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# Agriculture, forestry and climate: the road to new adaptation strategies The *AFClim* foresight study's key findings

**Farms and forests depend heavily on natural cycles and conditions, and are therefore particularly exposed to climate change. Adapting to evolving weather patterns, in other words, is a key challenge for these two sectors. Awareness of climate change is spreading, but that has done little to sway decisions over short-term issues so far. The preparation work to roll out several of these adaptation options tomorrow, however, needs to start today. That is what led the Centre for Studies and Strategic Foresight (CEP for *Centre d'Études et de Prospective*) to conduct a foresight study (*AFClim*) in order to analyse the phenomena at work and imagine solutions enabling farmers and foresters to adapt. This paper presents a few of the main results contained in the full report[1], which was published in September 2013.**

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. But some trends are already measurable today. The world's average temperature increased by 0.74°C between 1906 and 2005 (IPCC, 2007)[2]. And there is no longer any doubt that human activities have triggered these developments: more than 40 scientific academies around the world have confirmed this.

There are several levers to curb climate change. The first one is *mitigating* it. This principally involves reducing Greenhouse Gas (GHG) emissions in order to lessen their impact on the world's climate. Mitigation ranks among the European Union's top priorities: it has set a target to reduce GHG emissions by 20%, versus the 1990 benchmark, by 2020. There may still be time to take the necessary measures to avert serious damage before the end of the century, but some of the ravages are already inevitable. Therefore, the second lever involves establishing *strategies to adapt* to climate change.

The agriculture and forestry sectors depend heavily on natural conditions, and are therefore especially exposed to climate change. Many essential parameters in these sectors will change: *inter alia*, water availability will shrink, 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 for example restructuring farming and forestry operations in depth, blazing new trails to find new technical solutions, and building new industries.

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 CEP to conduct this 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.

This paper presents a few of the main findings contained in the full report published at the end of this exercise. It discusses climate change and perceptions thereof, zooms in on three of the fourteen case studies to use them as examples, describes the four scenarios created for this project, and sums up the main conclusions.

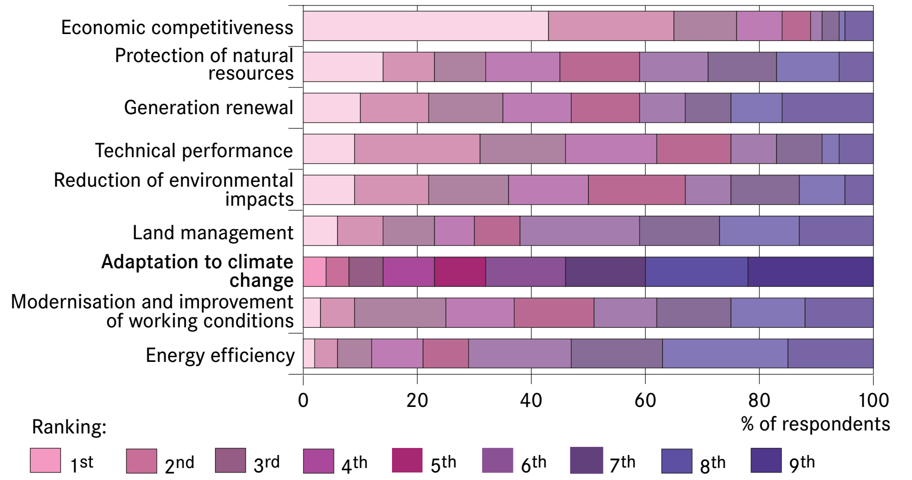
## 1 - Agricultural and forestry stakeholder perceptions

The notion of climate change has stretched beyond scientific research and into public debate. It has attracted extensive media coverage and is now in civil society's spotlight. In 2010, 84% of French people considered this phenomenon "a reality"[3]. The *perception* of this phenomenon will be one of the key factors determining the breadth and depth of efforts to adapt to climate change, as it will hinge on public policy and institutional decisions as much as more modest individual initiatives.

The foresight study by the *AFClim* group therefore entailed exploring perceptions relating to climate change among agricultural and forestry stakeholders, with two surveys[4].

1. Vert J., Schaller N., Villien C. (coord.), *Agriculture Forêt Climat: vers des stratégies d'adaptation*, Centre for Studies and Strategic Foresight, Ministry of Agriculture, Food and Forestry, 2013.
2. 2007 report on climate change. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.
3. 2010 IPSOS survey, French people no longer doubt climate change is a fact.
4. One in 2012 by the APCA (*Assemblée Permanente des Chambres d'Agriculture*) among advisors and elected officials, as part of *AFClim*, the other in 2010 by CNPF (*Centre National de la Propriété Forestière*), among engineers and researchers in the ANR research programme network *Dryade*.

Figure 1 - **Climate change and where it ranks among challenges facing agriculture**




*Agricultural chamber advisors' replies to the question "what are the top-priority challenges facing agriculture in your region/department?"* Source: 2012 APCA-CEP (MAAF) survey.

These surveys have shown that a vast majority (90%) of advisors and elected officials in chambers of agriculture have no doubts that climate change is real.

Climate science, however, is complex, and the timeframe over which these developments will unfurl seems distant. This explains the difficulty in understanding this phenomenon, and the fact that it is perceived as "difficult to master". One example of this is the uncertainty over existing links between climate change and specific and local weather variations. The feeling that unusual events are occurring, on the other hand, is fairly strong. The effects that survey respondents mentioned most often were increasingly erratic crop yields and quality, insufficient hay stocks, and shifts in phenologic stages. But, as agriculture is grappling with several other imperative demands today, adapting to evolving weather patterns still ranks low on its list of priorities (figure 1). That said, there are significant initiatives underway in farms today, even if they are not explicitly aimed at adapting. These initiatives include diversifying crops, water-efficient irrigation and others.

The perception of climate change among foresters is closely linked to the extreme weather events—storms and heatwaves—that have occurred over the past few years. Like farmers, they are seeing very real impacts in their forests—and perhaps even more so as production cycles are longer in their case. The respondents, here, mention withering first, and pathogen invasions and blowdowns second. A large number of them, however, do not necessarily see those developments as direct effects of climate change, which they by and large deem a "not very alarming" threat. However, views are more contrasted when we zoom in on specific regions or species. Beyond weather-related concerns, the perception of a species' vulnerability increases in synch with its economic weight in local industry. In other words, prairie conifers such as Douglas fir, beech and pedunculate oak top the list of concerns. Adaptation initiatives are starting to weave their way into management plans, but to varying extents in different areas. Efforts are the most advanced in areas where the forestry and logging industry plays a more prominent role in the region's economy.

## 2 - *AFClim* foresight study methods and rollout[5]

The *AFClim* foresight study deliberately focused on the concrete and local aspects of climate change, in order to present the adaptation initiatives that farmers and foresters 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 a set of quantitative data supplied by *Météo France* (France's national meteorological service).

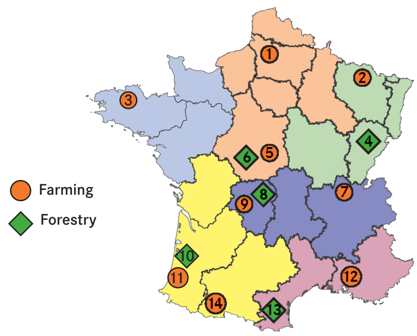
In order to root this study in local areas, the team followed a bottom-up approach (from local to national and particular to general). It started with 14 case studies, focusing on individual farming and forestry operations. Then, those case studies were combined with four context scenarios developed specifically for this exercise.

These case studies were selected to illustrate the diversity in production systems, 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 (figure 2).

## 3 - Examples from three foresight case studies[6]

The case studies reflect real situations or "models" built from field data[7]. The description of the local climate and estimates of the changes underway were based on *Météo France* climate models and IPCC scenario A1B. The timeframes for agriculture run through 2050 and the timeframes for forestry run through 2100, because silvicultural cycles are longer. All the case studies are structured 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 or forestry, according to current scientific knowledge. Lastly, in light of the resulting threats or opportunities, the group of experts collectively establishes a series of options to adapt the farm or forest.

Figure 2 - **Case studies**




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*

*The colours show the large geoclimatic areas as defined in the Climator research project[8].*

Source : authors

5. See also: Analysis N° 46, May 2012. AFClim foresight study. Farming, forestry and climate: the road to new adaptation strategies. Centre for Studies and Strategic Foresight.
6. The fact that we have chosen these three examples is unrelated to their relative importance among the other case studies: we chose them because they illustrate three contrasting situations in terms of production and expected weather variations.
7. INOSYS APCA - *Institut de l'élevage* data was used for farming cases, and a group of professionals provided data for forestry cases.
8. Brisson N., Levrault F. (Publishers), 2010. « Changement climatique, agriculture et forêt en France : simulations d'impacts sur les principales espèces.. Le livre vert du projet Climator (2007-2010) ». ADEME 336p.

## Oak grove in the Loire basin

### The forest stand and area

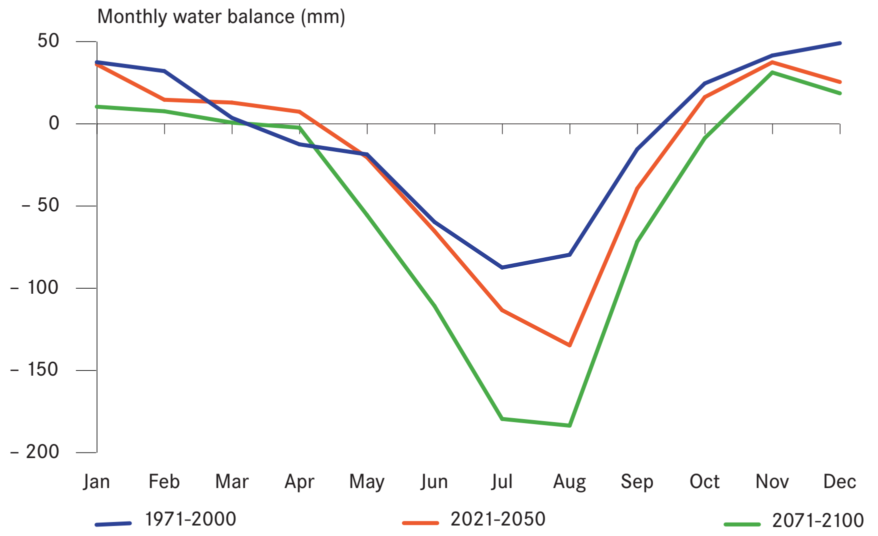
This case study focused on a state forest of pedunculate and sessile oak trees spanning 6,500 hectares in Indre. It comprises three large types of stands: a regular young tall oak forest (2,500 ha); a natural forest currently being converted (3,500 ha); and degraded stands of Scotch pine and pedunculate oak (200 ha). This forest's output is used for timber. High sale prices (up to €200/m$^3$) put annual earnings at €870/ha, and the internal rate of return[9] at 2.4%.

This French region (Centre) was in 13$^{th}$ place in France in terms of by sawn-wood volume in 2010, but is France's first region in terms of its oak timber harvests (14.6% of France's total). Harvests have been shrinking countrywide but remained stable in that region, despite the fact that some withering has been observed among pedunculate oak trees in these mountain ranges in recent years.

The forest under review stands on a heterogeneous geological substrate comprising sand, clay and limestone. The climate is continental, mitigated by the Atlantic's influence. Rainfall (approx. 700 mm) is evenly spread throughout the year.

### Climate change and its effects

Figure 3 - **Water balance evolution throughs from 2050 and 2100**




Source : Météo France

The average temperature will probably increase sharply (+ 3.2°C) by 2100, and even more so in summer. That, combined with a drop in annual rainfall (-181 mm in 2100) and long rainless periods should entail a significantly worse water balance in summer (figure 3).

Greater drought frequencies should lead to greater pedunculate oak and sessile oak withering and mortality, in particular if drier weather compounds with an expansion of parasites (leaf caterpillars, mildew, etc.). The risk of fires would increase substantially. The longer growing seasons could increase exposure to early and late frosting. The greater productivity due to the higher $CO_2$ rates will probably not offset the impacts of the drought, in particular for the pedunculate oak.

### The adaptation options

***Replace pedunculate oak with sessile oak and diversify with resinous trees***
The owner's goal with this first option is to sidestep the problems associated with pedunculate oak. He is nevertheless optimistic about sessile oak, and gradually replacing one variety with another during regeneration cutting operations. He is thinning out existing clusters of oak trees to help sessile oak, and controlling the understorey to limit competition for water. The degraded stands of oak interspersed with Scotch pine are gradually being replaced with plantations of Scotch and maritime pine for timber.

***Function segmentation, focusing investment on promising areas***
This second option factors in pedunculate oak withering and the probable decline in sessile oak productivity. It involves diversifying forestry production and objectives, i.e. leaving the less productive areas in their natural state and continuing to invest in the more favourable areas for oak timber production. Practices are also adapted (lower densities, control over herbaceous competition, and shorter rotations). Short-rotation coppice development is also under consideration in some of the less productive areas.

***Variety substitution and shorter rotations***
Here, the owner makes a more radical decision to replace current varieties with hardwood ones that are better suited to the future conditions, and to dedicate a large portion of the forest to producing short-rotation fuelwood. Plans will probably involve planting birch, grey poplar and wild service trees on hydromorphic soil, and maritime pine on less restrictive soils, for biomass or timber, on short rotations (25 years).

9. The rate of return on investments in forests is equivalent to bank saving account rates.

## Winegrowing in Beaujolais

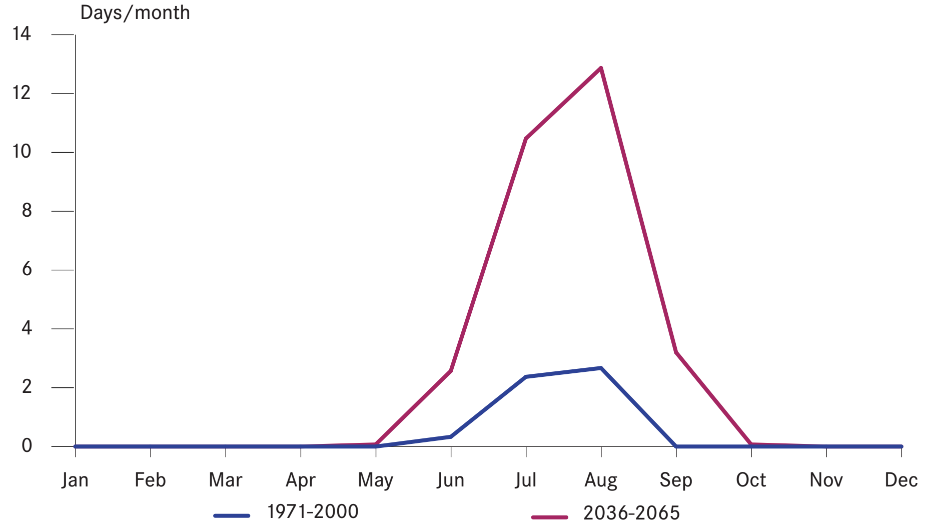
### The vineyard and area

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/AWU it generates, however, only provides this vineyard's owners with a low income and they depends heavily 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

Figure 4 - **The number of hot days (over32°C) through 2050**




Source : Météo France

By 2050, rainfall between July and September will probably decline fairly significantly (-200 mm compared to 1970-2000), entailing considerable water stress and lowering flow levels, which are already noticeably low. Temperatures will exceed the average 32°C five times more often, and phenological cycles should shift 8 to 10 days earlier (figure 4).

The high temperatures could degrade the quality of the wine, but this vineyard will need to continue to meet AOC 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

***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 optimising 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 jeopardise consumer perceptions and AOC standard compliance.

***Maximise yields by developing irrigation***

This second option involves irrigating to maximise yields. This strategy would keep water comfort at adequate levels in the vineyard, but would involve substantial investment and would only be feasible 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 mechanisation, and consider forestation in the patches that are more sensitive to erosion.

## Suckler herd in Creuse

### The farm and area

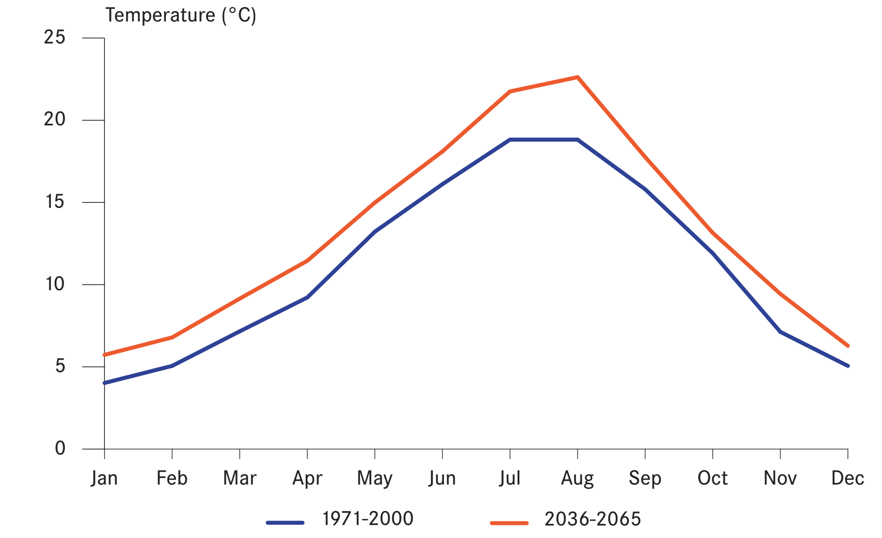
This farm is a typical *Limousin* region "cow-calf" production system. It is family-run (1.5 AWU), covers 95 ha of UAA including 91 ha of grasslands, and has roughly 100 heads of cattle, yielding 80 calves per year. Practically all its calves go to fattening farms in Italy. This simple and economic system generates approximately €19,000/AWU a year. But it is sensitive to weather conditions in spring, depends on the outside because grass accounts for a substantial portion of its forage resources, and depends on a single market outlet.

This system accounts for about one-third of the holdings in the *Limousin* area, which is home to approximately 10% of France's livestock. Beef production in turn accounts for more than half the value that agriculture generates in this region. The terrain spans a series of medium-altitude (300 to 700 m) plateaus, and the climate is temperate and oceanic. Rainfall is abundant, and evenly spread throughout the year.

### Climate change and its effects

Climate variations in this area looking at 2050 seem fairly insignificant, and indeed more favourable for agriculture in comparison to other French regions.

Figure 5 - **Average monthly temperatures through 2050**




Source : Météo France

The average temperature will probably increase by one or two degrees evenly throughout the year (figure 5), rainfall levels will probably not change during the first six months of the year but decrease slightly in summer and autumn, and there will probably be more hot days (over 25°C) in July and August.

The main impact from these developments will be longer grass growth periods in spring and autumn, combined with slower grass growth in summer. Weather conditions will be more favourable for corn in the medium-altitude areas, beyond the lowlands where it is already growing, and water resources will be consistently abundant.

### The adaptation options

If climate change seems mostly auspicious for agriculture in this region, the "*Limousin* cow-calf" production system hasl have little room for manoeuvre in the event of major climate hazards. The options below could expand its scope.

***Two calving periods to tackle the grass shortage in summer***
The first option is to establish two calving periods in order to accommodate the changes in grass growth patterns. One period at the end of autumn and one at the beginning of spring could make the most of the available grass during those periods, when there is most of it, and reduce exposure to dry spells in summer.

***Introduce "stock" feed crops***
The second option involves introducing feed crops to build a stock. Rotating alfalfa, corn, protein-rich crops and cereals (in silage) could enable these farms to cope with weather hazards and fodder shortages in summer.

***Use corn to fatten livestock or produce milk***
The third option entails converting these breeding operations by branching into fattening or dairy production. This shift will be based on increasing corn production – which will be feasible in the more favourable weather conditions. It will also avoid reliance on Italian outlets but require heavy investment in farm buildings.

***"Extensify" breeding, with quality-certified production***
Conversely, the fourth option—extensifying breeding and securing quality certification for production—entails lightening livestock concentration and thereby reducing the need for fodder. It also involves selling output directly—again, easing reliance on Italian buyers.

## 4 - 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. Implementing these ideas, however, raises social, economic and organisational 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, summarising them for each scenario.

These scenarios were built using the eponymous method in foresight studies. The group collectively identified a corpus of social and economic factors that direct farmer and forester decisions, and clustered them into four components[10]. 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. The goal behind combining them with each of the scenarios, in other words, is not to concoct four self-sufficient national adaptation "plans" but to identify the favourable and unfavourable 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 6). The outcome of this work was then transferred onto two matrixes to qualify the level of change in production systems on the "ESR" (for Efficiency, Substitution and Redesign) matrix, and the strategy to cope with weather hazards (resistance or resilience)[11]. Lastly, the summary for each scenario (below) provides an overview of the adaptation approaches in farms and forests, 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.

In **Scenario No. 1 (Metropolisation and consumerism)**, marked by intense urbanisation 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 forests, the most profitable productive investments take precedence and withering areas are forsaken (e.g. the oak groves in the Loire basin).

In this scenario, disinterest in forests, the lack of investment aid and severe pressure on local property could lead foresters to turn away from production and active management in certain forests (e.g. pine forests in *Landes* and beech forests in *Haute-Saône*)[12].

10. 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.

11. In the interest of brevity, these matrixes are not presented in detail in this document. Please see the full report for further information.

12. See the corresponding case studies in the full report.

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

Scenario No. 1: **Metropolisation 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 reorganise 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 decentralisation 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 No. 2: **Liberalisation and focus on production**

Profitability rationale predominates, and trade liberalisation 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 and foresters 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.

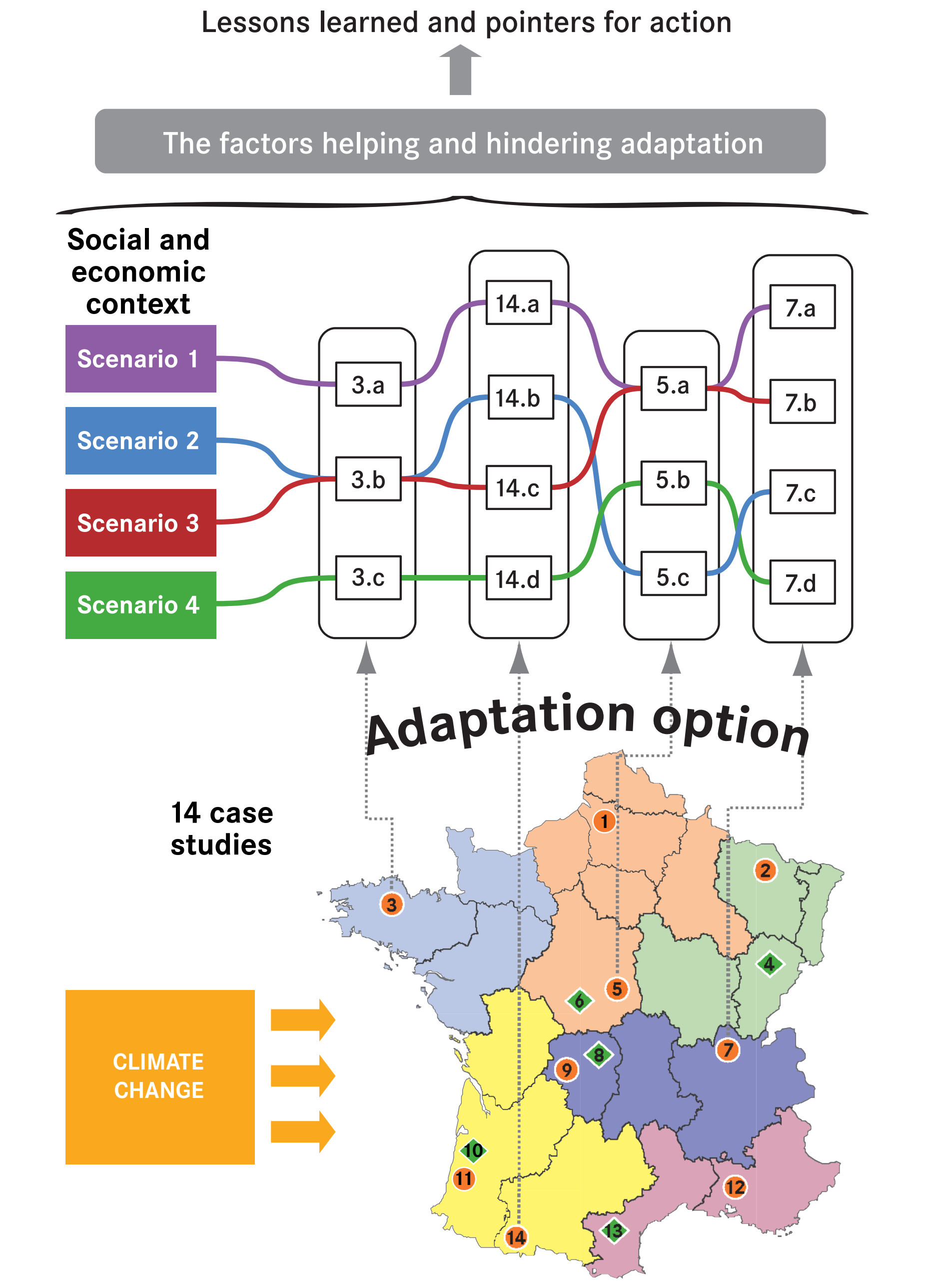
Scenario No. 3: **A mosaic of areas and stakeholders**

The view that globalisation triggers instability leads the world to withdraw into "regional blocks", and trade between those blocks shrinks. The "back-to-local" trend is at work within the regional blocks–especially in Europe and France, where an extensive decentralisation and relocation drive is set in motion. Government prerogatives are gradually transferred to local authorities, which are deemed to be in a better position to deal with the population's requirements when the world is weathering a crisis. 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 and forestry sectors 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 No. 4: **Energy and environmental transition**

Demands on farming and forestry proliferate, encompassing high-quality food production, energy production, environmental services and territorial development. Farmers and foresters 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 unanimously 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.

Figure 6 - The *AFClim* approach




Source : authors

In agriculture, efforts to adapt production systems hinge on optimising 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 to the shift and the increase in grass growth (e.g. suckler herd in *Creuse*). In perennial crops, it can involve forsaking typical products for consumers detached from local areas (e.g. winegrowing in *Beaujolais*). 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 and forests 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 No. 2 (Liberalisation 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 favourable upshot whenever possible.

The buoyant lumber market and tension on raw material supplied prompt certain foresters to increase productivity by diversifying varieties and shortening rotations. Others go as far as entirely replacing varieties (e.g. the oak grove in the Loire basin). These shifts require substantial investment, and therefore only occur where the expected returns are high. In other areas, forests may be forsaken.

High prices for agricultural products encourage farmers to secure production volumes. They may therefore principally resort to irrigation for annual and perennial crops (e.g. winegrowing in *Beaujolais*). The heavy investment and higher labour costs (compared to competitors elsewhere around the world) could nevertheless threaten a number of holdings (e.g. tree farming in *Vaucluse*[12]). This competition and higher production costs would also be inauspicious in livestock farming.

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 favourable 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 No. 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 specialise 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. mixed farming and livestock in *Meuse*[12]). 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*).

Forest owners will be keen on harnessing the potential of local resources and limiting reliance on the outside, and most of them will therefore decide to diversify varieties in order to improve resilience and maintain stand production. Doing so, however, will entail significant investment, and funds may therefore focus on the most promising areas and varieties (e.g. the oak groves in the Loire basin).

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—to reduce GHG emissions, manage water, etc.—complex.

In **Scenario No. 4 (Energy and environmental transition)**, the most advanced initiatives to adapt locally are quite logically favoured, in particular *via* public policy incentives. The strategies will be concurrently based on diversification and/or enhancing self-reliance, and on converting the production operations that will have trouble adapting to climate change. The bulk of those strategies, in other words, 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*[12]).

In the forestry sector, the development of renewable energies will open up promising outlets. Forest owners, however, will seek the smartest balance between timber production, fuelwood production, environmental amenities and weather-related risks, in particular by planting fast-growing varieties.

Scenario No. 4 entails the deepest-reaching transformation in farming and forestry production systems, to adapt in synch with efforts to address the other environmental challenges. It nevertheless raises questions about technical, economic and organisational 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 manoeuvre 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 compartments (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.

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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 watch-points. 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 studied under review, via irrigation). It may be one of the workable solutions to maintain productive capacity, but mainstreaming it will raise availability issues.

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 centres, 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, based on the perception surveys in the first part of this paper.

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, organisations and local areas.


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