

Final conclusion

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In exploring the new field of research that revolves around vine, wine and climate change, this book gathers the contributions of researchers and their partners, who for the last 10 years have engaged in a productive and enthusiastic scientific partnership through the LACCAVE and LACCAVE 2.21 projects, supported by INRAE. The 16 chapters of this book present the project results along with updated summaries to help readers better understand the climate impact on grapevines and wines, assess adaptation levers, and co-create strategies at different scales, from winegrowing estates to national policy. This book provides new knowledge from a range of disciplines to strengthen the adaptation capabilities of wine industry stakeholders. This desire to participate in the adaptation processes themselves led LACCAVE participants and book contributors to come up with a series of key messages calling for adaptive co-management of winegrowing areas, and to pursue a new, cross-disciplinary and transformational approach to research.

The co-creation of key messages for industry stakeholders

At the closing seminar of the LACCAVE 2.21 project held 24–26 November 2021, researchers and their partners came together to produce a series of messages for the vine and wine industry, political leaders, and society in general. Drawing on theme-based summaries, preliminary messages were put forward, improved upon and selected at workshops before being put to winegrowers at the SITEVI trade show,⁵¹ which followed the seminar. This original and participatory approach to message creation led to the drafting of a press release, which was covered by a number of media outlets.⁵² Three years on, these messages remain relevant and topical, which has everything to do with the increasingly marked effects of climate change on the industry.

51. International trade show for vine and wine producers.

52. In particular, an article published in *Le Monde* on 16 December 2021 and entitled “*Climat : les pistes du projet Laccave pour sauver les vignes*” (Climate: LACCAVE project plotting a path to vine salvation). There was also coverage by *Le Paysan du Midi*, *Vitisphère*, and, at a later stage, *France Inter*, the *Financial Times*, and CBS, among others.

The first message is a serious warning. It is worth reiterating that the impact of climate change is only intensifying in winegrowing areas. It is disrupting the way vines and their ecosystems function and has knock-on effects on wine characteristics, the development of industries and markets, the geography of winegrowing areas, and the risks and viability of many businesses.

However, adaptation solutions are possible if the rise in average temperature is restricted to around 2°C and if industry, the authorities and the research world continue to work together. There are many adaptation levers and they need to be trialled at a faster pace. With this in mind, participants in the LACCAVE project selected eight other messages targeting these levers:

1. The conservation and improvement of winegrowing soils must be given priority if we are to promote the resilience of vineyards by monitoring grass cover, adding organic matter (compost, mulch, conservation grazing, etc.), taking anti-erosion measures, etc.
2. Renewing and diversifying planting material is also a key option as it would enable the planting of later-ripening grape variety/rootstock combinations that are resistant to drought and higher temperatures and produce less sugar or more acids. This option encompasses ancient varieties, those grown in other regions, and new varieties. To bring this about and encourage the sharing of information, support must be given to collections and conservatories, individual and collective experiments and observation networks, all of which must also be coordinated.
3. Water should be managed in a systemic way and on a regional scale and take into account wine types, grape varieties, winegrowing practices and soil management, which regulates the circulation of water and its recharge from autumn and winter precipitation. Precision irrigation can be used to control vine water status, but its generalized use is neither possible nor desirable. Water-efficient and agroecological farming practices should be promoted, as should good crop management so that most vineyards can remain rainfed.
4. While there are methods for adapting winemaking to limit the effects of climate change (by reducing alcohol content or adjusting acidity, for example), systemic and applied oenological research into new varieties is still required.
5. Spatial heterogeneity across a small winegrowing region is a resource for adaptation, which involves new knowledge, mapping and modelling. Local management of fires, ecosystems and landscapes requires a winegrowing governance structure that includes other local stakeholders. Climate change thus requires new approaches to landscape engineering in winegrowing regions.
6. Climate risks are disrupting economic strategies. Private insurance schemes must be applied along with public and joint support schemes and investments, prevention measures, improved information and warning systems, and new options for wine reserve management and market diversification.
7. Taking consumers into account is essential to understanding their preferences as wines and adaptation innovations evolve, and also to raising their awareness and involving them in strategies designed to tackle climate change.
8. The wine industry must contribute to climate change mitigation by reducing its emissions and capturing carbon. There are many avenues for doing so, such as soil and landscape management, logistics, and building insulation. Such engagement will not go unnoticed by consumers, thus enhancing the image of wine.

One final, all-encompassing message is that the LACCAVE project highlighted the need to design and evaluate combinations of these various adaptation levers, using systemic and participatory approaches to build strategies at different scales of action: vineyards, catchment areas, winegrowing regions and the domestic wine industry, where the adaptation strategy developed as a result of this project is implemented.

Adaptive co-management of winegrowing areas at multiple scales

“Creating and coordinating adaptation strategies at different scales” gradually became a major research issue in the LACCAVE and LACCAVE 2.21 projects, as the chapters in the second part of this book showed. Yet over and above the desire to produce scientific knowledge that can spur action, the project participants helped put together a new management perspective for the vine and wine industry, one that involves moving towards adaptive co-management of winegrowing areas, regions and the wines they produce. This proposal takes up the results of research into the management of social and ecological systems in response to climate change (Plummer, 2013; IPCC, 2022). It is also the pragmatic outcome of LACCAVE’s foresight studies, the results of which were enhanced by participatory forums in seven winegrowing regions, and then harnessed to co-create the national adaptation strategy (chapter II-7).

Adaptive co-management gradually emerged as an approach in exploring different adaptation pathways, and in highlighting the issues and outcomes involved. Doing nothing and relying solely on nature and tradition is not an option, as it would mean suffering the ever-increasing impact of climate change. Nor does relying on changes to practices and grape varieties within the framework of the industry’s existing rules seem sufficient in the face of the quickening pace of climate change. That said, the widespread relocation of vineyards with a view to finding favourable climate conditions elsewhere would appear to be impossible on a political and societal level and entail a whole host of unknowns. Liberal regulation, based on the promises of the market and technological innovations, would totally disrupt the industry and has been roundly rejected by stakeholders (Touzard *et al.*, 2020). On the other hand, speeding up innovation to allow winegrowing to stay in its existing terroirs is a popular option in all regions, albeit with an awareness that the excessive artificialization of systems could potentially sever the links between wine and its local region. This is where adaptive co-management comes in, by mapping out this latter adaptation pathway.

Adaptive co-management of a vineyard and its region and wines can be seen as an iterative (or circular) process of exploring, implementing, monitoring/evaluating and rethinking solutions (planting material, technical and oenological practices, management of local resources, communication and organizational actions in the industry, etc.) to develop sustainable winegrowing that is able to withstand climate change (Boyer and Touzard, 2021). At local and regional level, it is founded on a collective approach, which may be led by a protected designation management body, for example, and open to consumers and stakeholders involved in managing local resources necessary for adaptation, such as soil, ecosystem, landscape and water. This process is backed up by a

dynamic of continuous experimentation and learning, designed to make winegrowing systems more resilient. Its development is linked to a series of conditions and actions, many of them already envisaged or implemented:

- Updating PDO or PGI principles, which may continue to safeguard a specific quality linked to a region, but which may evolve and which must express, above all, a guarantee of adaptive (and sustainable) co-management of the region's resources;
- More flexible specifications, including more practices linked to the environment and climate change mitigation, a direction that the INAO has already taken with the option of introducing varieties of interest for adaptation and testing innovations;
- The development of training courses for winegrowers and industry stakeholders, and of "new terroir engineering", combining skills in diagnosis, spatial analysis, climate simulation, experimentation, and the adaptive and participatory management of local resources;
- Changes in public policy, recognizing the contributions of agriculture and winegrowing, and supporting innovations and approaches associated with the adaptive co-management of winegrowing areas.

Cross-disciplinary, transformational and media-friendly research

The adaptive co-management of winegrowing areas also hinges on researcher involvement, and calls for a new era of partnership and participatory research into grapevines and wine. This "new" way of doing research was tested pragmatically in the LACCAGE project and provides a thread common to every chapter in this book. The desire to study and support climate change adaptation processes in the industry led researchers to embark on a new way of producing scientific knowledge that is cross-disciplinary, transformational and media-friendly.

The complexity of the impacts of climate change, the many aspects and dimensions of the analysis of adaptation solutions, and their combination at different spatial and temporal scales in the design of strategies have prompted researchers from different disciplines and laboratories to work together on vine and wine, and produce interdisciplinary and systemic knowledge. Growing demands from stakeholders in a well-organized industry that is increasingly concerned by the quickening pace of climate change have also led researchers to involve these stakeholders in their projects and to engage with them in reflection, discussion and actions aimed at transforming winegrowing activities and how they are managed at the regional and sectoral level. In addition to these participatory initiatives with industry stakeholders, wine's special place in French society also led researchers to produce documents and videos for a wider audience, and to take part in a number of media initiatives. In the process, viticulture and wine have become a means of raising public awareness of climate impacts and the challenges of mitigation and adaptation. Although the issue of mitigation was not covered in the LACCAGE project, and is given little consideration in this book, researchers and their partners affirmed the importance of combining it with adaptation. To give ourselves continued room for manoeuvre in terms of

adaptation, we need to do everything we can to keep global warming below a 2°C temperature rise, a level that seems compatible with the adaptive co-management of “terroir-based viticulture”.

Supporting just such an outcome are new INRAE guidelines promoting participatory science and research and the backing provided over 10 years by its ACCAF meta-programme. It has also been influenced by general sociopolitical changes, which have expressed the urgent need for climate action (COP21 in Paris) and looked to scientists to come up with new policies, although the measures implemented to date are still too limited. That said, the initiatives, commitments and collective actions instigated by researchers in projects such as LACCAVE have all been meaningful.

This book describes an adaptation pathway embarked on by researchers and their partners and leading to changes in their activities, professions and contributions. These changes include producing scientific knowledge on processes (impact and adaptation) based on observations and modelling; providing expertise based on this knowledge; developing new participatory methods; raising the alarm on key issues; becoming communicators and debaters; co-creating solutions and supporting public policies; and opening up areas of social experimentation for the transformation of winegrowing systems.

This pathway transformational science (Fedele *et al.*, 2019) is but one step, however, in developing knowledge for climate change adaptation. The fact is that the contributions in this book raise a whole host of questions. It goes without saying that we need to continue our work on climate impacts, particularly at the grapevine and terroir level, and on the many interlinked effects in viticulture ecosystems and landscapes. The exploration and analysis of solutions must be extended to new areas and options encompassing, for example, agroecological, digital, biotechnological and robotic innovations. Though risk management and awareness of extreme events is an issue that has yet to be addressed in any great depth in winegrowing, it is becoming crucial. The evaluation of solutions (multicriteria, environmental, economic) and their combination in adaptation pathways in particular remains a key area of work. In more general terms, the conditions for developing adaptive co-management of winegrowing areas and related industries (including the testing and evaluation of innovative systems) should be at the heart of new research conducted at regional level, which should be compared and benchmarked nationally and internationally.

The international dimension is indeed crucial and one of the key perspectives of this book. The work presented in these chapters concerns French vineyards and related industries. Given the size of its vine and wine sector, the diversity of its winegrowing areas and wines, and the importance of its research facilities and partners, France is a living lab for the study of adaptation. The country has the potential to make a widespread and global impact, extending its historical influence in the world of wine and its teaching and research. Climate change is affecting all the world's winegrowing areas (chapter II-1), triggering an even wider range of potential initiatives, projects and partnerships. The authors of this book are already involved in European and international projects, and many of their results have been presented at international conferences or under the auspices of the OIV, with scientific partnerships being strengthened. This book seeks to provide the basis for a change of scale by calling for an international interdisciplinary research programme that will continue with the work and methods developed in the LACCAVE project and presented here. Climate change is global, and so is viticulture

and wine, albeit with qualities that express local characteristics. If we are to prolong the history of a great plant and drink that express and enrich part of the culture and pleasures of our societies, then adaptive responses to climate change will require greater cooperation and action on a global scale.