Agriculture, forest, climate: the road to new adaptation strategies in France (the AFClim foresight)

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Abstract: Agriculture and forestry are particularly exposed to climate change. Although its effects are already tangible, stakeholders in these two sectors still face a lot of uncertainties about climate change and have difficulties in designing farming and forest systems adapted to the future climate. For these reasons, the *Center for Studies and Strategic Foresight* of the French ministry of agriculture carried out a foresight study, based on an interdisciplinary group of 30 experts. It aimed at designing adaptation strategies to climate change for agriculture and forest. This paper focuses on agriculture.

Our approach started with 14 concrete case studies in France (9 in agriculture and 5 in forestry), accounting for the diversity in farming systems (cereals, winegrowing, fruit production, dairy breeding, etc.) and pedoclimatic conditions. For each case, we modeled the effects of climate change on the farming system around 2050, using agroclimatic simulations. Then, with the help of the expert group, we designed different technical adaptation options for each case. Afterward, we built four contrasting scenarios of socioeconomic context and matched the previous adaptation options with these scenarios.

Our results revealed three main adaptation strategies for cropping systems: securing yields through irrigation, avoiding water stress and diversifying crops. The most-likely chosen strategy strongly depends on possible future socioeconomic contexts though. In scenario "*metropolization and consumerism*", adaptation remains limited and based on technical optimization. In scenario "*liberalization and focus on production*", adaptation mainly relies on irrigation and negative environmental impacts could occur. In scenario "*a mosaic of areas and stakeholders*", adaptation strategies are very heterogeneous and reinforce local specialization, which causes mixed environmental effects. Adaptation to climate change is logically more pronounced in scenario "*energy and environmental transition*": cropping systems are deeply redesigned in order to enhance their resiliency through diversification and autonomy.

Thanks to the *AFClim* foresight study, we thus brought new insights about resources and constraints for adaptation to climate change and showed that designing adapted cropping systems will require actions to raise awareness, collective action and integrated public policies.

Keywords: agriculture, climate change, adaptation, case study, scenario, foresight

Introduction

The planet's climate is changing. Higher temperatures, shifting rainfall patterns and more frequent extreme weather events are only a few of its symptoms. What the impacts of climate change will be like, and how far they will reach, have not yet been ascertained. However, some trends are already measurable today. The world's average temperature has increased by 0.85 °C over the period 1880-2012 (IPCC, 2013). In addition, there is no longer any doubt that human activities have triggered these developments.

Agriculture heavily depends on natural conditions, and is therefore especially exposed to climate change. Many essential parameters in this sector will change: inter alia, water availability will decrease, growing seasons will be longer, droughts will occur more frequently, and the risk of frosting will decline. Awareness of climate change is spreading, but that has done little to sway decisions over short-term issues today. The preparation work to roll out several of these adaptation options tomorrow, however, needs to start today. This preparation work includes restructuring farming operations in depth, blazing new trails to find new technical solutions, building new industries, etc.

The fact that this topic is so complex, and that stakeholders are understandably struggling to grasp the issues associated with adaptation, prompted the French Ministry of Agriculture's *Center for Studies and Strategic Foresight* (*Centre d'études et de prospective, CEP*) to conduct the *AFClim* foresight study, to look beyond the short term and to understand our capacity to take action, by exploring the various feasible adaptation options and then combining them with various possible scenarios. This study is not a forecast or planning exercise: it is rather a tool to raise awareness, trigger action and support decisions.

While *AFClim* also deals with forestry, this paper only focuses on agriculture. It presents a few of the main findings contained in the full report[312] published in 2013 (Vert *et al.*, 2013). It first explains the methods and rollout, zooms in on one of the fourteen case studies to use it as an example, describes the four scenarios created for this project, and sums up the main conclusions.

AFClim foresight study methods and rollout

The *AFClim* foresight study deliberately focused on the concrete and local aspects of climate change, in order to present the adaptation initiatives that farmers will be in a position to take from an angle that they can relate to. To do that, this exercise was based on the collective expertise of a group of approximately 30 people from a variety of fields and backgrounds, spanning professionals, researchers, government officials and civil society representatives. This group, chaired by the CEP, met a dozen times in 2012. Discussions were also based on available scientific literature, and on a set of quantitative data supplied by Météo France (France's national meteorological service).

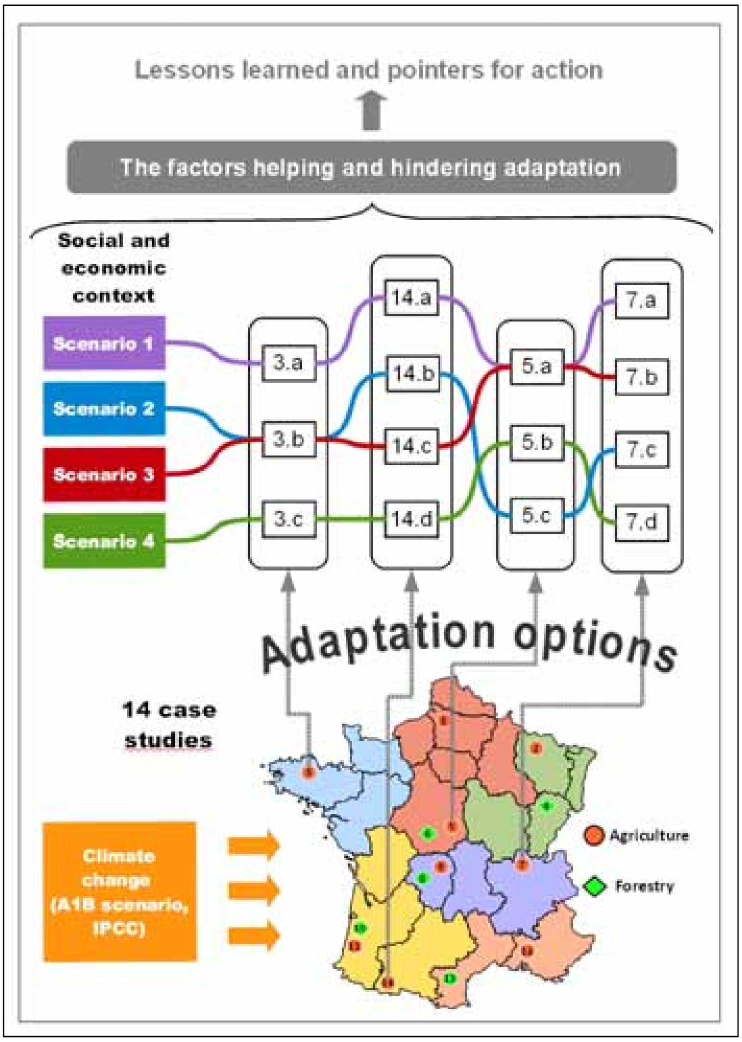
In order to root this study in local areas, the team followed a bottom-up approach (from local to national and particular to general). It started with 14 case studies in France, including 9 cases in agriculture (Figure 1), focusing on individual farming operations. The case studies were selected to illustrate the diversity in production systems (cereals, winegrowing, fruit production, dairy breeding, etc.), disparities from one region to another, and contrasting local climates as clearly as possible. The goal, however, was not to attempt to represent all situations on a countrywide scale.

The case studies reflect real situations built from field data, for instance the INOSYS network (Fèvre, 2012). The description of the local climate and estimates of the changes underway were based on Météo France climate model ARPEGE (Déqué *et al.*, 1994) and IPCC GHG emission scenario A1B. The timeframes for agriculture run through 2050. All the case studies are struc-

[312] Please see the full report for further information.
http://agriculture.gouv.fr/IMG/pdf/CEP_Prospective_agriculture_foret_climat_cle0f7d9d-1.pdf

tured in exactly the same way. They start with a technical and economic analysis and a description of the area and its climate today. Then, Météo France data from the nearest reference station are used to estimate how the climate will evolve and the possible effects on farming system, according to current scientific knowledge and in particular the Climator project results (Brisson and Levrault, 2010). Lastly, in light of the resulting threats or opportunities, the group of experts collectively designed a series of adaptation options. Afterward, we built four contrasting scenarios of socioeconomic context and matched the previous adaptation options with the different scenarios (see part 4).

Figure 1: The *AFClim* approach and the 14 case studies. Source: Villien and Schaller, 2013.



1. Industrial crops in Somme
2. Mixed farming and livestock in Meuse
3. Dairy livestock farming in Côtes-d'Armor
4. Uneven beech forest in Haute-Saône
5. Arable crops in Cher
6. Oak grove in the Loire basin
7. Winegrowing in Beaujolais
8. Douglas fir forest in Limousin
9. Suckler herd in Creuse
10. Maritime pine in Landes
11. Irrigated corn in Landes
12. Tree farming in Vaucluse
13. Fir plantation in Mediterranean medium mountains
14. Sheep rearing (meat) in Hautes-Pyrénées

Example of one foresight case study: winegrowing in Beaujolais

The vineyard and area

This winegrowing enterprise spans 14 hectares and markets "Beaujolais" and "Beaujolais villages" wines. It has a 1.6 Annual Work Unit (AWU), meaning that this mostly family-run operation has a heavy workload. It produces 550 hectolitres of wine per year and sells 95% of its output in bulk, to merchants. The aging vines are almost exclusively Gamay. Some of them were recently grubbed up and replaced with Chardonnay. The machinery is aging but this vineyard has little debt. The €7,000 per AWU it generates, however, only provides this vineyard's owners with a low income and they heavily depend on "Beaujolais Nouveau" sales.

About one in four winegrowing enterprises in the Beaujolais area resemble this one, and vineyards account for almost half of the agriculture sector's economic weight in the Rhône department. The soil in this area is poor, shallow and often sloping. The climate is semi-continental, but benefits from its Mediterranean influence. The winters are cold and dry, and the summers hot. Watercourses throughout this area sink to very low levels.

Climate change and its effects

By 2050, rainfall between July and September will probably decline fairly significantly (-50mm compared to 1970-2000), entailing considerable water stress (P-ET0 reduced by 200mm) and lowering flow levels, which are already noticeably low. Annual mean temperatures will increase by 2°C, and temperatures will exceed the average of 32°C five times more often than in the recent past (1971-2000). Phenological cycles should shift 8 to 10 days earlier. The high temperatures could degrade the quality of the wine, but this vineyard will need to continue to meet AOC (*Appellation d'Origine Contrôlée*) standards nonetheless. The risk of wilting in summer will probably increase, and the low watercourse levels will allow very little margin for irrigation.

The adaptation options

Here are the four adaptation options the group of experts designed for this case.

Adopt practices to shield vineyards from the effects of high temperatures

This first option is to limit the effects of high temperatures on grape seed quality by optimizing the use of space. This involves planting on the north-facing hillsides, or switching to certain practices including high trellising, mulching, no longer trimming leaves, etc. These techniques, however, may not be enough to avoid altering the quality of the wine. This in turn could jeopardize consumer perceptions and AOC standard compliance.

Maximize yields by developing irrigation

This second option involves irrigating to maximize yields. This strategy would keep water comfort at adequate levels in the vineyard, but would involve substantial investment and would only be feasible if water is available (other uses, etc.) and in the vineyard areas that are not particularly steep, to avoid erosion.

Use vine varieties that are better adapted to water stress

The third option would involve planting new vine varieties, which are more resistant to water stress. If irrigation is unfeasible, later grape varieties – Merlot, Syrah or Grenache, i.e. varieties that are better suited to hot and dry conditions – could be a few of the solutions. This, however, would entail forsaking AOC certification, which is only an option if the area's entire wine industry rallies together around new alternative initiatives.

Develop nut plantations and energy crops

Shifting towards other crops is the fourth option. If the winegrowing industry descends into a crisis, operators could develop less water-intensive crops (nuts and energy crops) on the plots fit for mechanization, and consider forestation in the patches that are more sensitive to erosion.

The social and economic scenarios, and case study contextualisation

The 14 case studies provided the core of the *AFClim* foresight exercise, and provided a technical angle on leads to adapt production systems to the effects of climate change. From the 5 case studies dedicated to cropping systems, we can identify three main adaptation strategies: securing yields through irrigation, avoiding water stress and diversifying crops.

Implementing these ideas, however, raises social, economic and organizational issues. The group of experts therefore built four context scenarios on a national scale to factor in those issues. Then, they combined the options they had imagined for the case studies with each of the scenarios, analysed each combination in order to home in on the factors that will help or hinder efforts to adapt, summarizing them for each scenario.

These scenarios were built using the eponymous method in foresight studies (De Jouvenel, 2004). The group collectively identified a corpus of social and economic factors that direct farmer and forester decisions, and clustered them into four components[313]. Then, they devised several courses for each one. Various combinations of these micro-scenarios separated into components then made it possible to develop four larger scenarios. They provide plausible, consistent and deliberately contrasting pictures of the future context surrounding French farms and forests (see box 1).

The adaptation options in the case studies cannot be disconnected from their local context or extrapolated to a national scale. In other words, the goal behind combining them with each of the scenarios, is not to concoct four self-sufficient national adaptation 'plans' but to identify the favorable and unfavorable contexts for the adaptation initiatives under review. These combinations were based on expert opinions at the workshops, and the principal criterion was consistency between the scenarios and adaptation options under review (Figure 1). The outcome of this work was then transferred onto two matrices[1] to qualify the level of change in production systems on the ESR (for Efficiency, Substitution and Redesign) matrix (Hill and MacRae, 1995), and the strategy to cope with weather hazards (resistance or resilience; Dauphiné and Provitolo, 2007). Lastly, the summary for each scenario provides an overview of the adaptation approaches in agriculture, highlights the main drivers and the factors thwarting efforts to implement these approaches, and explores the potential economic, social and environmental consequences that these imagined futures can entail.

[313] The four components: farmers and foresters; demands on farming and forestry; the European and international context; public policy and governance. In all cases, a single IPCC scenario (A1B) is used.

Box 1: The key aspects of the four social and economic context scenarios

Scenario #1: Metropolization and consumerism

Society becomes pervasively urban, acutely neglects rural areas and develops a utilitarian view of the environment. Demand for healthy goods (i.e. high nutritive quality and health standards) outweighs heterogeneous demand encompassing environmental concerns and production systems. Farming and forestry become economic sectors on a par with the others. The specific bodies disappear and the agricultural sector reorganizes to meet demand for healthy food downstream. The quest for competitiveness is the main driver pushing these changes. Economic growth is feeble but regular. Petroleum prices are high and worldwide demand for agricultural commodities remains on a steady upward trend without any major crises. Government embarks on an advanced decentralization process, strengthening already powerful local authorities. Large metropolises and other urban areas leverage this opportunity to consolidate their influence over land management and public policy in general.

Scenario # 2: Liberalization and focus on production

Profitability rationale predominates, and trade liberalization and market-based regulation prevail. Emerging countries establish their presence as key players in the world's economy. This development model is still powered by fossil fuel, at the expense of efforts to curb climate change. Government keeps its interference in economic enterprise to a minimum. CAP budgets nosedive. Farming and forestry become financial commodity markets, their specific bodies disappear and downstream sectors regulate the market. Farmers focus on production and on staying competitive. Severe tension on food and energy supplies shift the spotlight to output volumes in farms and forests, relegating environmental protection to the sidelines at best.

Scenario #3: A mosaic of areas and stakeholders

The view that globalization triggers instability leads the world to withdraw into 'regional blocks', and trade between those blocks shrinks. The 'back-to-local' trend is at work, and an extensive decentralization and relocation drive is set in motion in France. Government prerogatives are gradually transferred to local authorities, which are deemed to be in a better position to deal with the population's requirements. This context leads civil society to assert its role in public affairs, and stakeholders join forces in networks pursuing common goals. Innovation and integration become the central goals shaping developments in renewed urban areas. Demands on farming sector flourish, and are geared to consolidate each area's strength with a view to forming multipurpose areas furnishing local populations with living environments, products and services.

Scenario #4: Energy and environmental transition

Demands on farming and forestry proliferate, encompassing high-quality food production, energy production, environmental services and territorial development. Farmers are disinclined at first but eventually rally together and embark on an environmental and energy transition. Policy to protect the environment and stem climate change slowly but surely gains legitimacy and enters into force as economies recover throughout Europe. Developed countries finally agree that an environmental and energy transition is the only way to go, and emerging countries follow suit, to the point where environmental and weather-related issues shift towards worldwide governance.

In Scenario #1 (Metropolization and consumerism), marked by intense urbanization and subdued environmental requirements, the adaptation options are associated with feeble driving adaptation strategies, and marginal system tweaking only enabling limited adaptation to climate change. In agriculture, efforts to adapt production systems hinge on optimizing technical resources and on harnessing available resources, and the associated strategies depend on substantial production volumes in a buoyant economy. In grass-fed livestock farms, this entails adapting husbandry (grazing period and reproduction schedule) to the shift and the increase in grass growth. In perennial crops, it can involve forsaking typical products for consumers detached from local areas (e.g. winegrowing in Beaujolais, option 3). In the case of annual crops, decisions on water management foster farming circles and enable frequent irrigation, which in turn secures yields. Demand for healthy and inexpensive products predominates in this scenario, and farms accordingly focus on supplying them. All the necessary and available resources are leveraged, without radically altering production systems and without seriously considering the environmental concerns.

In Scenario #2 (Liberalization and focus on production), the focus shifts to cost-efficiency and market-based regulation. Maintaining competitiveness in order to increase yields becomes the top priority. This entails rolling out strategies to block the adverse effects of climate change, or to tap into its favorable upshot whenever possible. High prices for agricultural products encourage farmers to secure production volumes. They may therefore principally resort to irrigation for annual (e.g. arable crops in Cher or corn in Landes) and perennial crops (e.g. winegrowing in Beaujolais, option 2). The heavy investment and higher labor costs (compared to competitors elsewhere around the world) could nevertheless threaten a number of holdings (e.g. tree farming in Vaucluse). This competition and higher production costs would also be inauspicious in livestock farming. Many mixed crop-livestock systems may reduce breeding or even shift toward farming only. In this scenario, fiercer international competition will outweigh constraints associated with climate change. Adaptation initiatives will therefore remain fairly circumscribed and focus primarily on protecting production potential in the favorable areas. In other areas, the investments required to address weather-related constraints may be dismissed, and certain activities may shift to new purposes or be abandoned, notwithstanding the serious social consequences.

Scenario #3 (A mosaic of areas and stakeholders) involves relocating economic activities, which will in turn prompt stakeholders to join networks pursuing common goals and afford local authorities a more prominent role. Each area bases decisions on its comparative advantages and priorities, leading to a diversified assortment of adaptation strategies on a national scale. In the farming sector, territories will probably specialize further. Their strategies will probably depend on the sector's economic weight and on the local effects of climate change. The farmers who can harness these developments could focus on intensifying production (e.g. industrial crops in Somme, mixed farming and livestock in Meuse). On the other hand, vulnerable positions could locally weaken a number of industries and lead farmers to refocus on new purposes or abandon productions (e.g. winegrowing in Beaujolais, option 4). The broad spectrum of strategies and interactions in this scenario make it difficult to form an overall picture. The heterogeneous variety of efforts to adapt could also render policies requiring country-wide consistency complex, e.g. to reduce GHG emissions, manage water, etc.

In Scenario #4 (Energy and environmental transition), the most advanced initiatives to adapt locally are quite logically favored, in particular via public policy incentives. The strategies will be concurrently based on diversification and/or enhancing self-reliance, and on converting the systems that will have trouble adapting to climate change. The bulk of those strategies will be aimed at reinforcing system resilience by striking a balance between food production, biomass production and environmental services. In livestock farms, this will entail extensifying production to a greater or lesser extent, diversifying forage resources, and building protein self-reliance. Adapting crop production will involve harnessing synergies with efforts to tackle the major environmental challenges, and hence entail extensive system redesign. Production will be redirected towards crops that need less water (e.g. irrigated corn in Landes). Other cropping systems (e.g. arable crops in Cher, industrial crops in Somme) will develop conservation agriculture techniques. Scenario #4 entails the deepest-reaching transformation in farming production systems, to adapt in synchrony with efforts to address the other environmental challenges. It nevertheless raises questions about technical, economic and organizational support.

Lastly, providing contexts to flesh out the adaptation options imagined for the case studies clearly highlights the variety of situations and the fact that there is no one-size-fits-all solution to tackle them all. In areas where climate change is expected to have moderate effects and resources are available, production systems will be altered modestly, mostly in order to 'resist' climate change. On the other hand, in areas where there is little room for maneuver and more substantial impacts are expected, more radical system reconfiguration needs to be considered, often with a view to increasing resilience. These changes will also ripple through other environmental issues (biodiversity, water management, etc.). Synergies between efforts to deal with these environmental challenges and to adapt farms and forests will not be available every time. It will therefore be important to remain watchful, in particular with regard to reducing GHG emissions.

Discussion and conclusions

Climate change will significantly impact farms and forests, even though the impacts are difficult to discern today. The *AFClim* foresight study's originality lies in its focus on 14 tangible case studies. This bottom-up approach nevertheless has limits. The simulations were based on a single IPCC scenario and therefore did not factor in the uncertainties surrounding climate change momentum and effects. As it used average figures, it only factored in climate variability from a qualitative perspective in the analysis (in particular as regards extreme weather events such as droughts and storms). Lastly, the necessarily limited number of case studies, compared with the wide variety of existing situations, limits this exercise's bearing on a larger scale.

These limits, stem from methodological choices, do not prevent this study from homing in on certain lessons and watchpoints. Water management is one of them. Climate change can exacerbate tension on this resource, but it appears to be one of the keys to adaptation in the case studies under review, via irrigation. It may be one of the workable solutions to maintain productive capacity, but mainstreaming it will raise availability issues in a context where water resources will be locally noticeably scarcer (Godot, 2013).

More generally, the *AFClim* foresight study shows that there are technical levers to start adapting to climate change today. The first set of levers encompasses practices to deal with water stress (deferring grazing periods, crop cycles, etc.). Another is based on using varieties that will better withstand the new weather conditions. A third one combines the strategies to enhance production system resilience, and centers on diversification.

However, given the fact that adapting to climate change ranks lower on farmers' and foresters' lists of priorities than other challenges, the chances that these developments will occur spontaneously are scant. They will only occur if the conditions are right and incentives are available. The conditions and incentives, in turn, hinge on government, professional and scientific research circles, and will involve a combination of support policy, regulation, and efforts to build new industry channels and develop new crop varieties. This collective drive will only gather speed when awareness is widespread—which is not entirely the case yet.

Ultimately, the cornerstone upholding every effective adaptation strategy is undoubtedly a continuous drive to raise awareness, disseminate knowledge, build learning capacity on the ground, and a proactive attitude on the part of all farming and forestry sector stakeholders. That is the goal behind the *AFClim* foresight study, and why it hopes to encourage discussions among industry sectors, organizations and local areas.

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