge shared within the network and with stakeholders, of system analysis framework, definition of adaptation levers, evaluation of the perception of CC issues by actors.

2. Improvement of the climatic simulations at the regional level. Improvement of the understanding of local variability of climate and climate modelling tools (link with Adviclim)

3. Review of the impacts of climate change on grapevine and wine

4. Advanced knowledge on the genetic basis of adaptation to drought (2 Ph-D), high temperatures (link with ANR Duravitis) and response of phenology (link with Perpheclim)

5. Characterization of vineyard adaptation practices (1 Ph-D), associated project development for innovations in the vineyard(recycling water for irrigation, cultivation under solar panels) and in the cellar (yeast strains with lower alcohol yield, technical tests or dealcoholisation acidification), setting up experimental plots to study the diversity of existing plant material (Vitadapt, Greffadapt, Vassal, link with Perphéclim).

6. Development of modelling tools to describe the long term evolution of landscapes and to integrate the various dimensions of the adaptation in 3 small regions (Roujan, Banyuls and Loire Valley, 2 Ph-D).

7. Economic analyses of the conditions for adaptation (WP5): Implementation of surveys to assess the potential costs of adaptation in farms, and evaluation of the consumer willingness to pay by experimental economics (1 Ph-D) .

8. Innovations and role of research for adaptation (WP3, 7): survey implemented at the national level and in 3 wine regions to examine the links between research networks and the potential for adaptation to climate change

9. Construction of adaptive scenarios for the vine and wine sector (WP7)

Operational outputs for decision makers, possible applications:

Multi-agent modelling tools, foresight exercise, lower alcohol yield yeasts, improved knowledge of plant material, consideration of the perception by growers and consumers.

Recommendations:

To implement local studies with stakeholders to identify real strategies and to experiment their components. To maintain the scientific network nationwide and to extend international strategies.

Perspectives:

- To maintain the scientific network nationally and formalize international dynamics.
- To develop new research topics for issues not yet taken into account (evaporative demand, soil, multiple stresses, etc ...)
- To implement participatory learning approaches with actors
- To consider a second step with Laccave II

KEYWORDS:

Vine, wine, industry, adaptation, multidisciplinary, local, prospective, technical, organization, location

HIGHLIGHT(S) OF THE PROJECT

Category:

1. A scientific result
2. A technical innovation
3. An expertise
4. An exemplary partnership
5. A remarkable event (e.g. a conference)

Highlights should be submitted only if they are relevant for the project. It is not mandatory to mention a highlight for each of the five categories listed above.

Please refer only one highlight by category.

TITLE Climwine2016 « Sustainable grape and wine production in the context of climate change"- Bordeaux 10-13 avril 2016. International Symposium

CATEGORY : a remarkable event

SUMMARY

The international symposium Climwine2016 was organized to end the LACCAVE project. It brought together about 200 researchers from 19 countries. 46 oral communications and 60 posters were presented. The multidisciplinary nature of the project was kept for the symposium. A website was created https://colloque.inra.fr/climwine2016. This symposium was the occasion of extensive media coverage at regional and national levels.

CONTEXT AND ISSUES AT STAKE

Defined as an major scientific deliverable in the project application, the organization of the Symposium Climwine was officially decided by the participating teams in February 2015. The location was collectively chosen. The objectives of this event were firstly to include the project in the international scientific dynamic on climate change, and secondly to present collectively the approaches and achievements of the LACCAVE project to a large audience in order to give them a national and international visibility. A major challenge was to organize a scientific event with a multidisciplinary character.

RESULTS

From 10 to 13 April 2016 on the site of Bordeaux Sciences Agro, the Climwine2016 symposium brought together about 200 scientists from 19 countries. 46 oral lectures and 60 posters were presented during 4 half days and a technical visit was organized on a splot dedicated to analyze the local climate variability from the Life-Adviclim project. More formal and friendly times allowed participants to meet with stakeholders and political representatives. Ten internationally renowned scientists including members of the International Scientific Committee were invited to participate in the symposium This event could be implemented through a local organizing committee of 10 members and an international scientific committee. The budget of the event was 50 000 euros. A partnership policy has raised 15,000 euro grant. The detailed program of

the event, a brief CR and oral presentations can be found on the site https://www6.inra.fr/laccave/ClimWine2016.

PERSPECTIVES

A regular edition of this event was considered, but it was not decided who would take over the establishment of a second edition. This issue will be further considered with the follow-up of the project.

EXPLOITATION AND DISSEMINATION

The Symposium was advertised at regional and national levels. A brief report was published on the different communication media owned by Inra and partners. The report written in French and English is available on the above mentioned site. A book containing twenty written contributions is being prepared as Proceedings of Congress (expected early 2017).

KEYWORDS

KEYWORDS

climate change, vine and wine symposium, multidisciplinary, international

TITLE Foresight exercise for the Vine and Wine Sector in 2050

CATEGORY : an examplary partnership

SUMMARY

The foresight exercise on "the vine and wine sector in the context of climate change," was launched with the scientists of Laccave project working with France-Agrimer prospective specialists and INAO. This partnership tested a novel method and proposed 4 pathways to corresponding to 4 strategies. The work will be used at regional scale with stakeholders engaging new partnerships with INRA.

CONTEXT AND ISSUES AT STAKE

Studies on the adaptation of agriculture to CC require the exploration of possible developments across sectors or territories. “Mechanistic simulations” often focused on a single component of adaptation do not allow to answer the question. Foresight offers this opportunity, while strengthening the links between participants and providing a method to build strategies at the scale of a sector, including the programming of research. This exercise should rely on a strong partnership with industry players and specialists of foresight methods. The exemplary partnership with France-Agrimer and INAO brought together both conditions and conduct for two years a national foresight exercise.

RESULTS

The foresight exercise started in 2014, and was coordinated by a dozen of LACCAVE scientists and experts from the INAO and France-AgriMer. A new method was used to develop pathways

leading to the implementation of adaptation strategies. By setting a climatic scenario for 2050, 4 major coping strategies have been defined: "conservative" integrating marginal changes in current vineyards; "Innovate to stay" opening the vineyards to innovations in order to maintain their current locations; "Nomad vineyards" highlighting the potential relocation of vineyards; "Liberal" testing a situation where "everything is possible everywhere". The task consisted in selecting and combining assumptions that may be related to these 4 strategies (influence-dependency matrix between 70 assumptions), starting from expert scientists, results of another foresight exercise and one survey made in 3 regional vineyards. Four pathways were finally described by linking micro-scenarios from the matrix analysis, offering possible stories that lead to adaptation strategies until 2050. The partnership with France-Agrimer and INAO was exemplary for the living exercise and above all open up new opportunities.

PERSPECTIVES

Work on the construction of pathways is a contribution to research on methods of foresight exercise but the results will mainly be used to initiate a new step of the study. The results will be presented to stakeholders in several wine regions, and will support the co-construction of 'climate strategies "at the regional level. The partnership with France-Agrimer and INAO, which are in direct relationships with regional wine organizations, is a guarantee for the development of this new stage and the expansion of the partnership with Inra.

EXPLOITATION AND DISSEMINATION

Aigrain P., Brugière P., Duchène E., Garcia de Cortazar I., Giraud-Heraud E., Gautier J., Hannin H., Lagacherie P., Lebon E., Ollat N., Teil G., Touzard JM., 2016. Lessons from a Prospective Study on the French wine industry under climate change, ClimWine International Symposium, April 10-13, Bordeaux, France

France Agrimer, 2016. Une prospective pour le secteur Vigne et Vin dans le contexte du changement climatique. Les Synthèses de FranceAgrimer, à paraître

Ollat N., Touzard J.-M., Van Leeuwen C. 2016. Climate Change Impacts and Adaptations: New Challenges for the Wine Industry. Journal of Wine Economics, 11:139-149.

KEYWORDS

Foresight exercise, grapevine, wine, climate change, partnership

TITLE : **Publication in PNAS**

Van Leeuwen C, Schultz HR, Garcia de Cortazar-Atauri I, Duchêne E, Ollat N, Pieri P, Bois B, Goutouly J-P, Quénol H, Touzard J-M, Malheiro AC, Bavaresco L, Delrot S. 2013. Why climate change will not dramatically decrease viticultural suitability in main wine-producing areas by 2050 ? P.N.A.S, 2. www.pnas.org/cgi/doi/10.1073/pnas.1307927110

CATEGORY : Expertise

SUMMARY

This short publication is a response made by an European scientific consortium to a study published in the same journal (Hannah et al., 2013). It highlights some methodological

limitations of the cited study and shows that according to the criteria used in the work, most European wine regions would no longer be able to produce quality wines. The importance of the implementation of adaptation practices was underlined.

CONTEXT AND ISSUES AT STAKE

Climate change is a major issue for all vineyards in the world and attracted the interest of many scientists from different disciplines. Climate modelling and future climate simulations for different wine regions are of great interest. The results of these studies, however, must be treated with caution, according to the criteria used to assess the suitability of the different regions. Modelling is also submitted to uncertainties. Media interest for this type of scientific results is great and the LACCAVE community was requested to comment the major results of the American study. In order to complete this task in a scientific way, scientists of the European consortium led to LACCAVE members, analysed accurately the publication of their colleagues and release a scientific answer.

RESULTS

The paper raised the interest of the US study and addressed some of its weaknesses which led to alarmist conclusions. In a limited format (500 words), a consortium of European researchers (France, Germany, Italy, Portugal) was able to demonstrate the limits of the US study and defend the perspective of adaptation by human actors as a major factor of resilience to climate change of wine regions in Europe.

PERSPECTIVES

This note has strengthened the links between the European teams working on these themes. Other articles were published in collaboration thereafter. It provides the elements to the LACCAVE participants to answer to the questions of professionals and media.

EXPLOITATION AND DISSEMINATION

This note has been taken over by the media. The simulation work of the wine-growing potential of the various French and European regions were conducted under LACCAVE and is the subject of communication and scientific articles (Wood et al, 2014. Fraga et al, 2016. Quénol and al., Proceedings Climwine, Schultz et al., Proceedings Climwine).

Furthermore the "Special Mention of the OIV" price for the book "Climate Change and terroirs by Hervé Quénol Ed Lavoisier, should be emphasized as an additional highlight result in this category.

KEYWORDS

Production potential, simulations, climate, climate change adaptation

TITLE The sensitivity of consumers to the wines of global warming and its economic consequences

CATEGORY: 1 advanced scientific results

SUMMARY

The Ph-D of A. Fuentes, co-funded by ACCAF, has set up an experimental economics method to reveal the willingness to pay of consumers and analyse the objective bases of this willingness from the characterization of wines. The results highlight that the willingness to pay vary according to the characteristics of the wines linked to global warming, but also show that a fatigue effect can be observed by repeated consumption.

CONTEXT AND ISSUES AT STAKE

Climate change is expected to alter the relationships between wine quality and its geographical origin. This questions the ability of consumers to adapt their preferences to these developments. It is important to define the intrinsic and extrinsic characteristics of the wines that determine the willingness to pay of consumers. An experimental economics work was developed to test the preference of consumer groups and their willingness to pay for these new types of wine. In a first step, the acceptability of consumers for wines with characteristics related CC is evaluated and in a second step it is necessary to evaluate the evolution of their perceptions .The objective is to provide microeconomic models mobilizing the theory of product differentiation and the organizations.

RESULTS

An original protocol combining experimental economics and sensory analyses was developed to characterize the willingness to pay (WTP) and the hedonic judgment of consumers. The experimental market offered the opportunity to study the effect of sustainability tastes, their heterogeneity, taking into account the preferences and long-term consumption patterns. This Ph-D thesis was undertaken in a collaborative way between economists (Aliss, Gaia) and oenologists (Bordeaux, Montpellier) from the LACCAVE project.

- Effect of temporality in experimental economics: empirical verification of the instability of consumer tastes depending on the time of exposure to a product (innovative results in the field of experimental economics)

- Consumer fatigue effect for wines of global warming which is expressed in their willingness to pay 'revealed' by an incentive system.

- Influence of different sensory characteristics of the wines of climate warming on the assessment of consumers and the enhancement of the wines on the market

- Valuation differentiated by consumers for oenological processes (dealcoholisation and acidification) aiming to 'correct' the adverse effects of global warming.

PERSPECTIVES

The question of the stability of tastes and economic consequences, which was revealed during this work on wines of climate warming, should be investigated and generalized to other contexts (eg the issue of organic wines and “nature” wines, or wines that meet societal concerns), a

European project started on this topic, coordinated by ISVV and UR Oenology of Bordeaux, from September 2016.

EXPLOITATION AND DISSEMINATION

Fuentes et al., 2016 Climwine2016 Oenométrie and XXIII (25-28 May 2016)

The scientific and academic valuation of many work mostly start in the 3rd quarter 2016. Submissions to high level journals have fallen behind because of the heaviness of the work (both referred journals: Food quality and Preference and American Journal of Agricultural Economics).

This project was supported by the OIV which has funded additional experiments that helped to deepen our analysis.

The Ph-D of E. Neethling (systemic and multidisciplinary approach to adaptation at the local level) and A. Coupel-Ledru (genetic determinism of adaptation to drought) can also be highlighted in this category.

KEYWORDS

Consumer willingness to pay, economy, lassitude.

TITLE : LACAVE RESEARCHERS MOBILIZED FOR COP21

CATEGORY : CONTRIBUTION TO « SCIENCE FOR THE CITIZEN »

SUMMARY

The researchers of LACCAVE have mobilized to contribute to COP21. Three key messages were promoted: adaptation will be easier in the vineyards if the temperature rise remains under 2 °C; solutions combine innovations and actions at different scales ; collaborations between researchers and actors of the wine industry are crucial. These messages were developed during the COP21 event, in national press, TV and radio broadcasts, exhibitions and professional media.

CONTEXT AND ISSUES AT STAKE

In the context of the Paris COP21, scientists were called to participate in expertise, in support of policy makers, but also in public debates in order to disseminate scientific knowledge to the society as a whole and "push" the negotiations. Wine is an iconic product in France and in the world, deeply affected by climate change. Taking advantage of this “cultural proximity” between wine and many French people, the researchers of LACCAVE decided to disseminate strong messages about the global need for mitigation and adaptation.

RESULTS

The LACCAVE project provides many results that help to better understand i) the impacts of climate change on vine and wine, and ii) the systemic dimension of adaptation strategies, that can include selection of new varieties, oenological innovations, development of new agronomic practices, new way of terroir management, vineyard relocations, institutional changes…. The researchers decided to early disseminate some of this results during the COP21, before the end of the project. They invested the main scientific, professional and public events in 2015 by communicating around 3 messages: i) adaptation will be easier in all vineyards if the temperature rise remains under 2 °C, converging with the COP21 objectives ; ii) there is no single/simple solution, but a set of innovations and actions that should be combined at different

scales, especially at local and regional level ; iii) uncertainties about the effects of climate change call for closer collaboration between researchers and stakeholders of the wine industry, in order to increase responsiveness and adaptation of vineyards. These messages were developed in the main events related to the COP21 (Unesco conference, Grand Palais, "train for the Climate" ...), the national and international press (Le Monde, Les Echos, La Croix, Paris Match, pour la Science, Huffingtonpost, AFP, Reuters, American Scientific...), many TV and radio programs (Arte, TF1, France 2, France 5, France inter, France Culture ...), professional exhibitions and media (Salon de l'agriculture, Sitevi, technical journals ...) and presented to both the French Minister of Research and the President François Hollande. The project has strengthened the impact of INRA on the theme of climate change and has reached different audiences.

PERSPECTIVES

LACCAVE formally ended with the international symposium Climwine (Bordeaux 10-12 April 2016) and the publication of the results of a prospective for the French vineyards in 2050. The communication strategy and the contribution during COP21 helped to develop new scientific perspectives (Laccave2, European project) but above all new kinds of dissemination to wine producers and to the society.

EXPLOITATION AND DISSEMINATION

- Participation in events related to COP21: CSA Congress Montpellier, Paris Unesco conference, interventions in Grand Palais during COP21, contribution to the " climate train", many conferences in side events (SFER, Cité des Sciences, Academy of technologies ...)
- National and international press articles: Le Monde (3 items and a cartoon blog), Les Echos (4 items), Ouest-France, Paris-Match, Sud Ouest, Revue Parlementaire, Pour la Science, Science et Vie, Reuters , AFP, la Tribune de Geneve, Midi Libre ...
- TV Shows: Arte (X: enius), France 5 (Allo doctors Daily), TVnews TF1, France2 and France3, iTV, Science et Vie TV (award of Pariscience film festival), ORF TV ...
- Radio program: France Inter (la tête au carré), France Culture, RFI, Classic Radio, Voice of America ...
- Exhibitions and technical press: Salon de l'Agricultural, SITEVI, CNAOC congress, revue des oenologues, réussir Vigne, La Vigne, Vitisphère ...

KEYWORDS

wine, vine, climate change, COP21, advocacy, citizen science