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MARCO
MArket Research for a Climate Services Observatory

Case Study 7 Report: Agriculture & Forestry

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Summary

Forest and wine-growing sectors are particularly vulnerable to climate change. The choices made by forest-managers and wine-growers have therefore both short and very long-term implications which make climate services useful at many stages. In order to determine the current and future potential demand for CS in these sectors, we carried out a survey among wine and forest stakeholders. In addition, in order to assess the benefits of CS users in their decision-making process and, thus, the value of CS, we developed an economic model for the forest sector. This report contains our findings.

Approval

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1 Executive summary

Forest and wine-growing sectors are resp. perennial and semi-perennial ecosystems. This particularity makes them particularly vulnerable to climate change. The choices made by forest-managers and wine-growers have therefore both short and very long-term implications which make climate services useful at many stages.

In order to determine the current and future potential demand for CS in these sectors, we carried out a survey among wine and forest stakeholders. In addition, in order to assess the benefits of CS users in their decision-making process and, thus, the value of CS, we developed an economic model for the forest sector.

In the wine growing sector, it appears that climate services (CS) are mostly used to either solve a punctual crisis and/or to get short-term information about weather conditions, or to implement medium to long-term change (change in species/rootstock).

In the forest sector, CS are mostly used as long-term information in order to study the response of the growth of a tree species and its mortality to climate change. Coupling species distribution models with climate projection models, allows to project the optimal species regarding climate conditions in the future.

For immediate short-term information, CS are mostly provided by weather forecasting services while long-term information comes from integrated modelling frameworks.

Our survey also reveals many shortcomings which can in turn be used as recommendations. First, it appears that stakeholders ask for better communication, more transparency in the tools used to provide CS, and a more "bottom-up" (practical) approach. A market opportunity would be to consider integrated solutions which could be provided by specific companies to combine climate or weather information with technical solutions to face their consequences. Indeed, data from Marco Deliverable 3.1 (MARCO Consortium, 2017a), shows a prevalence of public entities in the provision of CS for both the agriculture and forestry sectors use, while close-to business solutions (as advisory services and decision support tools) are mostly provided by small and medium enterprises.

In addition, one huge opportunity for CS suppliers to the wine sector could be to project the geographic spreading of wines' optimal growing locations due to future climate change.

The numerical results suggest that, depending on the intensity on the climate event, the discount rate and the age of the forest, the CS may be worth [0-3743] €/ha for a storm such as hurricane Klaus in 2009 and [0-6] €/ha for a heat-wave such as the 2003 heat-wave.

Within this context, potentials for commercial CS in these sectors may be important and could take the form of new enterprises specialized in adivising forest managers and wine growers on the optimal forest rotation lengths, the type of species to plant or the adequate time to harvest.

2 Background: the French forestry and vine/wine industry sectors

This study forms part of MArket Research for a Climate services Observatory (MARCO), a research project funded through the European Commission's Horizon 2020 Environment and Resources programme. With growing appreciation of the risks (and 'opportunities') that climate change presents, climate services are helping organisations to mitigate, adapt, and become future-resilient. However, relatively little is known about the climate services market, with unaddressed gaps existing between supply and demand. MARCO endeavours to understand these gaps by providing a 360° view of Europe's climate services market, endowing suppliers and users alike with the insight to predict the sector's future direction and growth.

2.1 Presentation of the vine/wine industry from the INRA project LACCAVE (Ollat and Touzard, 2016)

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 more than 15% of agricultural production (in value), using 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 as a tourist attraction.

Like all agricultural crops, grapevine is sensitive to climate, with 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 have been used to reconstruct 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 vine areas are classified "Designation of Origin" and 26% fall under "Protected Geographical Indication" status. Wine prices depend on such status, which guarantee quality according to the origin and enabling synergies with wine-based tourism.

These biological and economic factors make the vine and wine industry very vulnerable to climate change, to the point that some alarmist simulations predict 50% reduction of surface suitable for the production of quality wines in France by 2050. Adaptation is therefore a major challenge, and the characteristics of vines' production and development define specific conditions for adaptation. It is a perennial plant with annual harvest, which allows the combination of strategies over the short- and longer- terms. Its ties to territory and highly regulated practices are the bases of "Appellations of Origin". This has major consequences for 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 adapt. This has major economic consequences for their future competitiveness.

At the European level, the viticulture sector is subject to the Common Agricultural Policy, which may take climate changes into account. At the national level (France), a plan called "Plan national déperissement du vignoble" aims at proposing a new solution targeting pests and pathogens potentially linked to climate change.

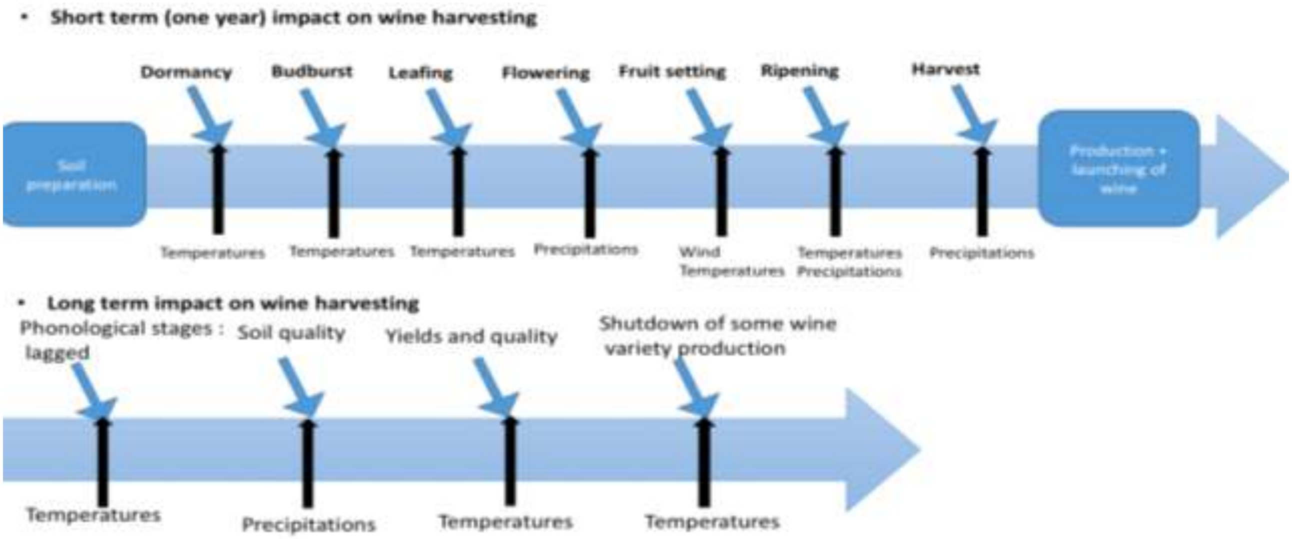

Figure 1: vine growing sector value chain and impacts of climate change at each stage

2.2 Forestry sector

The French forest covers almost 31% of France, which ranks fourth as the woodiest country in Europe. In total, the forest-wood sector employs around 440,000 people for a turnover of 60 billion euros, which is equivalent to almost 3% of the country's GDP. However, only half of the total biological increment of French forests is currently harvested and transformed in the wood industry (Houpert and Botrel, 2015). Although it is neither realistic nor desirable to harvest the entire production, this demonstrates the strong development potential of the sector. For nearly 40 years, numerous reports have prompted a greater mobilisation of wood for economic ends. However, the economic balance of the sector remains modest, and its trade balance shows a structural deficit of 5.8 billion Euros in 2014.

Meanwhile, a forest is a climate-sensitive ecosystem. Tree growth is impacted by temperature, frost dates, and precipitations, and tree mortality is impacted by an increased occurrence of droughts and storms. Even under conservative scenarios, future climate changes are likely to come with an increase in mean temperature (2-4.5°C globally) along with a modification of precipitation regimes with significant drought periods and increases in frequency and severity of extreme droughts. In particular, in Western Europe climate change is likely to mean higher mean winter rainfall, an increasing risk of winter storms and more severe precipitation deficits during summer. Extreme climatic events such as heat waves and drought episodes, like those experienced during summer 2003 in France, Germany and Spain, are therefore expected to occur at increased frequencies in Western European temperate forests (Bréda et al., 2006).

A review of drought and heat-induced tree mortality by Allen et al. (2010) suggests that no forest type or climate zone around the world is invulnerable to such risks, even zones which are not today considered water-stressed. However, the time and the intensity of a drought cannot be easily predicted by forest owners as it occurs at random points in time and cause a random-size damage. In forests the damage caused by a drought can take two forms. First, by constraining water availability, drought may induce large-scale tree growth decline (Bréda et al., 2006). Second, at some point, when the intensity of drought increases, this may result in premature mortality of roots or twigs, and could ultimately lead to tree death (Battaglia et al., 1998; Le Dantec et al., 2000).

Besides these direct effects, climate change also plays an indirect role in forest heath as it influences insect population dynamics and geographical shifts such as population increase due to warmer winter temperatures (Bentz et al. 2010 and fungus development (Scholes et al. 2014). Both increase the risks of infestations in forest ecosystems.

In this context, increases in the occurrence of extreme climate events poses new challenges to the forestry sector. This is all the more true as forest management takes place across long time horizons. This means that decisions at time of plantation are made for several decades, or even a century. The existence and the quality of climate information appears, therefore, to be as it can help forest managers make more informed decisions in order to reduce climate risks, and hence the economic losses in forest stands.

The forest sector is implicated by many climate policies as it represents a set of mitigation options through carbon sequestration and emissions substitution effects (see Fig. 3). These policies encourage the use of wood as a substitute for the use of fossil fuels, such as in domestic energy production.

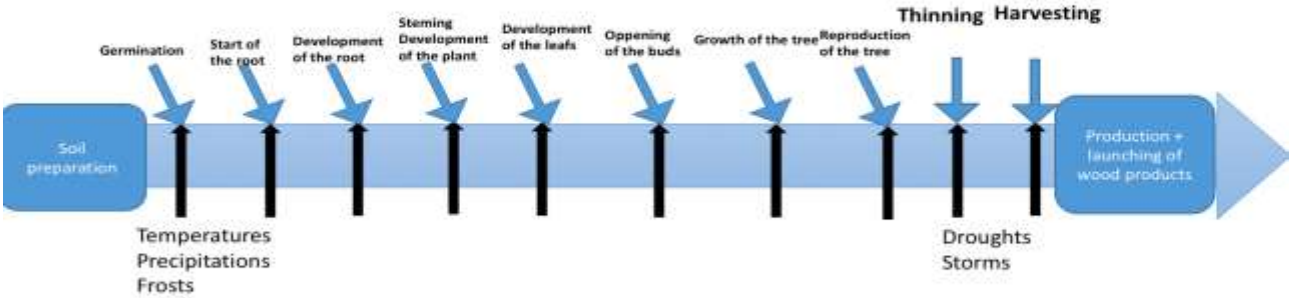

Figure 2: Forest sector value chain and impacts of climate change at each stage

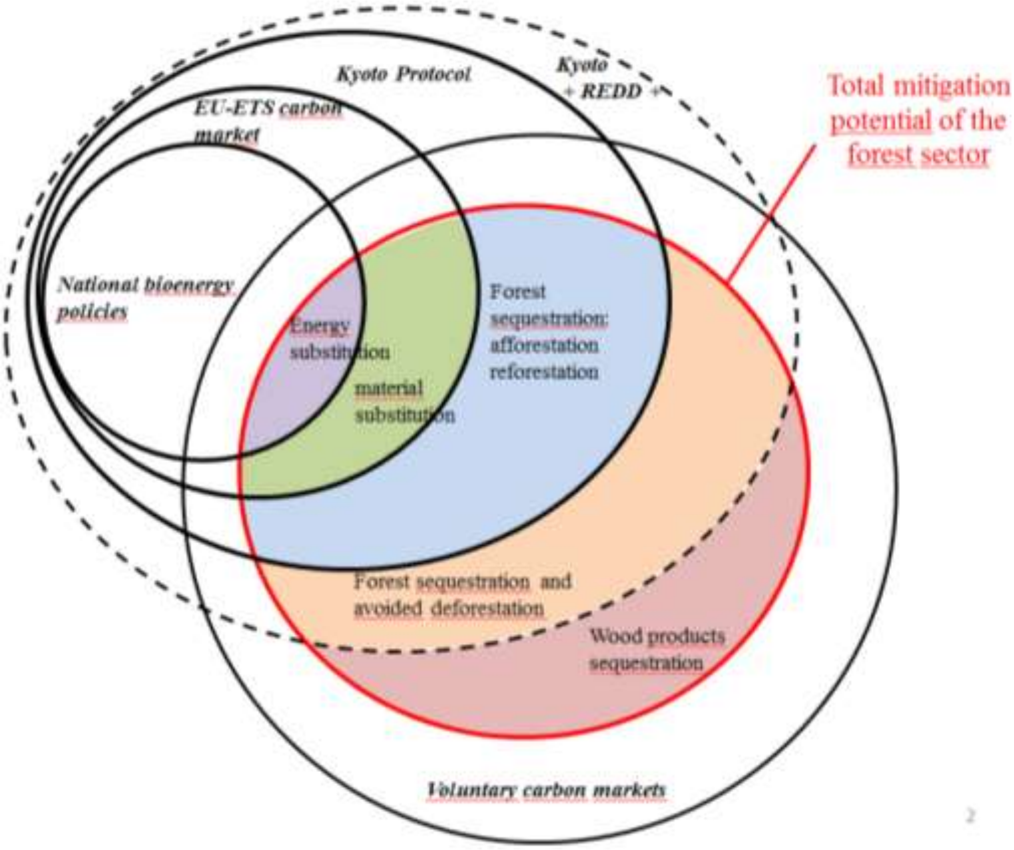

Figure 3: Forest sector policies in relation with climate change

2.3 Stakeholder mapping

We map stakeholders and their activities in Figures 3 to 5 (below). We separate activities in five categories, from the upstream to the downstream segments of the value chain. Input supply refers to the production of "raw" material (material or non-material) which will be used in the sector; production refers to the creation of primary products; trade refers to the logistical and commercial activities; processing refers to the transformation of primary products; and consumption refers to all consumption activities (either services or end-use products).

Figures 4 and 5 demonstrate that trading activities occur at various stages in the product life cycle, between primary production and processing activities and between processing activities and final consumption. It also shows that climate services mostly benefit to the input supply activities.

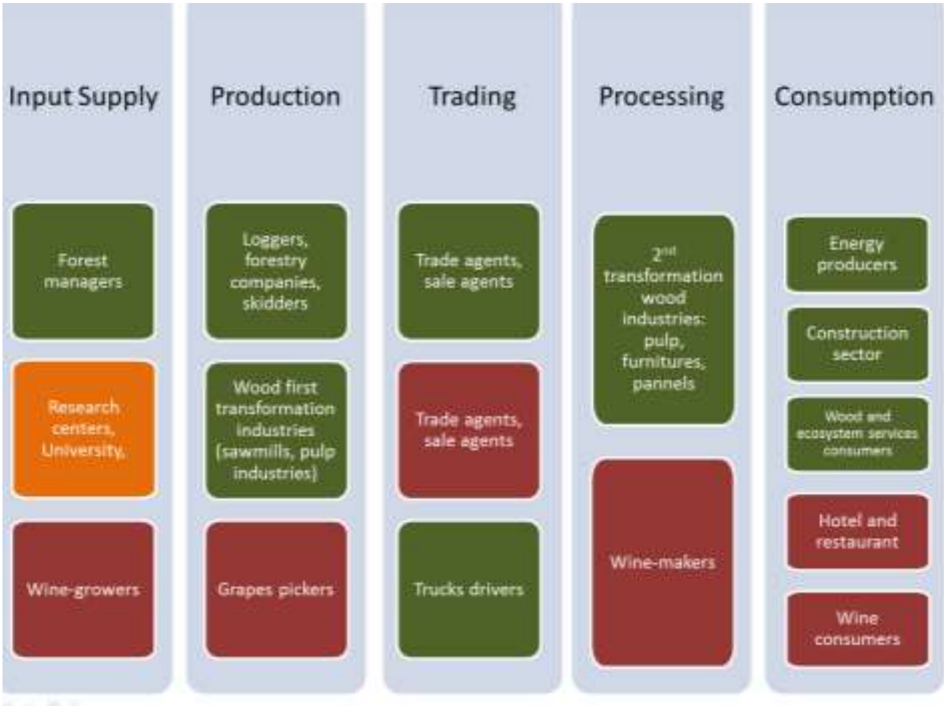

Figure 4: Stakeholder overview for: the wine sector (red), the forest sector (green) and intersectoral activities (orange)

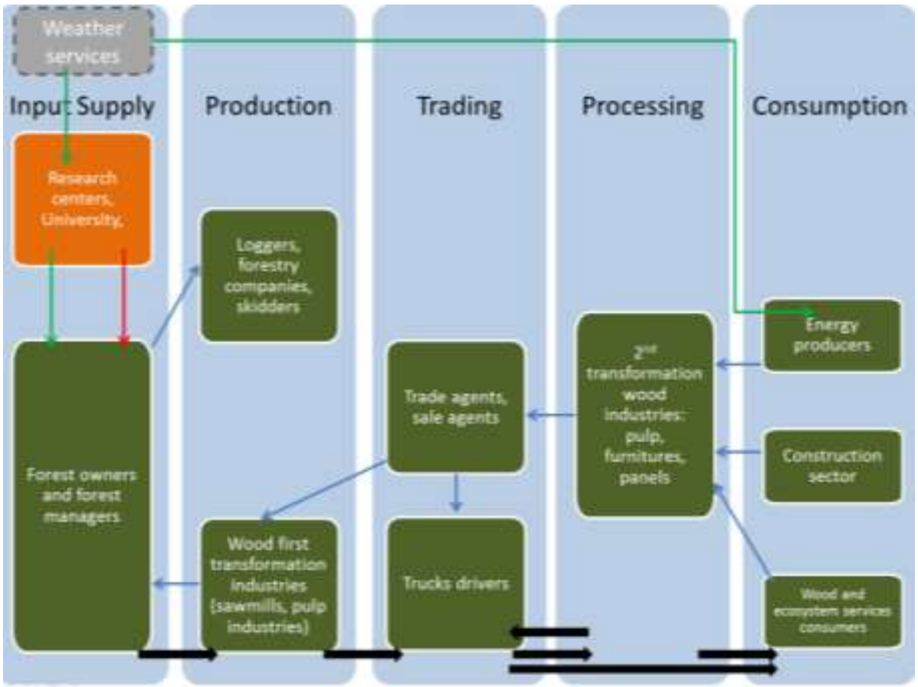

Figure 5: Interactions between stakeholders within the forest sector. Green arrows represent climate services, red arrows represent other services and information, blue arrows represent money flows and black arrows represent material/product flows.

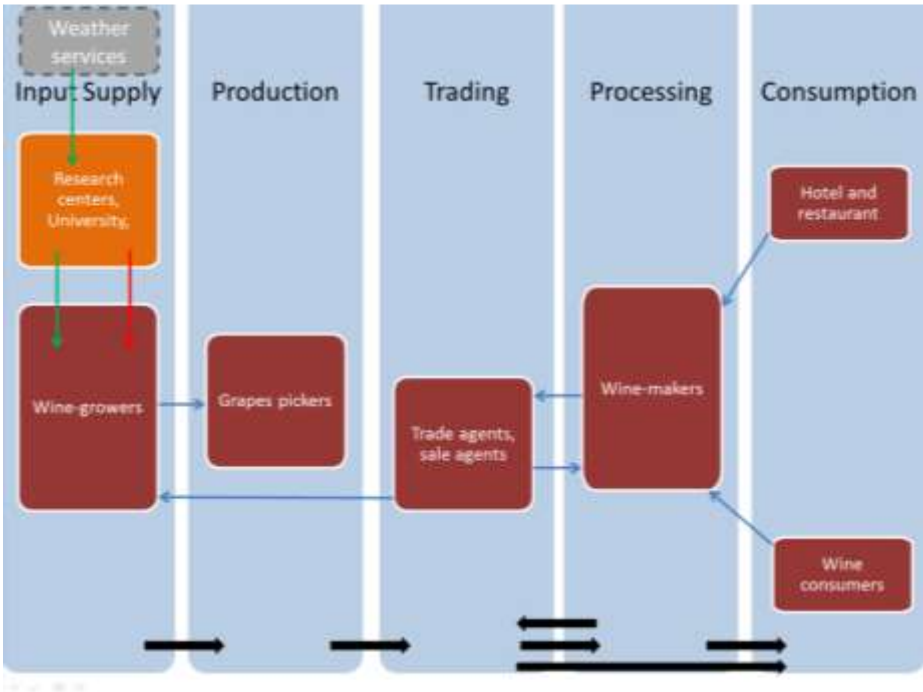

Figure 6: Interactions between stakeholders within the wine sector. Green arrows represent climate services, red arrows represent other services and information, blue arrows represent money flows and black arrows represent material/products flows.

2.4 Forest Value Chain Analysis

The forest sector (NACE 02, 16, 17 and 31) remains a relatively small sector in France. With 279, 000 workers and a production value of 38 billion Euros, it represents just over 1% of the national workforce and economic output.

We can divide the sector vertically as follows. In the forestry sector the main agents are forest owners, forest management consulting experts, and logging companies. The outputs consist of raw materials, i.e. timber suitable for sawing / processing or industrial wood.

The base level (NACE 02) employs 29,000 workers and produces €2.23 billion of added value. This level is most directly impacted by climate change, as trees' biological growth is a key variable in forests' operational profitability. Further, climatic conditions play an important role in the exploitation phase of the forest.

Rising up the value chain we find the wood transformation industries, such as sawmills and other primary manufactures (NACE 16, 65,000 workers) or paper industries (NACE 17, 60,000 workers). Generating €2.95 and €4.29 billion of added-value respectively, this level represents the bulk value creating across the value chain. Its operations are capital intensive with strong capital immobilization, competition (both internal and international) is high, and innovation is commonplace. New products expected to emerge soon include bio-based products, improved energy materials, and cross laminated timber.

At the end of the value chain we find the industries involved in the further processing of wood, such as furniture manufacturing (NACE 31). While added value generated by this sector in France remains limited (€2.41 billion), this level is labor intensive (125,000 workers) making it important from a social point of view. On the one hand, the openness of the furniture market means that it is only marginally dependent on the upstream levels levels of the value chain in France, but on the hand this renders the sector vulnerable to global market shocks in the timber sector.

	Input Supply	Production	Trading	Processing	Consumption
Activities	Forest management	Logging, hauling (wood in forest), sawmilling, pulp, panels production (1st transformation)	Transactions, sales (long term contracts or spot markets), transportation	Paper production, wood chipping, furniture production, etc (2nd transformation)	Sales, distribution, recycling, land-filling (end-of-life products), ecosystem services consumption
Actors	Forest managers: forest experts, forestry cooperatives, engineering offices (for privately-owned forests), French National Forest Office (ONF) for state-owned forests NACE codes: 02.4; 02.1	Loggers, forestry companies, skidders, sawmills, pulp and panels industries NACE code: 02.2	Trade agents, logging trucks drivers NACE codes: 49.41; 49.2; 52.1	Paper industries, furniture industries, etc NACE codes : 16.1 ; 16.2	Wood products and ecosystem services consumers, construction industries, energy producers (electricty and heat), newspapers
inputs	Forest (biological increment)	Fuel and raw wood	Fuel and first transformation wood products	Fuel and first transformation products + recycled papers	Fuel and second transformation wood products, other ecosystem services

					(regulation, recreation, cultural)
Outputs	Raw wood, ecosystem services	Logs, chips, pulp	Logs, chips, pulps	Furniture, paper, construction wood, lumber, panels	Heat, electricity, buildings, newspapers, books, (recycled) wood products
Locations	Forest	Forest	Multiple possibilities	Multiple possibilities	Multiple possibilities
Challenges	Need of climate information (new species to grow, time to harvest), adequacy between forest resource and downstream demand	Fuel scarcity, good weather conditions for skidders (frosty ground), presence of logging roads, adapted machinery for efficient/effective use of the wood resource in sawmills, adequacy between products produced and downstream demand	Transportation, Fuel scarcity, information on prices	Paper recycling techniques, competitions between subsectors (pulp & energy & panels); exports abroad	Price fluctuations, wood products volumes (competitions with other sub-sectors), low wood products demand
Possible solutions	Better climate services	Innovations for new skidding methods (cable, horses, balloons), sawmills technological	Improved routes and planning	New products (recycling, circular economy, bio-based	Stimulate consumption substitution from non-wood products to wood

		improvements, new products (bio-based economy), need for weather information (harvesting)		products)	products

Table 1: forest value chain analysis

2.5 Wine Value Chain Analysis

As the forest sector above, we can also identify a vertical structure for the wine sector, with lower levels of the value chain directly linked to the resource and more directly affected by climate change, and upper levels impacted more indirectly. The main difference is that wine is a strongly differentiated good, and in spite of the openness of the markets the upper levels remain strongly dependent on the lower levels.

At the bottom level we have the cultivation of grapes for wine (NACE 01.21). For the same reason of product differentiation, the resource level can concentrate the highest side of value of the chain. With a production value of €9.22 billion, wine growing accounts for 11% of French agricultural output.

Climate change is expect to have dramatic impacts on the distribution of productive wine growing areas, with areas of traditional production declining in quantity and/or quality, while other regions become more attractive to vineyard plantation. Possible solutions imply changes in agronomic practices and/or grape variety selection.

In comparison, wine production (NACE 11.02) contributes a much lower level of output, at €1.53 billion. It is often located in proximity to the vineyard regions on which it depends for its inputs, and is vulnerable to both any potential climate-induced problems in grapes growing, and competition from new wine regions. Changes in consumer preferences could also present a threat. Overall, wine producing industries are in the unfortunate position of being affected by climate change but, unlike grape producers, have no tools to actively respond to threats.

	Input Supply	Production	Trading	Processing	Consumption
Activities	Wine-growing	Grapes harvesting	Transactions, sales, transportation	Winemaking, vinification	Sales, distribution
Actors	Wine-growers NACE code: 01.21	Grape-pickers NACE code: 01.21	Trade agents, carriers NACE codes: 49.41; 49.20;	Wine-makers NACE code: 11.0	Wine consumers, hotels & restaurants, export market

			52.10		
inputs	Land and vines	Grapes and fuel	Grapes and fuel	Pressed grapes and yeasts	Wine
Outputs	Grapes	Grapes	Grapes	Wine	Pleasure
Locations	Countryside (several regions in France but not everywhere)	Countryside	Multiple possibilities	Multiple possibilities but mostly next to production	Multiple possibilities
Challenges	Need of climate information (new species to grow, growing locations), water shortage, change in temperatures regime	Fuel scarcity, need for climate information (time to pick up grapes, aromatic balance, sugar rate)	Transportation	To make wine without too much sugar, reputational challenge (quality, taste)	Price fluctuations, products volumes, export market
Possible solutions	Better climate services: genetic improvements, new rootstocks, better growing locations (higher locations, north slopes, higher latitudes), switching from one species to another (e.g. white to red	Earlier picking, new aromatic balances, new wine tastes	Improved routes and planning	New wine products	

	wine species)				

Table 2: Wine value chain analysis

3 Climate services analysis

3.1 Methodology

In order to get a global overview of the climate service use and production within both the forest and the wine sectors we carried out a survey with a range of stakeholders in both sectors. This survey aims to understand the nature of climate services, and determine who produces - and who consumes - these services. We also sought to examine which stakeholders use them most, the extent to which climate services are used, and to what ends. The survey contains around 30 questions, and was sent to a dozen researchers and managers in the forestry and wine growing sector[1] (Appendix 9.2). It allows us to determine the climate risks faced by the sectors, and which sector is most impacted.

Our questionnaire was divided into four groups of questions, concerning:

a. the organisation and the respondent (name, position, sector, size and geographic scale of the organisation)
b. perception of the risk (perception of climate risks, level and time scale of it, how they predict climate change and its impact on the activities)
c. demand for climate services (impact of climate event, level of the impact, use of climate services, access to CS, data and information use, frequency of use, etc.)
d. perception improvement of CS (comprehension, relevance, trust, etc.)

The list of contacted stakeholders is presented in Appendix 9.1, and Figure 7 (below) shows how they are distributed within the value chain.

[1] Example for the wine sector: https://lobianco.org/lef/limesurvey/index.php/423633?lang=fr

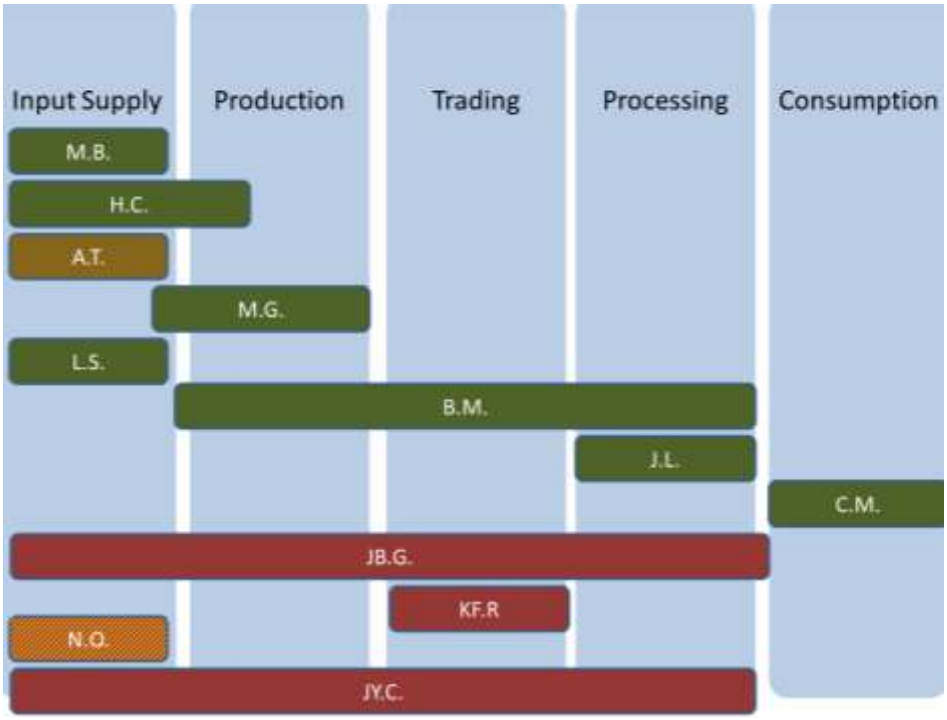

Figure 7: stakeholders contacted for our survey and their position in the value chain (red: wine sector, green: forest sector, orange: research and universities). Initials refer to the names of the stakeholders presented in Appendix 9.1.

In the following section we present the main conclusions from this survey.

3.2 Benefits of Use: existing/ potential sector needs and actual demand

In the wine growing sector, the most high-impact climate phenomena are changes in mean temperature, occurrence of droughts, late spring frosts and hail storms. Mean temperature and spring frosts influence the early stages of the plant development during the beginning of the season, while droughts and hail can impact all stages. Climate services (CS) are used to solve a punctual crisis and/or to get a short-term information (use of fire and candles to protect against frost; determine the best period to treat vines against pathogens; to determine the best period to harvest at time horizons from few hours to one month; or to implement medium to long-term change (change in species/rootstock, at time horizons spanning 10-30 years).

In the forest sector, short-term use of CS is less represented. The two only significant short-term uses we found in the responses to our survey were (1) weekly weather forecasts about heavy frost during winter which makes the harvest possible and (2) the use of decadal/seasonal weather forecasts in order to project fuelwood consumption. In the value chain, (1) impacts the production process while (2) impacts the consumption.

In the forest sector, CS is mostly used as long-term information (time horizon: 40 to 100 years) in order to study the response of the growth of a tree species and its mortality to climate changes. Coupling species distribution models with climate projection models, allows one to project the optimal species with respect to future climate conditions. One example of such a combination of models is that developed by the French Forest Service (ONF), as mentioned during an interview for this research (H.C.) (Privat, 2013; Le Bouler et al., 2011). The choice of new adapted species is by far the most frequently mentioned CS use in our interviews with forest-sector stakeholders. CS are also used to get information on the spread of potential pathogens and subsequent economic impacts in a given forest.

Overall, CS are mostly used punctually, only when needed. During our research for the case study, only two respondents (A.T and JB.G.) said they use CS frequently, from every day to weekly. According to their set of demands, the information used pertaining to climate events mostly concerns temperature, precipitation and wind. This is obtained by means of any available data, but historical data, seasonal forecasts, climate projections, and annual averages were cited most frequently. In the forest sector, information on burned areas by forest fires is also used. Mostly climate information is provided by weather websites, however scientific papers, climate models and forestry magazines, are also used.

3.3 Market Quantification

In forest and wine-growing sectors, CS are mostly provided by public institutions, with consequent investments due to high fixed costs. Recent data (MARCO Consortium, 2017c) show how insurance for climate change to the forest and timber sectors, and advice and consulting services for agriculture, already top the chart of climate services applications, as ranked by value (respectively 4th and 17th with 12.8 and 10.1 M€ in 2015/2016).

In split of the different applications of CS between the forestry and agricultural sectors, it is evident that CS applications in the forestry sector use remote sensing technologies much more than agriculture (Figure 4 of MARCO Consortium, 2017c). It appears, however, that in general CS provision is highly correlated between agriculture and forestry: 92 out of 107 CS suppliers that produce CS for the forest sector do so for the agriculture sector as well (a bit lower in the other direction, where only 92 out of 160 providers of CS for the agricultural sector also provide CS to the forestry sector (MARCO Consortium, 2017b)).

The revenue for precision farming downstream service providers from Copernicus in Europe was 9.21 million euros in 2015, and is expected to be 37,7 million euros in 2020. The use of their data allowed the creation of jobs in the sector, the increase of farmer's productivity and an appropriate use of agricultural inputs. The total investment in the Copernicus programme between 2008 and 2020 is to be 7.5 billion Euros , with a benefit of 13.5 billion Euros. Such an analysis does not exist in the forest sector as benefits from CS are hard to quantify.

In order to contribute to fill this gap and to quantify the benefits of CS use in users' decision-making process, we developed an economic model for the forest sector. Our contribution is to propose a methodology for elucidating the value of CS that consists, in this case, in the information provided to forest owners about the timing and the intensity of possible mortality increase and growth decline. We compare two economic impact scenarios: one where a hypothetical climat service is adopted into decision making processes, and another other where they are not. The model is then calibrated to environmental conditions of the Landes forest, in South West of France. The numerical results suggest that, depending on the intensity on the climate event, the discount rate and the age of the forest, CS may be worth [0-3743]

€/ha for a storm such as hurricane Klaus in 2009 and [0-6] €/ha for a heat-wave such as the 2003 heat-wave.[2]

3.4 Unmet needs

In the wine-growing sector one respondent (JB.G.) asked for more global adaptation solutions than simply irrigation or new species development. He asks for the use of adapted heirloom rootstocks/species and proposes the progressive introduction of new wines - with different aromatic balances - to consumers. The change in wine taste and its impacts on consumer choice has been studied in a Ph.D. thesis within the LACCAVE project (Fuentes-Espinoza et al., 2016; Giraud-Héraud et al., 2016). Irrigation is considered an unsustainable solution as water is projected by stakeholders (JB.G and JY.C.) to becoming more scarce in future.

In the forest sector, stakeholders ask for more regionally focused CS on temperature, rainfall and on the number of days of event that induces stress for the tree (frost, solar radiation, temperature). Usually, the information arrives early enough to adapt, but stakeholders ask for more frequent studies as climate evolves rapidly. One stakeholder (M.B.), however, specified that at present information is sufficiently timely as instantaneous reactivity is not necessary in the forest sector.

Both the agriculture and forest sectors share a need for more applied and business-orientated services (like advisory services and decision support tools) that link-up with the complex modelling and simulation activities performed at a more research and theoretical level. Table 3 (drawing on data from MARCO Consortium, 2017b) shows how public sector organisations constitute the majority supplier category to all sectors, however this is especially true in the case of the forest and agriculture sectors. At the same time, data from the same report show how small and the medium enterprises are the entities that offer more applied solutions.

Table 3 Share of CS providers by organisation, type and sector

2. Organisation type	All	For	Agr
Nat. Met Service	5.2	11.0	9.3
Public Climate Service Center	3.1	5.5	4.9
3. University or Research Performing Organisation	38.9	37.6	34.6
Non-Profit-Organisation	7.0	6.4	4.9
Industriy or professional body	1.0	1.8	1.2
Public administration / politics	12.0	11.0	17.3
Industry / large company	8.1	4.6	4.9
SME	22.7	19.3	19.8
Start-up	0.3	0.0	0.6
Other	1.6	2.8	2.5
Private	31.1	23.9	25.3
Public	59.3	65.1	66.0

[2] The complete working paper is available at: https://www6.nancy.inra.fr/lef/Cahiers-du-LEF/2017-10

4.	Total number of CS providers	383	109	162

3.5 Constraints and Opportunities

From our survey, it appears that cost or accessibility of CS are not constraining factors. Our survey reveals that the only accessibility constraint is related to a lack of knowledge about climate change. Therefore, we believe there is a huge opportunity to improve quality and communication on the supply side of CS, as well as to provide information not only for stakeholders already aware of climate change, but also to those not aware of it.

One opportunity for CS suppliers is linked to the impacts of climate change over the geographic distribution of species. In the wine sector, some northern regions, such as the UK, are likely to become wine production regions in the future.[3] Yet, land-owners in these regions are not always aware of this opportunity.

4 Use cases

We propose here two use cases from the results of our survey.

The first use case consists in growing new species and rootstocks in the wine sector. The initial climate information is provided by weather services (Météo-France) and used to feed research models (INRA). In addition, these models use other information to determine the optimal future species to grow in every region. For instance, if climate is becoming drier and warmer in a specific region, the model will choose an alternative wine species for this region. This information is then given to the wine-grower who can adapt her/his practices by changing the species grown. One major caveat of this kind of “top-down” approach is that the research model usually does not take short-term feedbacks from the field. This is because (1) there is a “time lag” between the adoption of a new species and the first harvest (and climate may have been change during this time lag) and (2) research models in the agronomy-climate sector often fail to account for sociological preferences.

The second use case is almost identical though it uses information on the distribution of tree species plus the IPCC scenarios on future climate conditions. The models are also developed by research centers (such as INRA, AgroParisTech) and present to policy makers the optimal location for every species.

[3] http://www.englishwineproducers.co.uk/files/4114/7508/1393/UK_vineyard_stats_May_2016.pdf

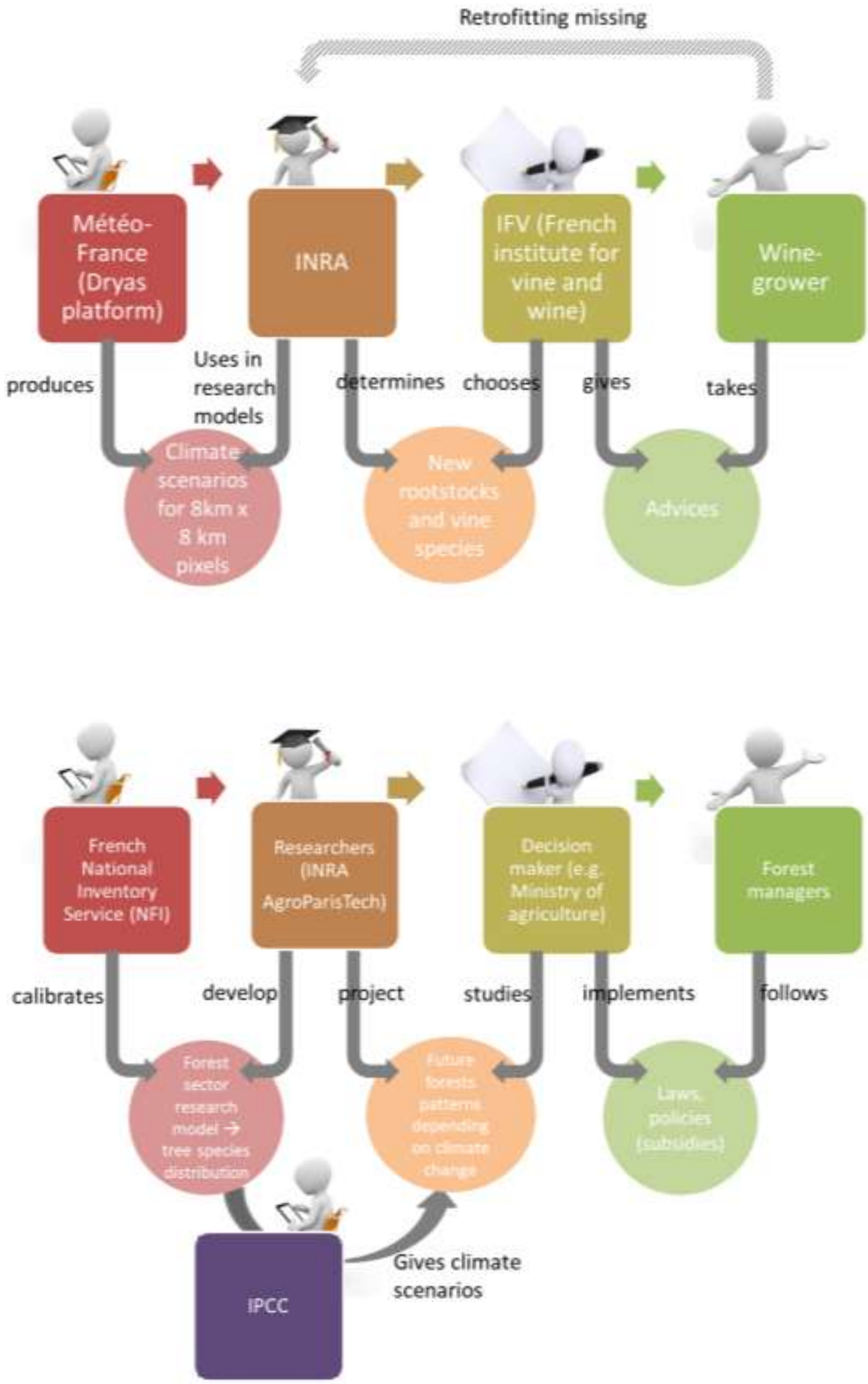

Figure 8: Use cases examples

5 Decision making and attitudes to risk

In the wine-growing sector, climate related risks lead to changing behaviour and to different adaptation practices in the short run and long run. In the short-term, adaptation strategies consist in growing vines either at higher altitudes and latitudes, or on the north slopes of hills. In the long-run, adaptation strategies will involve new grape species and/or going back to forgotten varieties. Climate change can also add value to some varieties (switch from white to red wine in some regions for instance). Stakeholders do not see climate change only as a collection of risks; they also bring to the fore the potential good impact in terms of wine quality and aromatic composition. In practical terms, CS provided in the wine growing sector is considered as being robust, comprehensive and relevant for those that used CS (one stakeholder, JY.C., did not use them and did not consider them reliable enough). However, the information typically arrives at a stage when the flexibility to adapt accordingly is constrained. Late information limits operational adaptiveness.

In the forest sector however, climate change is only seen as a threat, both in the short-run and in the long-run. Droughts and heatwaves are seen to occur more and more often. Changes in tree fruit-forming, and development of pathologies are feared in the short-run. In the long-run there is a risk of a modification of the distribution of the species and, even more, a risk that the species will not adapt. Adaptation to such risks already occurs (M.B.; H.C.): rotations are shortened, species composition are evolving when replanting. While it is not a finding of our own survey, the usage of CS for risk management solutions, such as insurance, for adressing climate change in the forest sector is already very important, and the MARCO Deliverable 4.3 ranks it in 4th place type of CS applications by value (12.8M€ in 2015/2016 at European level).

Some forest-owners in the south-west of France still wonder whether they should use their land for another activity such as solar panels farm (M.B.). In the forest sector, there are contrasting opinions about CS. Mostly, respondents find CS pertinent, trustworthy and comprehensive enough. However, A.T. pointed out that it is necessary to have information on the way data are collected, and on the techniques used to produce the final CS application (techniques to capture information, which models transform data, and which assumptions, etc.).

6 Recommendations

We believe that CS take-up by - policy makers and sector associations - could benefit from several improvements:

- Improve communication/dissemination: not only relating to CS, but also the impacts of climate change. Some stakeholders remain unaware - or not completely aware - of climate change and its future impacts.
- Transparency: avoid techniques that use black-box models and ensure reliability of data.
- Promote practical bottom-up approaches instead of top-down approaches: many stakeholders complain about the lack of realism of adaptation strategies proposed by CS suppliers. Sometimes, simple solutions already exist (using old grapes species, returning to “natural” forest management

practices) but stakeholders think these solutions are dismissed by ecologists and are not considered as "serious". One recommendation would be to consider these solutions as CS.

- Consider the potential geographic dissemination of CS: some wine-growing regions do not use CS as they have not been concerned to date This may change as climate modifies the potential distribution of species. CS which are not currently used could one day become critical in this area.
- Stakeholders are rarely aware of the cost of climate and adaptation information in the wine-growing and forest sectors as it is mostly provided by public institutions. This is a potential barrier to the growth of the CS market in these sectors, as stakeholders do not see the need to pay for information.
- One potentially important market for CS is the combination of climate/weather information and technical solutions to manage climate/weather risks. For instance, in the wine-growing sector one stakeholder asks for an integrated solution to face late frost in the spring. This integrated solution could be a company that would install fires/candles in the vineyard whenever the risk of frost is high. This example shows there is a need to externalize the risk and cost-burden associated with climate risks.
- Due to the long-term horizons used by the forestry sector, CS are almost always linked to long-term climate projections, and therefore mostly rely on complex integrated models. There is a need to transform these complex models into practical tools usable by forest managers.

7 Conclusion

In Western Europe, even under conservative scenarios, future climate changes are likely to come with larger winter rains, an increasing risk of winter storms and more severe precipitation deficits during summer. Extreme climatic events such as heat waves and drought episodes like those experienced during summer 2003 in France, Germany and Spain are therefore expected to occur at increased frequencies.

Forest management and wine-growing decisions involve long term horizons. In particular, decisions made at plantation time have consequences over decades, even century. A subsequent increase in the occurrence of extreme climate events imposes new challenges to forest managers and wine-growers, making their decisions highly climate-sensitive. Therefore, the existence and the quality of climate services appear crucial. In the context of forest management and wine-growing, they can take the form of recommendations on initial plantation densities, choices of new species or mix of species, choice of new rootstocks for wine, change in rotation lengths or landscape planning to minimize fire and insect damages.

Our survey revealed that these CS are mostly used punctually, only when needed and are mostly provided by public institutions, with consequent investments due to high fixed costs.

In the agriculture field, the economic literature extensively explored the concept of expected value of information. But the value of CS has never been assessed for perennial or semi-perennial systems such as forest and wine activities. Yet, a better assessment of CS value could both help public institutions and decision-makers to better calibrate their investments in this domain. Meanwhile, more and more private CS providers emerge which create a new market. Comparing the theoretical CS value with CS consumers' willingness-to-pay allow to better design the services exchanged on this market.

The revenue for precision farming downstream service providers from Copernicus in Europe was 9.21 million euros in 2015, and is expected to be 37.7 million euros in 2020. The use of their data allowed the creation of jobs in the sector, the increase of farmer's productivity and an appropriate use of agricultural inputs. Copernicus programme estimated that the benefit of using CS reached 13.5 billion Euros for 2008-2020 period. Such an analysis does not exist in the forest sector as benefits from CS are hard to quantify. To fill this gap, we made a first step towards a better economic assessment by developing an economic tool to evaluation CS for forest plantations. We show that the value of CS is highly dependant on the type of climate threat: information on storm occurrence has a much higher value ((€0-2000 per hectare) than information on drought occurrence (less that €10 per hectare) for instance. This is because drought mostly impact tree growth rate while storm directly impact tree mortality rate.

Within this context, potentials for commercial CS in these sectors may be important and could take the form of new enterprises specialized in adivising forest managers and wine growers on the optimal forest rotation lengths, the type of species to plant or the adequate time to harvest.

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9 Appendices

9.1 Annex 8: Climatically sensistive dependencies

Industial Sector/Sub-sector or Activity	NACE	Economic Rank of Sector	Dependency on Climatically Sensitive Infrastructure and Systems (CSIS)						
			Large Fixed Assets	Transport	Water	Other (climatically sensitive raw materials)	Market Demand	Energy	Ecosystem
Manufacture of wood and of products of wood and cork	*16*	1	Green	Green	Green	Green	Green	Green	Green
Manufacture of pulp, paper and paperboard	*17*	1	Green	Green	Green	Green	Green	Green	Green
Manufacture of furniture	*31*	1	Green	Green	Green	Green	Green	Green	Green
Manufacture of wine from grape	*11.0.2*	3	Green	Green	Green	Orange	Green	Green	Green
Silviculture	*02.1*	2	Red	Green	Red	Green	Green	Green	Red
Logging	*02.2*	2	Orange	Orange	Green	Green	Green	Orange	Green
Support services to forestry	*02.4*	2	Green	Green	Green	Green	Orange	Green	Green
Growing of grape.	*01.21*	3	Red	Orange	Red	Green	Orange	Green	Orange

Scoring

Red

Highly dependent on Cl
Infrastructure and Syste
sector's ore activities. S
cause an interruption in

Orange

Moderate dependency
sector/activity's core ac
business's operations a
to be significantly interr

Green

Low dependency on CSI

9.2 Stakeholders list (in italic: stakeholders directly contacted by phone/ did not respond to the questionnaire)

Sector	Name	Organisation - Position	Gender
Forest	Hélène Chevalier (H.C.)	National Forests Office (ONF)– Leader of Sylvicultural and infrastructures operations	F
Forest	Adrien Taccoen (A.T.)	AgroParisTech- Phd student	M
Forest	Mona Garandel (M.G.)	Forest town's head mission in Nancy Grand Est	F
Forest	Max Bruciamacchie (M.B.)	AgroParisTech- Forest manager	M
Forest	Lionel Staub (L.S.)	Forest Expert	M
Forest	Claude Michel (C.M.)	Parc Naturel Régional des Ballons des Vosges	M

Forest	Bertrand Mathieu (B.M.)	Scierie Mathieu	M
Forest	Jacky Lepaul (J.L.)	Entreprise Ogier	M
Wine Growing	Granier Jean-Baptiste (JB.G)	Les vignes oubliées domain – Winer grower and domain manager	M
Wine Growing	Jean-Yves Cahurel (JY.C)	The French Wine and Vine Institute (IVF) – Researcher	M
Wine growing	Karl-Frédéric Reuter (KF.R)	Champagne Bollinger	M

Table 4: stakeholders contacted (in italic: stakeholders contacted by

ID de la réponse	3
Date de soumission	2017-07-XX XX:XX:XX
Dernière page	6
Langue de départ	fr
Date de lancement	2017-07-XX XX:XX:XX
Date de la dernière action	5. 2017-07-XX XX:XX:XX
URL référente	
Pouvez-vous nous indiquer votre nom (par souci d'identification) ?	Granier Jean-Baptiste
Êtes-vous un homme ou une femme ? (cette question figure afin de connaître la parité des individus au sein des acteurs répondant)	Homme
Quel est votre secteur d'activité ?	Viticulture
Dans quelle organisation travaillez-vous ? Quel y est votre poste ?	Domaine les vignes oubliées Gerant
Comment caractériseriez-vous la taille de votre organisation ?	Petite taille (moins de 50 employés)
A quelle échelle géographique votre organisation opère-t-elle ?	Régionale
Comment percevez-vous les risques climatiques ? A quelle échelle temporelle, et à quel(s) niveau(x) ?	Dramatique Ces dernières années, la question est de savoir si nous allons avoir du raisin au vendange! Est-ce cycle ou faut-il s'habituer ?
Comment anticipez-vous l'impact du changement climatique dans votre secteur (croissant, décroissant) ?	gagner en altitude est peut-être une solution. Remettre des cépages et des sélections du début du siécle. Arrêt de tous les clones mal sélectionnés par l'INRA! Pendant 40 ans, la recherche a selectionné des clones produisant du sucre et donc de l'alcool
Pensez-vous qu'il vous sera nécessaire d'irriguer dans le futur (proche ou lointain) ?	L'irrigation n'est pas le problème essentiel du changement climatique. Il faut remettre les vignes sur des terroirs qualitatifs. On aura besoin d'eau pour d'autres cultures. Il faut revoir nos itinéraires culturaux. L'irrigation est une solution précaire qui empêche de chercher des solutions durable.
Pensez-vous qu'il vous sera nécessaire, à cause des impacts du changement climatique, de changer de cépage dans un futur proche, et/ou d'activité dans un futur lointain?	Changer de cépage surement pour revenir à des cépages oubliées (carignan, cinsault,...)
Quel(s) évènement(s) climatique(s) impacte(nt) votre secteur (que se soit de manière positive et/ou négative) ?	gel, grêle, pluie
A quel(s) niveau(x) votre secteur est-il touché par ces évènements climatiques (étapes de la croissance de la vigne, choix des cépages, apparition de maladies,récolte, exploitation, commercialisation, etc.) ? A quelle échelle temporelle ?	on est impacté de mars à septembre
Utilisez-vous des services climatiques ?	OUI

Comment l'information climatique impacte-t-elle vos actions d'adaptation et d'atténuation ?	date de traitement date de récolte
Comment avez-vous accès à l'information (site météo, fournisseur de services climatiques, coopératives, articles scientifiques, etc.) ?	site météo
A quelle fréquence avez-vous accès à l'information ? [journalière]	Oui
A quelle fréquence avez-vous accès à l'information ? [Commentaire]	
A quelle fréquence avez-vous accès à l'information ? [hebdomadaire]	Non
A quelle fréquence avez-vous accès à l'information ? [Commentaire]	
A quelle fréquence avez-vous accès à l'information ? [mensuelle]	Non
A quelle fréquence avez-vous accès à l'information ? [Commentaire]	
A quelle fréquence avez-vous accès à l'information ? [annuelle]	Non
A quelle fréquence avez-vous accès à l'information ? [Commentaire]	
A quelle fréquence avez-vous accès à l'information ? [trimestrielle]	Non
A quelle fréquence avez-vous accès à l'information ? [Commentaire]	
A quelle fréquence avez-vous accès à l'information ? [annuelle]	Non
A quelle fréquence avez-vous accès à l'information ? [Commentaire]	
A quelle fréquence avez-vous accès à l'information ? [pas de fréquence particulière, mais quand j'en ai besoin]	Non
A quelle fréquence avez-vous accès à l'information ? [Commentaire]	
A quelle fréquence avez-vous accès à l'information ? [dès que l'information est disponible]	Non
A quelle fréquence avez-vous accès à l'information ? [Commentaire]	
A quelle fréquence avez-vous accès à l'information ? [autre (veuillez l'indiquer en commentaire)]	Non
A quelle fréquence avez-vous accès à l'information ? [Commentaire]	
Quelle(s) information(s) climatique(s) utilisez-vous concernant les événements climatiques (températures, précipitations, etc.) ?	précipitations, température, vent
Quel type de données utilisez-vous (observations historiques, prévisions saisonnières, projections climatiques, etc.) ?	meteo classique

Quel(s) service(s) climatique(s) utilisez-vous concernant les événements extrêmes (sécheresses, tempêtes, inondations, etc.) ?	
Comment l'information climatique a-t-elle changé vos activités ? A quelle échelle temporelle ? (veuillez l'indiquer en commentaire) [dans la prise de décision]	Oui
Comment l'information climatique a-t-elle changé vos activités ? A quelle échelle temporelle ? (veuillez l'indiquer en commentaire) [Commentaire]	
Comment l'information climatique a-t-elle changé vos activités ? A quelle échelle temporelle ? (veuillez l'indiquer en commentaire) [dans la planification des différentes activités]	Non
Comment l'information climatique a-t-elle changé vos activités ? A quelle échelle temporelle ? (veuillez l'indiquer en commentaire) [Commentaire]	
Comment l'information climatique a-t-elle changé vos activités ? A quelle échelle temporelle ? (veuillez l'indiquer en commentaire) [pour informer et faire prendre conscience en dehors de l'organisation]	Non
Comment l'information climatique a-t-elle changé vos activités ? A quelle échelle temporelle ? (veuillez l'indiquer en commentaire) [Commentaire]	
Comment l'information climatique a-t-elle changé vos activités ? A quelle échelle temporelle ? (veuillez l'indiquer en commentaire) [pour cibler les stratégies d'investissement]	Non
Comment l'information climatique a-t-elle changé vos activités ? A quelle échelle temporelle ? (veuillez l'indiquer en commentaire) [Commentaire]	
Comment l'information climatique a-t-elle changé vos activités ? A quelle échelle temporelle ? (veuillez l'indiquer en commentaire) [autre (veuillez l'indiquer en commentaire)]	Non
Comment l'information climatique a-t-elle changé vos activités ? A quelle échelle temporelle ? (veuillez l'indiquer en commentaire) [Commentaire]	
Quel est le caractère le plus important de l'information climatique pour votre activité ? [robustesse]	Oui
Quel est le caractère le plus important de l'information climatique pour votre activité ? [Commentaire]	
Quel est le caractère le plus important de l'information climatique pour votre activité ? [facilité d'accès]	Non
Quel est le caractère le plus important de l'information climatique pour votre activité ? [Commentaire]	
Quel est le caractère le plus important de l'information climatique pour votre activité ? [gratuité]	Non
Quel est le caractère le plus important de l'information climatique pour votre activité ? [Commentaire]	
Quel est le caractère le plus important de l'information	Non

climatique pour votre activité ? [crédibilité de la sources des données]	
Quel est le caractère le plus important de l'information climatique pour votre activité ? [Commentaire]	
Quel est le caractère le plus important de l'information climatique pour votre activité ? [guide d'usage fourni]	Non
Quel est le caractère le plus important de l'information climatique pour votre activité ? [Commentaire]	
Quel est le caractère le plus important de l'information climatique pour votre activité ? [autre (veuillez l'indiquer en commentaire)]	Non
Quel est le caractère le plus important de l'information climatique pour votre activité ? [Commentaire]	
La nature des données est-elle suffisamment compréhensible ? Si non, pourquoi ?	OUI
La nature des données est-elle suffisamment compréhensible ? Si non, pourquoi ? [Commentaire]	
L'information que vous recevez est-elle pertinente ? Si non, pourquoi ?	OUI
L'information que vous recevez est-elle pertinente ? Si non, pourquoi ? [Commentaire]	
Avez-vous confiance en l'information climatique ?	Non
A quel degré ?	
Pourquoi ? Est-ce un facteur qui fait obstacle à l'utilisation de services climatiques ?	
L'information arrive-t-elle trop tôt, trop tard, ou bien au bon moment, dans vos prises de décision ?	trop tard
Comment l'information peut-elle être rendue plus utile dans la prise de décision ? (image, échelle spatiale/temporelle différente, description de ce qui est indiquée, liste d'impacts potentiels)	
Quel type d'information climatique, autre que celle que vous utilisez déjà, vous serait utile ?	
Pour quelle(s) raison(s) ? Vous pouvez, si vous le souhaitez, indiquer en commentaire sous quelle(s) condition(s) vous utiliseriez de l'information climatique. [raisons économiques]	N/A
Pour quelle(s) raison(s) ? Vous pouvez, si vous le souhaitez, indiquer en commentaire sous quelle(s) condition(s) vous utiliseriez de l'information climatique. [Commentaire]	
Pour quelle(s) raison(s) ? Vous pouvez, si vous le souhaitez, indiquer en commentaire sous quelle(s) condition(s) vous utiliseriez de l'information climatique. [pas d'utilité]	N/A
Pour quelle(s) raison(s) ? Vous pouvez, si vous le souhaitez, indiquer en commentaire sous quelle(s) condition(s) vous utiliseriez de l'information climatique. [Commentaire]	

Pour quelle(s) raison(s) ? Vous pouvez, si vous le souhaitez, indiquer en commentaire sous quelle(s) condition(s) vous utiliseriez de l'information climatique. [manque de connaissance à ce sujet]	N/A
Pour quelle(s) raison(s) ? Vous pouvez, si vous le souhaitez, indiquer en commentaire sous quelle(s) condition(s) vous utiliseriez de l'information climatique. [Commentaire]	
Pour quelle(s) raison(s) ? Vous pouvez, si vous le souhaitez, indiquer en commentaire sous quelle(s) condition(s) vous utiliseriez de l'information climatique. [difficulté d'utilisation]	N/A
Pour quelle(s) raison(s) ? Vous pouvez, si vous le souhaitez, indiquer en commentaire sous quelle(s) condition(s) vous utiliseriez de l'information climatique. [Commentaire]	
Pour quelle(s) raison(s) ? Vous pouvez, si vous le souhaitez, indiquer en commentaire sous quelle(s) condition(s) vous utiliseriez de l'information climatique. [incompréhension des données]	N/A
Pour quelle(s) raison(s) ? Vous pouvez, si vous le souhaitez, indiquer en commentaire sous quelle(s) condition(s) vous utiliseriez de l'information climatique. [Commentaire]	
Pour quelle(s) raison(s) ? Vous pouvez, si vous le souhaitez, indiquer en commentaire sous quelle(s) condition(s) vous utiliseriez de l'information climatique. [autre (veuillez l'indiquer en commentaire)]	N/A
Pour quelle(s) raison(s) ? Vous pouvez, si vous le souhaitez, indiquer en commentaire sous quelle(s) condition(s) vous utiliseriez de l'information climatique. [Commentaire]	
Quelle(s) information(s) seraient susceptibles de vous intéresser, de vous être utile(s) (précipitations, évènements extrêmes, nombre de jours de gel, etc.) ?	
Quel type de données utiliseriez-vous (données historiques, prévisions saisonnières, projections climatiques, etc.) ?	
A quel(s) niveau(x) de votre activité l'information climatique aurait-elle un rôle ? [prise de décision]	N/A
A quel(s) niveau(x) de votre activité l'information climatique aurait-elle un rôle ? [Commentaire]	
A quel(s) niveau(x) de votre activité l'information climatique aurait-elle un rôle ? [recherche]	N/A
A quel(s) niveau(x) de votre activité l'information climatique aurait-elle un rôle ? [Commentaire]	
A quel(s) niveau(x) de votre activité l'information climatique aurait-elle un rôle ? [planification des différentes activités]	N/A
A quel(s) niveau(x) de votre activité l'information climatique aurait-elle un rôle ? [Commentaire]	

A quel(s) niveau(x) de votre activité l'information climatique aurait-elle un rôle ? [cibler les stratégies d'investissement]	N/A
A quel(s) niveau(x) de votre activité l'information climatique aurait-elle un rôle ? [Commentaire]	
A quel(s) niveau(x) de votre activité l'information climatique aurait-elle un rôle ? [autre (veuillez l'indiquer en commentaire)]	N/A
A quel(s) niveau(x) de votre activité l'information climatique aurait-elle un rôle ? [Commentaire]	
Avez-vous d'autres commentaires à ajouter ?	
Désirez-vous être recontacté par la suite afin de connaître l'avancé et les résultats du projet ?	Oui
A cet effet, quel est votre adresse e-mail ?	6. [Answer provided]
Acceptez-vous que vos coordonnées soient transmis à la base de données du projet ?	Oui
A cet effet, quel est votre adresse e-mail ?	7. [Answer provided]