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## FoPIA-SURE-Farm 2 Case Study Report France

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## 1 Introduction

### 1.1 Desk study for the Frech FoPIA-SURE-Farm 2 workshop

Due to the COVID-19 crisis, it was not possible to run the second FoPIA-SURE-Farm workshop for the French case study. This report constitutes a desk assessment based on previous activities done with stakeholders on the Bourbonnais and on expert assessments. We consider this report as a preliminary analysis that could be confirmed and completed in a second moment with the contribution of stakeholders.

Performances of main indicators and relevance of challenges could be completely elaborated starting from the material of the FoPIA-SURE-Farm 1 workshop. We considered that the challenges occurring in the present are likely to affect the system in the future. Concerning the development of alternative systems (both system decline and improved systems), we started by drawing and validating the causal diagram describing all the cause-effect relationships in the system and, based on that, we could think about the possible consequences on indicators and resilience attributes in the different alternative systems. The causal diagram is therefore presented before identifying alternative systems, in order to facilitate the comprehension of the consequences of the alternative systems on the indicators.

The alternative systems were developed thinking about alternative system configurations that could mitigate or avoid the effect of challenges that we judged more dangerous for the system. It is important to take this into account when results are compared among case studies, because we cannot say that the alternative systems are visions developed by stakeholders: they rather constitute a possible configuration to be validated in a second moment.

### 1.2 Main indicators, resilience attributes and challenges

The farming system of the French case study corresponds to the Bourbonnais region (department of Allier) and consists of an extensive grassland-based beef system. The farming system addresses two main markets: the internal French meat market consisting of the production of high-quality beef, and the international market (mainly with Italy as a primary partner) consisting of the export of grass-raised weanlings to be fattened and finished elsewhere. Usually, female cows are kept for the internal market and consumption, whereas male cows are for export.

From each function defined in the SURE-farm project, we picked one or two indicators defined by the stakeholders of the FoPIA-SURE-Farm 1 workshop. Criteria for indicator selection were the relevance for the system, their performance as assigned by the stakeholders, and the

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capacity to significantly represent, based on our experience and knowledge of the system, the impact of possible future scenarios on them.

Selected indicators are listed in Table 1, along with an indication of their performance, a comment on their performance, and a description of their current development. The function “Food production”, was considered as one of the most important and performing functions in the FoPIA-SURE-Farm 1 workshop, and needs to be characterized both in terms of quantity and of quality. For this reason, we decided to select the indicators “Total quantity of beef produced” (including both finished beef for internal market and exported weanlings for the foreign market) and “Taste and regularity of beef”. The function “Other bio-based resources” was at the same time the least important and the least performing, however, we thought it was important to keep one indicator (“Total quantity of co-products produced and delivered”) because in the farming system we are observing more and more practices related to hedges valorization and agroforestry. The function “Economic viability” was at the same time one of the least performing functions and one of the most important functions, so we thought it was important to consider in the analysis the indicators “Revenue per workforce unit (WFU)” and “Beef price”. The functions “Natural resources” and “Biodiversity and habitat” are well performing because the system, based on the grazing of permanent pasture, is strongly connected to the landscape and most of the stakeholders of the FoPIA-SURE-Farm 1 workshop were well aware of this. We selected the indicators “Hectares of permanent grassland” and “Artificial nitrogen consumed” for “Natural resources” and we selected “Number of species” and Length of hedges” for “Biodiversity and habitat”. For the function “Attractiveness of the area” we thought it was important to consider the indicator “Number of people working on exploitations”, because such indicator is important in relation to the demographic challenges analyzed in the Risk Management workshop and the AgriPoliS workshop (the population of farmers in the region is decreasing). Concerning the function “Animal health and welfare” the indicator “Fraction of grazing over the total lifespan” was suggested in the FoPIA-SURE-Farm 1 workshop; however, we thought it was more relevant to substitute this indicator with “Fraction of permanent grassland pasture in the diet”. In fact, cattle in the Bourbonnais are often raised on pasture, but sometimes the pasture from permanent grassland is supplemented with cultivated grass from temporary grassland or cereals.



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*Table 1. Main indicators and their performance and development. Source: FoPIA-SURE-Farm 1 workshop (Accatino and Neumeister, 2019)*

Main indicators	Current level (score 1:5)	Current level (explanation)	Current development
Total quantity of beef produced	5	The farming system produces well above the need of France and fulfills a very high international demand	<u>Stable</u> (The system continues working at its full potential)
Taste and regularity of beef	3.5	Many farms produce under label (" <i>Label Rouge</i> ") and cereals supplements (increasing beef quality) are produced in the same region	<u>Increasing</u> (The French beef sector encourages to produce more high-quality beef and the Bourbonnais has a competitive advantage)
Total quantity of co-products produced and delivered	1	In the current situation the production is mostly focused on beef with poor attention on other forms of production	<u>Increasing</u> (more and more farmers are promoting practices of hedges valorization and trees are being planted for agroforestry)
Revenue per WFU	2	Farmers have increasing costs due to recurrent droughts (purchase of external feed) and beef prices are low	<u>Slightly increasing</u> (farmers are more and more adapting to recurrent droughts, finding ways to protect their revenues despite the droughts)
Beef price	2	Consumers have a low willingness to pay for high-quality French meat	<u>Slightly increasing</u> (Concerning the internal market, the demand for high quality French beef is slowly increasing, whereas in the foreign market Italian demand is increasing also because of lower demand from the Polish and Irish producers)
Number of people working on exploitations	2	Population of farmers is ageing and the farm profession is less attractive for the new generations	<u>Slightly decreasing</u> The system is still in demographic crisis. However, the COVID-19 crisis might create new awareness about the importance of the farming profession
Hectares of permanent grassland	4	Permanent grassland is the main characteristic of the landscape	<u>Stable</u> Despite some increases in the cultivation of temporary grassland and cereal, the permanent grassland still remains the dominant element in the Bourbonnais
Artificial nitrogen consumed	2	There is a high availability of organic manure, therefore the need of artificial nitrogen is low	<u>Slightly increase</u> (the slight increase in the cultivation of cereals and of permanent grassland increases the need in chemical fertilizer). This corresponds to a decrease in the function "natural resources", as this indicator is negatively correlated to it.
Number of species	3	The number of species in the grassland landscape is considered average (lower than in a more forested landscape)	<u>Increases and decreases in different aspects</u> (increasing agroforestry increases the number of species, however the increase in temporary grassland lowers the number of grass species)
Length of hedges	5	Hedges are characteristic element of the landscape and are among the necessary conditions to have label certification	<u>Stable</u> (Hedges continue to be encouraged by policies and necessary to obtain the label)
Number of farms promoting direct selling	3	Some farms promote direct selling or, more in general, "open farms"	<u>Stable</u> (no substantial changes are observed)
Fraction of permanent grassland pasture in the diet	4	Overall cattle is raised on grass for a big part of the year	<u>Slight decrease</u> (feeding with cultivated grass and cereals is more needed for increasing droughts)

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Among the resilience attributes, we selected the three that we considered most relevant according to the FoPIA-SURE-Farm 1 workshop, the Risk Management workshop and the AgriPoliS workshop. We selected “Reasonably profitable” as economic viability is one of the main concerns of the stakeholders according to the insights of the FoPIA-SURE-Farm 1 and of the Risk Management workshop; we selected “Socially self-organized” because the Risk Management workshop highlighted the need of better organizing the coordination among actors of the value chain for improving the farmers’ conditions; we selected “Coupled with the local and natural capital” because one of the main characteristics of the Bourbonnais is the strong coupling with the landscape and its dependency on natural resources.

*Table 2. Main resilience attributes and their presence in the farming system. Source: FoPIA-SURE-Farm 1 workshop (Accatino and Neumeister, 2019)*

Main resilience attributes	Current level (score 1:5)	Current level (explanation)	Current development
<b>Reasonably profitable</b>	<b>1</b>	Strongly linked with indicators “revenue per WFU” and “beef price’ and judged by stakeholders to perform poorly	<u>Stable</u> (in order to improve, helps should arrive from policies and the consumers’ willingness to pay should increase)
<b>Socially self-organized</b>	<b>3</b>	The Risk Management focus group highlighted that some social self-organization is present among the actors, however it should improve for improving the farmers’ conditions	<u>Increasing</u> (the role of cooperatives, banks, and insurance companies is increasing)
<b>Coupled with local and natural capital (production)</b>	<b>4</b>	Strong coupling with grassland and on the use of organic manure	<u>Slight decrease</u> (The higher frequency of droughts decreases the coupling to permanent grasslands and increases the use of conserved grass and cereals as feed)

The activities with stakeholders (workshops, focus groups, interviews) performed in the case study area produced a list of challenges presented in D5.3 (Reidsma et al., 2019). We selected the most relevant challenge, i.e.:

- Increasing frequency of droughts (environmental challenge)
- Low profitability (economic challenge)
- Decreasing farmers’ population (internal social challenge)



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- Consumer's behavior (external social challenge)

Concerning the social challenges, we made the distinction between “internal” and “external”, considering that “internal challenges” are relevant to internal dynamics of the system (even though they can be triggered by external causes), whereas “external challenges” are mainly due to the relationship between the farming system and the external society (even though they can be triggered by causes internal to the system). We highlight that “Consumer's behavior” includes two important – and contradictory – aspects of the behavior of the consumer: the low willingness to pay for high-quality French meat and the social distrusts towards practices and beef systems. Those two aspects come from different parts of the society, but are to be considered together as a whole challenge that regulates the relationship between the Bourbonnais and the rest of the external society.



## 2 Results

### 2.1 Maintaining the status-quo

#### 2.1.1 Introduction

In this section, we define the status quo of the Bourbonnais farming system. The status quo is determined by ranges of values (delimited by lower and upper boundaries) of indicators, resilience attributes, and challenges. When one or more limits are passed, the system is likely to lose its current status quo and would probably assume another configuration. This exercise makes it possible to identify which are the elements (being them indicators, resilience attributes, or challenges) closer to the boundaries and more likely to push the Bourbonnais to lose its current status quo.

#### 2.1.2 Indicators

Among the indicators listed in Table 1, we selected a subset considered representative of the most fundamental aspects of the system. We considered the indicators of the functions strictly related to the main identity of the system, which is producing beef in strong relation with the natural capital. Therefore we consider the indicators related to “Food production”, “Natural resources”, “Biodiversity and habitat quality”, and “Economic viability”. Indicators related to “Other bio-based resources” and “Attractiveness of the area” are to be considered not strictly necessary to the core identity of the system and indicators related to “Quality of life” and “Animal health and welfare”, are to be considered as consequences of the selected indicators. Selected indicators are represented in Table 3, with their current level, along with lower boundaries for considering the system as still staying in the status quo. The upper boundary is not indicated as not relevant for assessing system collapse.

*Table 3. Status quo of the system represented via indicator value, for each indicator, the current level, and the lower boundary are represented. In the “Current level” column the values corresponding to the boundary are in bold.*

Indicator	Lower boundary	Current level
<b>Total quantity of produced beef</b>	<b>3</b>	<b>5</b>
<b>Taste quality and regularity of beef</b>	<b>2.5</b>	<b>3.5</b>
<b>Revenue per WFU</b>	<b>2</b>	<b>2</b>
<b>Beef price</b>	<b>2</b>	<b>2</b>
<b>Hectares of permanent grassland</b>	<b>3</b>	<b>4</b>

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Length of hedges	3	5
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### **Total quantity of produced beef**

In terms of quantity, the Bourbonnais is producing well above the demand of the internal French market and is satisfying a big demand on both the national and international market. We believe that the system can still maintain its status quo even though the total food production would be lowered to a certain extent. The system is currently performing at its maximum and some decrease can be tolerated without causing a collapse. We even believe that a decrease in the production would put some relief on the system (i.e., less methane emission and more energy and money focused on quality and landscape maintenance)

### **Taste quality and regularity of beef**

We pointed out that quality is an important component of the production of the Bourbonnais. Quality is mainly determined at the same time by the presence of cereal components in the diet and the good animal welfare for cattle. We believe that this indicator can have some elasticity both for improvement and for worsening without causing the loss of the status quo of the system.

### **Revenue per WFU and Beef price**

For these two indicators of economic viability, we believe that the system is at its limits. Those indicators were judged to perform very poorly in the FoPIA-SURE-Farm 1 workshop and we believe that they correspond to the lower limit of their range of variability. At moment, prices of beef are around 3.83 euros per kg of carcass for finished beef and 2.40 euros per kg for sold weanlings. Indeed a further decrease in these two indicators would cause an important abandonment of the farms in the Bourbonnais and would cause the closure of many farms, making the system collapse. For these indicators, the current level corresponds to the lower boundary (i.e., the system is at the tipping point) whereas the upper boundary is not relevant.

### **Hectares of permanent grassland and Length of hedges**

We believe that, at moment, these two indicators are not at a tipping point as the production of the Bourbonnais can be, at some extent, de-coupled from grassland. Even this is not desirable, some permanent grassland is converted into temporary grassland and cereal and some grassland is being converted to agroforestry, but permanent grassland (even if decreased) still is the main component of the landscape and extensive cattle rearing still remains the main farming activity in the area. In this case, lower limits are posed because we believe that the status quo of the Bourbonnais must be set also in terms of the cultural value of its landscape.

However, we believe that the system is not at the lower level both for maintaining the historical landscape and for guaranteeing the productivity of the system.

### 2.1.3 Resilience attributes

The lower and upper boundaries, along with the current performance, of resilience attributes are represented in Table 5.

*Table 5. Status quo of the system represented via values of resilience attribute. For each resilience attribute, the current level, the lower boundary are represented. In the “Current level” column the values corresponding to one of the boundary are in bold.*

Resilience attribute	Lower boundary	Current level
<b>Reasonably profitable</b>	<b>1</b>	<b>1</b>
<b>Socially self-organized</b>	<b>3</b>	<b>3</b>
<b>Coupled with the natural capital</b>	<b>3</b>	<b>4</b>

For the three resilience attributes, the upper boundary was not considered relevant (the higher are these attributes the better is for the system). We believe that the attributes “Reasonably profitable” and “Socially self-organized” are currently at their lower boundary (i.e., an ulterior decrease of them would cause the loss of the status quo). The attribute “Reasonably profitable” is at the lower level for the same reason of the indicators “Revenue per WFU” and “Beef price”, considered as performing very low. The attribute “Socially self-organized” is at the lower boundary: the Risk Management focus group highlighted that the system should protect farmers by increasing the degree to which actors are well coordinated in the value chain and in increasing the role of cooperatives. The attribute “Coupled with the natural capital” is not at a tipping point as the production of the system is not put at risk by some decrease of this attribute (as for the indicators “Hectares of permanent grassland” and “Length of hedges”) however, it is important for maintaining the cultural and historical identity of the region.

### 2.1.4 Challenges

The lower and upper boundaries of challenges, along with their current performances are represented in Table 6. While the lower boundary was not relevant for challenges in this analysis, the upper boundary was critical to consider. Concerning the challenge “Consumers’ behaviour” the joint effect of its two dimensions are considered in the score (i.e., the low willingness to pay for high-quality French beef and the social distrust to farming practices). We believe that the system can tolerate some slight increase in drought frequency and social

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pressure, however the system is at its limit (i.e., close to collapse) concerning the economic and demographic challenges (i.e., “Low profitability” and “Decreasing farmers’ population”).

*Table 6. Status quo of the system represented via values of challenges. For each challenge, the current level and the upper boundary are represented. In the “Current level” column the values corresponding to one of the boundary are in bold.*

Resilience attribute	Current level	Upper boundary
<b>Increasing frequency of droughts</b>	3	3.5
<b>Low profitability</b>	<b>4</b>	4
<b>Decreasing farmers’ population</b>	<b>3</b>	3
<b>Consumers’ behaviour</b>	4	4.5



## 2.2 Causal loop diagram of the system

Sections 2.4 and 2.5 will be dedicated to the formulation of future alternative systems, with a discussion of their possible impacts on the different indicators and resilience attributes. Before proceeding to alternative systems, we studied a cause-effect diagram of the system, to be coherent in the assessments. The purpose of this section is to present the causal loop diagram (CLD), to give an overview of the functioning of the farming system. The CLD was constructed via expert-assessment and needs to be validated or corrected by stakeholders. In order to facilitate the understanding of the diagram, we present two parts separately, the biophysical part (Section 2.2.1) and then the social-economic part (Section 2.2.2). The full version of the diagram is then provided at the end (Figure 1). It is important to note that not all the elements of the system are included in the diagram and some exogenous elements are not included.

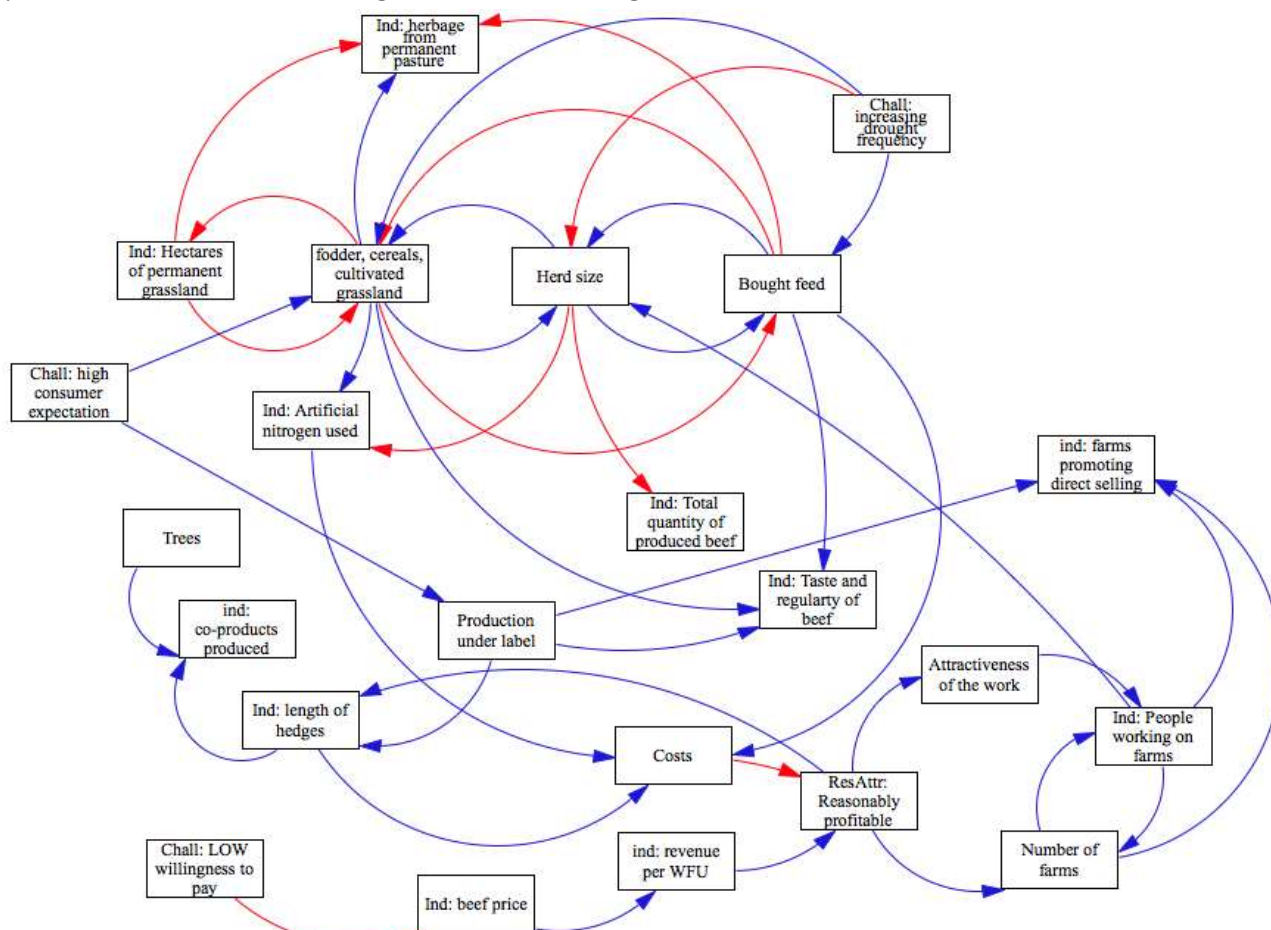


Figure 1. Causal loop diagram of the Bourbonnais system, including relationships between indicators (ind), challenges (chall), resilience attributes (ResAttr) and intermediary components of the system. Arrows link a cause to an effect, blue arrows represent a positive influence (an increase in the cause provokes an increase in the effect) and red arrows represent a negative influence (an increase in the cause provokes a decrease in the effect).

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### 2.2.1 Causal diagram of the biophysical component of the system

The most important elements of the biophysical component are those related to land use and cattle. Concerning land use, we consider “hectares of permanent grassland” and “fodder, cereals, cultivated grassland” (i.e., all the cultivated land that removes space to permanent grassland). Permanent grassland is in competition for land with other agricultural uses; therefore these two elements have a mutual negative relationship. The herd size represents the amount of cattle in the system and is directly positively affecting the indicator “Total quantity of produced beef”. The herd size can be increased if feed complements are available; this is possible by means of directly bought feed or if some land is cultivated with fodder, cereals, or cultivated grassland. On the contrary, the increase of the herd size increases the need for bought feed or other agricultural land uses. Bought feed and cultivated feed are mutually exclusive, so their mutual relationship is negative. We believe that permanent grassland can decrease but will remain the dominant element of the landscape in the Bourbonnais, therefore it is not likely to be a limitation to the herd size. It might become less productive though (because of droughts), therefore it is important that the availability of complement is the limiting factor for the herd. Those elements of the landscape are affected by elements of the socio-economic component of the system. The possibility of increasing the herd size and of cultivated land can be possible with increasing number of people working on exploitations, and the possibility to buy external feed depends on economic availability (“Reasonably profitable”).

The indicator “Artificial nitrogen consumed” is positively affected by the presence of fodder, cereals and cultivated grassland, because those land uses are intensively cultivated and need more artificial nitrogen. The herd size increases the availability of manure for organic fertilization, therefore it decreases the use of artificial nitrogen.

The quality of beef, identified by “Taste and regularity of beef”, is mainly determined by two factors. The first factor is the presence of cereals in the diet, because cereals increase the fraction of fat in the beef, giving a better taster than beef of cattle completely raised on grass. The second factor determining quality is the certification of the farm (e.g., Label rouge), as the certification gives a proof of high quality. The indicator “Fraction of permanent grassland pasture in the diet” is positively affected by “Hectares of permanent grassland” and negatively affected by complementary feeds (“bought feed” and “other agricultural uses”).

The presence of hedges is mainly determined by the economic possibility of farmers to maintain them and by the presence of productions under label. In fact, in the rules for obtaining the certification, the maintenance of the landscape with good quality pastures and hedges is mandatory. The presence of hedges and of trees in the landscape give the possibility to increase the delivery of co-products coming from the valorization of wood from hedges or from agro-



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forestry practices. The resilience attribute “Coupled with the local and natural capital” is positively affected by the “hectares of permanent grassland”, the “Length of Hedges”, and negatively affected by “Artificial nitrogen consumed”.

### 2.2.2 Causal loop diagram of the socio-economic component of the system

One of the most important elements of the socio-economic component of the system is the resilience attribute “Reasonably profitable”, which is positively affected by the costs and negatively affected by the revenue (indicator “Revenue per WFU”). The costs are directly determined by the elements of the biophysical components that constitute an expense for farmers, i.e., maintenance of hedges and pasture, bought feed, and the use of chemical fertilizer. The revenue is positively affected by the indicators “Total quantity of produced beef” and the “Beef price”. The “Beef price” is determined by the costs, but also on other external elements, including the willingness to pay of consumers for high-quality French beef, prices on the international market of weanlings and from the behavior of different value chain actors. From the Risk Management focus group it emerged that farmers are often a weak element in the value chain and do not have strong negotiation power. We therefore decided to include the resilience attribute “Socially self-organized” as a main determinant of the indicator “Beef price”.

The resilience attribute “Reasonably profitable” increases the attractiveness of the job of farmers (despite other external determinants might have an influence) and keeps the number of farms high (preventing them for closing). The attractiveness of the job and the high number of farms positively influence the indicator “Number of people working on exploitations”. The indicator “Number of farms promoting direct selling or tasting” is likely to increase if farms produce under label and if there are more people working on the farm (so that some people can be dedicated to the activities strictly related to the crop or cattle management and other people can be dedicated to the direct selling or to the open farm), however, we are aware that many other factors can influence this indicator.

## 2.3 System decline

### 2.3.1 Introduction

In this section we discuss some scenario of system decline, answering to the question: *“What would the system look like in case the challenges will increase beyond its upper boundaries”?* For each challenge, we discuss the impact it could have on the different indicators and resilience attributes.

We do not discuss the influence on the following indicators: “Number of species”, “Number of farms promoting direct selling or tasting” and “Socially self-organized”. The



indicator “Number of species” is too generic and does not have a clear link with the other components; for example a change in landscape configuration can bring to a decrease in certain species but in the increase of others. The indicator “Number of farms promoting direct selling or tasting” is too difficult to unambiguously link to other components of the system and depends on too many factors not included in the causal diagram. The resilience attribute “Socially-self organized” is not easy to link with the causal loop diagram and is considered more a part of the scenario setting than a consequence.

### 2.3.2 Performance of indicators and resilience attributes

#### **Increasing drought frequency**

If we consider droughts as shocks, the impact will be deleterious on “Total quantity of beef produced” and, in absence of insurance scheme, it will be also deleterious in the “Revenue per WFU” and in “Reasonably profitable”. However, this challenge is more about the increase in the frequency, so drought frequency is considered more a gradual stress than a shock. The most likely impact of an increase in the drought frequency on the Bourbonnais system is that the landscape would change and the farmers will be more and more focused on quality rather than quantity of beef produced.

A tabular representation of the effects of increased drought frequency is given in Table 7. Droughts will decrease the productivity of permanent grassland, therefore farmers will need either to buy external feed or to cultivate land in order to provide hay, fodder, or cereals to their cattle. In addition to that, it is already observed that, in answer to droughts, farmers plant more trees so to provide shelter to cattle and to stimulate the fertility of the grassland. The presence of more trees will stimulate forms of agroforestry and therefore the valorization of bio-based products other than cattle. Therefore the landscape is likely to change with less permanent grassland, more intensively cultivated grassland, more forage and cereal, and more trees in the landscape. The increased cultivated land and the decreased number of cattle will make the system more dependent on artificial nitrogen and the overall result will be a system less coupled with the natural capital.

The increased amount of cereals in the diet will improve the quality of beef, as the presence of cereal in the diet increase the fat and, as a consequence, the taste of the beef. The farmers are therefore induced to invest more in quality than in quantity and will produce more under label. The production under label requires the valorization of hedges; therefore, despite an increase in cultivated land, the remaining pasture and the hedges will likely be taken care of. On the economic side, we expect that the farmers will be subject to increased costs and, if consumers

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are not willing to pay increased costs for quality, the resilience attribute “Reasonably profitable” will decrease.

*Table 7. Effect of excessive increase in drought frequency on the indicators and resilience attributes of the Bourbonnais system. Arrows are to be interpreted as follows: → implies no change, ↗ implies moderate positive change, ↑ implies strong positive change, ↘ implies moderate negative change, ↓ implies strong negative change.*

Main indicators or resilience attribute	Increase or decrease	Explanation
Total quantity of beef produced	↘	The permanent grassland will become less productive, so the strategy of the farmers will be to decrease the stock. However, with increased bought external feed or cultivated grass, fodder, or cereal, the farmers can adapt and re-increase the herd. So the total effect will be a non-strong decrease
Taste and regularity of beef	↗	The main strategy of the farmer would be to focus on quality rather than on quantity. The diet of cattle will be richer and richer in cereal, increasing the taste of the beef.
Total quantity of co-products produced and delivered	↗	More trees will be planted to give shelter to cattle and to stimulate the productivity of grassland, therefore we expect that some products from agroforestry will be valorised
Revenue per WFU	↘	The farmers will likely decrease the stock and at the same time will have additional costs (feed purchase and chemical nitrogen), so in absence of changes in consumer's willingness to pay, the revenue is likely to decrease.
Beef price	↗	The production costs will increase and they will be likely to be internalized in the final beef price
Number of people working on exploitations	↘	it is likely that the job of farmer will become less attractive because of increased physical effort, uncertainty on the weather and on the revenue
Hectares of permanent grassland	↘	More and more permanent grassland will be likely to be substituted by cultivated grassland, fodder and cereals for feeding cattle.
Artificial nitrogen consumed	↗	With increased cultivation of grass, fodder, and cereals, the demand for artificial nitrogen is likely to increase.
Length of hedges	↗	Given that more and more farmers will focus on quality rather than quantity, they will be encouraged to produce under label and therefore they will valorize the landscape
Fraction of permanent grassland pasture in the diet	↘	Being the permanent grassland less and less productive, the farmers will try to compensate with complementary feed
Reasonably profitable	↘	Cost will likely increase and it will be harder to sell beef at the right price, therefore, we expect that this resilience attribute will decrease.
Coupled with local and natural capital	↘	The system will become less dependent on the natural capital as cattle rearing will be less coupled to the permanent grassland.



### **Decrease in profitability**

Although according to the scheme, the low profitability is linked with “Reasonably profitable” and is a consequence of internal components of the systems, there are some external factors influencing this challenge (some of them not included in the model). Profitability depends on the internal costs (which can be increased by other factors, e.g., droughts), but also on the willingness to pay of consumers, and on some other external mechanisms (not included in the scheme) that contribute to the definition of prices. A tabular representation of the effects of decreases in profitability is given in Table 8. In discussing this challenge we assume that there is no increase in subsidies or other forms of help by the policy. By scenario definition, the indicators “Revenue per WFU” and “Beef price”, as well as the resilience attribute “Reasonably profitable” will decrease, because they are part of the challenge.

If profitability becomes very low, we expect that many farms will close their activities and only a few farms, the most technical will survive. This will cause a drop in the indicators “Total quantity of beef produced” and “Number of people working on exploitations”. Having more land available (because of the land abandoned by the closed farms), the remaining farms are likely to cultivate some grass, fodder, or cereals; therefore it is very likely that cattle will receive many feed supplements, increasing “Taste and regularity of beef” and decreasing “Fraction of permanent grassland pasture in the cattle’s diet”. In addition to that, farms will focus exclusively on beef production, without dedicating budget to the maintenance of the hedges (decrease in “Length of Hedges”) and to the production of other bio-based product (decrease in “Total quantity of co-products produced and delivered”). The production of beef, will be less coupled to the local and natural capital.

Some indicators are likely to change in one direction at the farm level, but will change in the other direction at the farming system level, because of the decreased number of farms. The “Artificial nitrogen consumed” will increase at the farm level, but will overall decrease at the farming system level. Concerning “Hectares of permanent grassland”, the remaining farms will try to cultivate their own feed, but much space will be left by the remaining farms, so, overall the permanent grassland will be increased. However, this grassland will be mostly abandoned, without maintenance or valorization, and with the possibility of being invaded by forest or bushes.



## D5.5 Impacts of future scenarios on the resilience of farming systems across the EU assessed with quantitative and qualitative methods

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*Table 8. Effect of excessive decrease in profitability on the indicators and resilience attributes of the Bourbonnais system. Arrows are to be interpreted as follows: → implies no change, ↗ implies moderate positive change, ↑ implies strong positive change, ↘ implies moderate negative change, ↓ implies strong negative change.*

Main indicators or resilience attribute	Increase or decrease	Explanation
Total quantity of beef produced	↓	Only a few technical farms will survive, and many farms will close. Thus, we expect that the total quantity of beef produced will be decreased at the farming system level.
Taste and regularity of beef	↗	The few farms remaining in the system will have more land available and will cultivate more cereals, fodder, and grass. We then expect that more cereals will be in the cattle's diet and this will increase the quality.
Total quantity of co-products produced and delivered	↘	The farms that will be able to stay profitable will more likely focus on the production of beef without valorizing co-products.
Revenue per WFU	↓	This indicator is indeed part of the challenge, and, according to the scenario, it will be decreased.
Beef price	↓	This indicator is indeed part of the challenge, and, according to the scenario, it will be decreased.
Number of people working on exploitations	↓	We expect that the decrease in profitability will provoke the closure of many farms and therefore many farmers will leave the sector.
Hectares of permanent grassland	↗	Because most of the farms will terminate the activity, it is likely that more land will be left free. Even though the surviving farms are more likely to invest on crop and grassland cultivation, at the farming system scale, hectares of permanent grassland will be left abandoned. However the pasture will not be taken care of and it might be invaded by forests and bushes.
Artificial nitrogen consumed	↘	While the artificial nitrogen will increase at the farm level, it might decrease at the farming system level, because there are less farms.
Length of hedges	↓	Given the low profitability, the surviving farms are less likely to spend their money on hedge maintenance, and many hedges will be left on abandoned farms.
Fraction of permanent grassland pasture in the diet	↘	The remaining farms will probably increase the share of fodder and cereals in the cattle's diets
Reasonably profitable	↓	By definition, in this challenge, this indicator is imposed to decrease.
Coupled with local and natural capital	↓	The system will tend to be less coupled with the natural capital as the remaining farms



### **Decrease in farmer's population**

The demographic challenge is mostly a consequence of the low profitability, because the attractiveness of the job is mainly given by the economic aspect. If we consider the decrease in farmer's population as a direct consequence of the low profitability, then, the consequences of this challenge will be the same as in Table 8. However, we also try to imagine the demographic challenge as separated by the economic challenge, considering that the decrease in farmers' population might be due other factors (e.g., existence of preferred jobs, unwillingness to engage the physical demanding job of being a farmers, personal reasons, etc.). By definition, the indicator "Number of people working on exploitation" will decrease.

The effect of a decrease in farmers' population alone (without the economic challenge) is given in tabular form in Table 9. The number of farms will be decreased and the remaining farms will invest a lot on the quality. They will have more land available, so they will be able to cultivate their forage, but at the same time to valorize hedges and the pasture. Therefore, if the "Total quantity of beef produced" will be less at the farming system level (the system will likely be focused on the internal French market), the quality of beef produced will be increased, because the farmers will likely produce under label and will include cereals in the cattle's diet. Those remaining farms will also likely produce other products from the valorization of hedges and agro-forestry (increase in the "Total quantity of co-products produced and delivered"). It is reasonable to think that the population of farmers will be lowered until there will be a new equilibrium between supply and demand. The remaining farms will be addressed to a niche market willing to pay the good price for the high-quality product. This is why the economic indicators and resilience attribute might increase ("Revenue per WFU", "Beef price", "Reasonably profitable").

The remaining farms will mostly produce under label; this means that they will valorize the organic manure provoking a decrease in "Artificial manure consumed", hedges and pastures will be valorized. We overall expect that the production of beef will be more coupled with the natural capital.

## D5.5 Impacts of future scenarios on the resilience of farming systems across the EU assessed with quantitative and qualitative methods

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*Table 9. Effect of excessive decrease in farmers' population on the indicators and resilience attributes of the Bourbonnais system. Arrows are to be interpreted as follows: → implies no change, ↗ implies moderate positive change, ↑ implies strong positive change, ↘ implies moderate negative change, ↓ implies strong negative change.*

Main indicators or resilience attribute	Increase or decrease	Explanation
Total quantity of beef produced	↓	Less farms will be present, therefore the total production will decrease at the farming system level.
Taste and regularity of beef	↑	If we do not consider the economic aspect, we can say that the remaining farms will be there for personal choices, therefore they will be under label and they will take care of pastures and hedges. They will give some cereal feed supplements to their cattle, bought or cultivated.
Total quantity of co-products produced and delivered	↗	Farmers will be likely to diversify their production and therefore also to produce other products.
Revenue per WFU	↗	The remaining farms will be likely to be profitable and have a better revenue. The lower concurrency will allow to find niches of consumers for the high quality beef.
Beef price	↗	The higher quality of beef produced will likely increase the price.
Number of people working on exploitations	↓	By definition this indicator is decreased.
Hectares of permanent grassland	↗	Much land will be left free from closed farms, therefore it will remain permanent grassland. In addition, the remaining farms will be more likely to take care of the pastures.
Artificial nitrogen consumed	↘	Farmers will try to valorize the organic manure, as they will be working more under label.
Length of hedges	↑	Remaining farms will work under label and they will be therefore dedicated to the valorization of hedges
Fraction of permanent grassland pasture in the diet	↘	In order to increase quality, more cereals should be given to cattle
Reasonably profitable	↗	The farms will be less, but they will reach an equilibrium in which they are profitable
Coupled with local and natural capital	↗	The remaining farms will be under label and will valorize grasslands trying to use less artificial nitrogen. Therefore the system will be more coupled to the local and natural capital.



### **Exacerbation of negative consumers' behavior**

This scenario assumes that the negative and contradictory behavior of the consumer leads to extremes and will put a great pressure on the system. On the one hand, the consumer will expect the system to be of very high-quality, characterized by a high valorization of the landscape, a high quality of the beef, an increased animal welfare. On the other hand, the consumers have a low willingness to pay for this high-quality French beef and they will continue buying cheaper beef of less quality. We think that this is the most difficult challenge as the system is solicited from two sides: from one side farmers will try to increase the quality of beef and of the landscape (increasing costs), from the other side farmers have to face all the problems related to the lower revenues. We therefore think that this is the scenario most adapted to be labeled “system decline” as farmers have less room for adapting to the situation.

Many farms will fail as the economic-related indicators and resilience attributes will drop (e.g., “Revenue per WFU”, “Beef price”, and “Reasonably profitable”), so we can expect that the number of people working on exploitation will decrease and, consequently, the “Total quantity of beef produced” will decrease. The remaining farms will likely cultivate some cereals and will try to produce under label to satisfy consumers' expectations (increase in “Taste and regularity of beef”), however, the low budget will make it very difficult for them to well valorize hedges and pasture. Some farmers will destock the herd and cultivate more cereals, in order to be able to sell also cereals on the market. The “cerealisation” puts the permanent grassland into danger and will increase the consumption of artificial nitrogen. Overall, the system will be less coupled to the natural capital.

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*Table 10. Effect of excessive intensification in negative consumers' behaviour (i.e., low willingness to pay and distrust for farmers' practices) on the indicators and resilience attributes of the Bourbonnais system. Arrows are to be interpreted as follows: .→ implies no change, ↗ implies moderate positive change, ↑ implies strong positive change, ↘ implies moderate negative change, ↓ implies strong negative change.*

Main indicators or resilience attribute	Increase or decrease	Explanation
Total quantity of beef produced	↓	Most farms will fail, so the total production will be decreased.
Taste and regularity of beef	↗	The few remained farms will be likely to produce good-quality beef
Total quantity of co-products produced and delivered	↓	No room for the valorization of co-products will be given
Revenue per WFU	↓	The low willingness to pay of the consumer will decrease the price and lower the revenues.
Beef price	↓	The low willingness to pay of the consumer will decrease the price
Number of people working on exploitations	↓	Many farmers will abandon the job
Hectares of permanent grassland	↘	Permanent grassland will be less valorized and it is likely that many farmers will convert their production to cereals
Artificial nitrogen consumed	↗	It is likely that the total artificial nitrogen will increase, because of a decreased herd and an increased surface to fertilize.
Length of hedges	↘	Although remaining farms will be under label, there is less budget for the valorization of the pasture and the hedges.
Fraction of permanent grassland pasture in the diet	↘	in order to increase quality, more cereals should be given to cattle
Reasonably profitable	↓	By definition, the low willingness to pay of consumers will make this resilience attribute drop
Coupled with local and natural capital	↓	The remaining farms will struggle to valorize grassland

## 2.4 Alternative systems

### 2.4.1 Introduction

The formulation of alternative systems was expert-based, i.e., no stakeholders were consulted for these alternatives. Therefore, conclusions must take this into account. We do not exclude



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that, in the future, these alternative systems will be submitted to stakeholder's opinion and will be enriched with other alternatives generated by stakeholders.

While analyzing the challenges, we concluded that the exacerbation in consumers' negative behavior is the one that, despite not being at a tipping point, would put the highest level of stress on the system. In addition to this challenge, the farmers of the Bourbonnais are close to tipping points regarding the demographic (drop of farmer's population) and economic challenge (low profitability). In thinking of the alternative systems, we thought about configurations that posed some relief on the system from the socio-economic perspective. From the environmental point of view, we observed that the increasing frequency of droughts is something to which farmers are adapting, focusing more on meat quality than on meat quantity.

We thought that alternative systems should reduce to a certain extent the amount of cattle in the area. Apart from reducing emissions, we think that this would keep the system more adapted to the increased drought frequency and would allow to have a better balance between quantity and quality of beef production, while maintaining a good equilibrium between cultivated land, permanent grassland and landscape valorization. The three formulated alternative systems envisage different forms for maintaining the economic viability of the farming system and at the same time mitigate the challenges posed by the consumer's behavior. The impact of the different systems are depicted in Table 11, and their explanation is in the following subsections.



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*Table 11. Current perceived performance of main functions and presence of resilience attributes (FoPIA-SURE-Farm 1) and their expected change in future systems. → implies no change, ↗ implies moderate positive change, ↑ implies strong positive change, ↘ implies moderate negative change, ↓ implies strong negative change, V implies that a boundary condition is relevant for a future system. Arrows and tick marks in bold font are results obtained in the workshop. Arrows and tick marks in normal font are deductions from what has been said in the workshop.*

Indicator	Current level	Status quo	System decline	Only export	Only French market	Tourism
Total quantity of beef produced	5	→	↓	↓	↓	↓
Taste and regularity of beef	3.5	↑	↗	-	↑	↗
Total quantity of co-products	1	↑	↓	↗	↑	↗
Revenue per WFU	2	↗	↓	↑	↑	↑
Beef price	2	↗	↓	↑	↑	↑
Number of people working on exploitations	2	↘	↓	↓	↗	↑
Hectares of permanent grassland	4	→	↘	↘	↗	↘
Artificial nitrogen consumed	2	↗	↗	↗	↘	↗
Length of hedges	5	→	↘	↘	↗	↑
Farms promoting direct selling	3	→	↘	↓	↗	↑
Fraction of permanent pasture grassland in the diet	4	↘	↘	↑	↗	↘
Reasonably profitable	1	→	↓	↑	↑	↑
Socially self-organized	3	↑	-	-	↗	↑
Coupled with the local and natural capital	4	↘	↓	↗	↑	→
<b>Boundary conditions</b>	<b>Domain</b>					
No large increase in drought frequency	environmental	V		V	V	V
International demand of weanlings	economic	V		V		
Internal demand for (high-quality) beef	economic	V			V	V
Aids from the banks	economic	V			V	V
Insurance schemes	economic	V		V	V	V
Green aids	institutional	V		V	V	V
Farm population should not decrease	social	V			V	V
Not a much higher social distrust	social	V				
Decreased social distrust	social				V	V
Aid from policies	institutional				V	V
Interaction with other tourism business	economic					V

## 2.4.2 Only-export system

We imagined an alternative system for the Bourbonnais based on its specialization on raising weanlings for export. The earlier activities with stakeholders (first FoPIA-SURE-Farm workshop and Risk management focus group) highlighted the problem related to the consumer preference: many French consumers are not willing to pay high prices for high-quality French beef and prefer beef in other forms, often in the form of minced meat, which comes mostly

from the dairy sector. Therefore, a system based only on the weanling export would avoid this problem, as the demand from the Italian market is currently stable and even increasing.

### **System narrative**

*In this system, the internal French market will not be addressed, with the exception of a small fraction of farms focused on a very niche internal market of high-quality French-finished beef. The specialization of export (mostly to Italy) constitutes a more stable output as the demand from the Italian market is even increasing, as the Italian value chain misses suckling cows for being self-sufficient. In this way, the difficulty to address the internal French market will be avoided. At the same time, the farmers of the Bourbonnais will do their best to address the social concerns about environment and animal welfare. Farms will have smaller herds (to reduce methane emissions) and, as a consequence fewer farms will be able to survive economically. The production will be lowered, however the international demand will keep the price still competitive. The raising of weanlings will be almost completely done on grass in order to promote a good local image of the animal welfare. This scenario will make it possible to still valorize the grassland resource of the Bourbonnais even in face of the decrease in the consumption of high quality local meat in the French market.*

### **Impacts on indicators and resilience attributes**

In this system, we imagine that the number of farms will decrease, as well as the total number of people working on exploitation. However, the new production will reach a new equilibrium between demand and supply, making the farmers' activity rentable: the prices and the revenue will increase and the system will be reasonably profitable. Given that the raising of weanlings will be done completely on grass, we can imagine that the grassland resource will be valorized, however, given the reduced number of cattle farms, it is reasonable to think that many farmers that abandoned the activity of breeders will be encouraged to grow crops (e.g., cereals) for other markets. This will be possible also because the presence of some cattle reduces the dependency on external chemical fertilizers. Overall we can say that the permanent grassland is likely to slightly decrease (as cattle farms will be less) and the chemical fertilizer is likely to increase. Given that the consumption will be abroad and not in France, farmers will be less encouraged to have a French label certification, so they will be less motivated to maintain hedges, unless policy-based rules will apply about that. The raising of cattle will be done on grass, so in this sense it will be coupled with the natural capital.

### **Boundary conditions**

Boundary conditions for this system regard first of all environmental conditions: the system will be more and more relying on grassland resources, therefore the droughts should not increase too much and insurance scheme should protect farmers in case of droughts. The system will be



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dependent on international market demand, therefore an important boundary condition is related to the external demand. Moreover, because the weanlings are consumed abroad, the system will be dependent on the international market demand and, in addition to that, a French label will not have an effect. In this sense, it is important that French internal regulations protect the landscape and put as a constraint the hedges valorization.

### Considerations

It is to be noted that this alternative puts the system in a fragile situation, being it only dependent on the international demand. This alternative might be a good option in case the internal French demand for high-quality French beef drops and if, at the same time, strict regulations are posed on beef production. In addition, it is important to say that, even though the Bourbonnais is a system completely based on farms, it has no control on the animal welfare and on the practices abroad, where weanling are intensively fattened on cereals.

#### 2.4.3 Only-French-market

This scenario is envisaged for two reasons: the first reason is that we wanted to present a dual and opposite scenario to the “only-export scenario”, based on strategies aimed at valorizing the internal production and consumption of high quality French beef; the second reason is that, due to the COVID-19 crisis, we are observing that there is an increasing awareness in the society of the importance of the role of farmers, and about the importance of the country’s food self-sufficiency. We therefore try to imagine an alternative state of the Bourbonnais based on the cooperation of the external society in the farming and beef production.

### System narrative

*The COVID-19 raised the awareness in many countries about the primary importance of food self-sufficiency. In addition to that, the reputation of the farmer in the society increased along with the feeling of gratitude for farmers for guaranteeing food production during the crisis. Production for the internal market will be more and more encouraged and, on the contrary, the export (especially the transportation of live cattle) and imports will be discouraged. The internal production will be more and more controlled so to have a higher quality and the environmental awareness will push policy-makers to protect the landscape and animal welfare. Consumers will be willing to pay higher prices for French beef. The growth of cattle will be slower and grass-based.*

### Impacts on indicators and resilience attributes

The production of the Bourbonnais will be only focused on the internal market; therefore the raise of weanlings for export will drop. As a consequence, the total quantity of beef produced will be less. However, the system will be more and more focused on the quality, cattle will spend more time on permanent grassland with a balanced adding of cereals to the diet. The hedges

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and the pasture can then be valorized. The presence of more people on the farm will promote forms of direct selling and tasting and alternative activities, such as the valorization of co-products. The system will be more coupled with the natural capital and less artificial nitrogen will be used.

### **Boundary conditions**

This scenario increases, at the same, time the profitability of farms in the Bourbonnais as well as the landscape quality. What makes such a win-win solution possible is the presence of good policies that help farmers; on the one hand to produce beef for the internal market, and on the other hand to valorize the landscape. It is important that many people will stay on the farm, as many activities will be needed and the workforce need to be trained and encouraged to approach the profession. Last but not least, this state is subject to the climatic conditions and the drought frequency should not increase too much. The social distrust should decrease considerably.

#### **2.4.4 Tourism**

This scenario was formulated because in the first FoPIA-SURE-Farm workshop, one of the suggested strategies was based on promoting a good image of the Bourbonnais in order to decrease the social distrust of society about cattle breeding. In addition, we noticed that the function “Attractiveness of the area” was not assigned a high importance. Therefore, we imagined a state in which the attractiveness of the area is assigned a higher importance and more consumer will be able to visit the region. One of the biggest sources of problem is that external consumers often have a distorted image of the Bourbonnais given by the media. Increasing the tourism would correspond to bring the consumers to the region and would serve to improve the reputation of the Bourbonnais and, at the same time, to promote other activities such as agro-tourism. Indeed the Bourbonnais has also a number of historical sites and a landscape that might be very attractive to tourists.

### **System narrative**

*Tourism will be more and more developed in the region. Farm activities will not only be based on cattle breeding but also on agro-tourisms and other activities related to the external society such as education. People will be more and more attracted to the Bourbonnais, which will become a region of excellence for the food produced but also a place to visit for the beauty of its landscape. Farmers have multiple sources of income, coming from their different activities and the number of people working on the farm increases. Interactions with other forms of tourism will embed the farming activity in a more economically dynamic context (e.g., trekking and cycling tracks, historical sites, gastronomic holidays).*



### **Impacts on indicators and resilience attributes**

With this alternative state, the production will be mainly focused for the internal market and the production for the international trade will be decreased, causing a decrease of the total production. However, the production will be extremely focused on quality, with a valorization of the landscape, permanent grasslands and the hedges. More people will work on the farm and in the farming sector in general, as more people are needed to do varied activities. The price of beef will be higher, because of an added value and the revenues will be higher (e.g., subsidies or labels). Co-products are more likely to be valorized. However, the diet of cattle will include also cereals and some farmers will cultivate some cereals to increase the beef taste and this could cause an increase in the use of artificial fertilizer. Farmers promoting direct selling or tasting will increase.

### **Boundary conditions**

In order to have a system of this type, it is important that policies provide their support to the transformation of farms into some business able to promote forms of agro-tourisms. Banks should finance the starting of the new forms of business. The social distrusts by society should decrease in order to have visitors to the region. It is also important that the farming sector interacts with other local organizations for tourism to promote synergies.

## **2.5 Strategies towards the future**

In order to analyze the strategies for reaching the different alternative futures, we took into consideration the list of strategies done for D5.3 (Reidsma et al., 2019) for the French case study. This list was elaborated by examining the material from interviews (learning capacity and demography), FoPIA-SURE-Farm 1 workshop, AgriPoliS workshop, and the Risk Management focus group. Most of those strategies were applied in the past, whereas other strategies were proposed as suitable for the future. For each strategy we evaluated their suitability to the different alternative systems and we added some scenario-specific strategies that we considered suitable for the different systems.

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*Table 9. Current strategies and future strategies for different future systems. Current strategies are based on FoPIA-SURE-Farm 1. Strategies statements proposed for future systems that are currently been implementing in the present are underline. Current strategies statements (not indicated in the workshop for future systems) are indicated in italics. Bold font indicates that these strategies were mentioned during the workshop for a specific system. Normal font indicates that, based on the discussions during the workshop, it seems likely that strategies will be applied in certain systems.*

Strategy	Domain	Status quo	All-export	Only French market	Tourism
Developing farmers' associations and cooperatives	Social	V		V	V
Diversification of the production	Agronomic	V			V
Diversification of buyers	Economic	V	V	V	V
Facilitating young farmers' installation	Social	V		V	V
Professionalise the workforce	Social	V	V	V	V
Investing in new technologies and practices	Agronomic	V	V	V	V
Improving food self-sufficiency in the region	Agronomic	V		V	V
Improving feed self-sufficiency in the region	Agronomic	V	V	V	
Developing grass fattening	Agronomic	V	V	V	
Adopting practices that mitigate floods	Agronomic	V			
Adopting practices that fulfil social expectations	Social	V		V	V
Bank help in debt limitations	Economic	V		V	V
Good risk assessment by banks	Economic	V		V	V
Advancement of payment by cooperatives	Economic	V		V	V
Insurance schemes	Economic	V	V	V	V
Improve life quality at work	Social	V		V	V
Facilitating exchange of information between farmers	Social	V		V	V
Monitoring farmers' situations	Social	V		V	V
Insurance replacement service	Social	V	V		
Policy supports direct payments and insurance schemes	Institutional	V	V	V	V
Building a positive image of the Bourbonnais	Social			V	V
Improve the coordination among actors of the value chain	Social/Economic			V	V
Improve access of farmers to public markets	Institutional			V	
Promoting communication between farmers and other actors	Social			V	V
Better tax policy	Institutional			V	
<i>Policy for landscape protection</i>	<i>Institutional</i>		V		V
<i>Facilitating the export</i>	<i>Institutional</i>		V		
<i>New business model</i>	<i>Institutional</i>				V
<i>Coordination with actors outside agriculture (tourism)</i>	<i>Social/Economic</i>				V

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The strategies for the only-export system are mostly focused on the specialization of the farms of the Bourbonnais for promoting the raising of weanlings for the international market. International markets will determine the final price; therefore there would be little interest in maintaining a high number of farmers as their number will reach an equilibrium with the international market; however, the policy-makers could facilitate the exports. Farmers will need to maximize the diversification of buyers, finding different buyers in the same foreign countries or in different countries. Farms should invest in technical aspects for being efficient in grass-raising of weanlings. Drought would be a problem, as the system would be mostly based on grass; therefore on the technical side it will be important to promote feed self-sufficiency and to promote practices for feed storage. On the financial side it is important to have good insurance schemes. It is important to promote the landscape valorization (e.g., hedges maintenance) as farmers will not be encouraged to fulfill the expectation of the French consumers. Other strategies are not as important as for other alternative states, but will still be relevant (e.g., developing farmers' associations, help from banks).

As for the Only-French-market state, we believe that almost all the strategies are concretely important. In this state, farmers will be sustained economically and will need to increase their role in the value chain. Therefore, all the strategies apply that can promote the installation of new farmers, the coordination among actors of the value chain, and the protection of farmers in case of droughts (insurance schemes, increase of the feed self-sufficiency). The reputation with the consumers should be consistently kept high by adopting good practices and by promoting a good image of the Bourbonnais.

The tourism state would be the most transformative, as the farming system will not only be a place of production of beef and weanlings, but also a region of excellence for food quality and for the landscape. The consumer will physically visit the region. This will require a transformation of the system also outside the farms, expanding in other sectors. Strategies that apply in the only-French-market scenario will still apply but with a wider meaning. For example, the strategy "Facilitate young farmers installation" would mean to bring also new competences in the region for developing side activities to the farming. All the types of interactions among actors will need to be facilitated, and will apply at all levels, i.e., among farmers, with other actors of the value chain, and, in this particular scenario, also outside the agro-food sector (e.g., tourism). Strategies aimed at improving feed self sufficiency will be important but not as much as in the only-French-market scenario. The image of the Bourbonnais will need to be carefully promoted, and will also be subject to other rules also concerning the laws of tourism. Investment should be promoted and transformations should be permitted by banks.



### 3 Interpretation

#### 3.1 Tipping points

We believe that the system is close to tipping points for those elements concerning the economic and demographic aspects. Production is not a problem, because the Bourbonnais produces well beyond the French demand, so a decrease in production can be sustained. Concerning the environment, we believe that the system is well coupled with the natural capital. However, a change in the configuration could maybe deteriorate permanent grassland and landscape quality, but without compromising the functioning of the farming system. Participants of the FoPIA-SURE-Farm 1 workshop highlighted the low performance and at the same time the high importance of the economic viability. A decrease of the beef price and of the farmers' revenue will most probably provoke a system decline. The economic challenge is then strictly connected to the demographic challenge. The system is at the moment of the generational renewal and probably a depopulation of the region will provoke a collapse of the system.

Concerning the consumers' expectation, we don't think that the system is at the tipping point in its current configuration. However, we expect that, if the pressure of external society will reach the limit, the collapse will be quite abrupt because the farms will have a more severe budget restriction, due to the lower revenue and higher expenses to promote quality, good practices and landscape quality

#### 3.2 Thresholds exceeded

We believe that the most deleterious interactions between thresholds in the system is the one between social pressure and low profitability. This interaction will cause a vicious feedback between rural population, landscape maintenance, profitability and consumer's behavior. The low willingness to pay of the consumers lowers the economic viability of the system. For this reason, many farmers will likely quit, lowering the population of farmers at the farming system level. The maintenance of the landscape will be lowered because of the reduced budget of farmers and a decrease in the rural population. At its turn, the low level of landscape maintenance will exacerbate the negative impression of the consumer who will have its expectation deluded and will lower their willingness to pay.

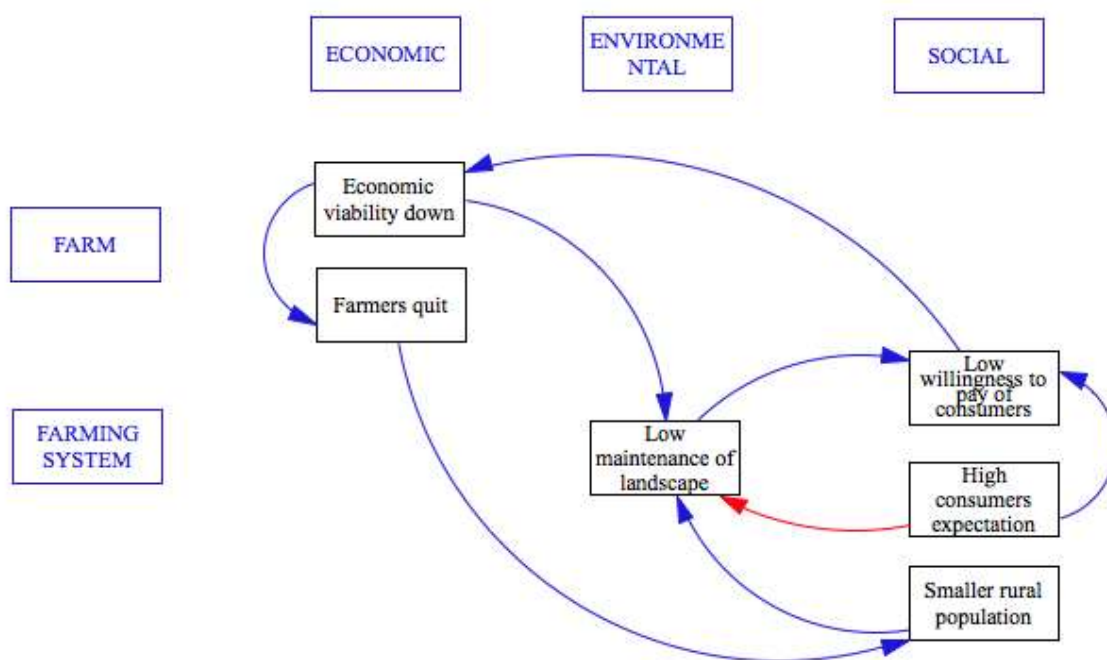


Figure 2. Interacting thresholds in the farming system.

### 3.3 Linking alternative systems to scenarios

The scenarios developed for the Bourbonnais were compared with the storylines of the Eur-Agri-SSP scenarios. The compatibility with the scenario was scored, by comparing the importance of a range of indicator for the system, on a scale from -1 to 1, where values -1 to -0.66: strong incompatibility, -0.66 to -0.33: moderate incompatibility, -0.33 – 0: weak incompatibility, 0-0.33 weak compatibility, 0.33-0.66: moderate compatibility, and 0.66-1: strong compatibility.

#### 3.3.1 Eur-Agri-SSP1 “Sustainability”

Firstly, it should be noted that it is difficult to adapt the Bourbonnais (historically based on the production of beef) system to this scenario, as this scenario envisages a progressive reduction in animal-source food production in favor of an increase in plant-based food production. However, the Eur-Agri-SSP1 scenario envisages the production of meat in a few places in Europe, in systems characterized by high feed self-sufficiency. The Bourbonnais has a high potential to meet the criteria of being one of the few beef systems in Europe that produce beef in a sustainable way (in connection with land and with the local resources). It is also to be considered that most of the beef production is extensive and based on grass, thus with a low feed-food competition. In contrast, the presence of cattle is at the current state quite high in the region, provoking a relatively high level of methane emissions from enteric fermentation.

In general the status quo and the alternative systems are comparable with the sustainability scenario. The only-export scenario and the tourism scenario, however, have a lower compatibility because they involve some elements, such as transportation of agricultural commodities in Europe

The compatibility of the only-export scenario to the Eur-Agri-SSP1 scenario is considered “low”. On the one hand, the amount of cattle will be lower, with a reduction in the methane emissions and with a probable increase in cultivation of crops for human consumption. On the other hand, such system relies on exports and, if we assume that also other regions will follow the same Eur-Agri-SSP scenario, we believe that it is not realistic to have a system based on export. In addition to this, if the weanlings are raised on grass with high animal welfare, the fattening in the other regions is based on maize with low animal welfare and less respect of the environmental rules.

#### 3.3.2 Eur-Agri-SSP2 “Status quo”

The compatibility with this system was evaluated as the extent to which the formulated alternatives are similar to the status quo. All the three alternative states are characterized by a decrease in the production of beef in order to have a less intense production and a higher valorization of the product. All the three scenarios are quite different from the status quo: the



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first two (All-export and “Only-French-market”) because they exclude a part of the market in which the system invested so far, the third because it includes the tourism, which is a completely new dimension of the system. However, we can say that the Only-French-market scenario is more similar to the status quo because the status quo, with the increase of drought frequency is focusing more and more on quantity and on a production less linked to the grassland resource. The tourism scenario is the most different because it consists in a transformation of the business.

### 3.3.3 Eur-Agri-SSP3 “Regional rivalry”

The Eur-Agri-SSP3 scenario is based on the increase in local production with a decrease in trade exchanges between the regions. The All-export scenario is considered not compatible with this scenario because it cannot be sustained without the possibility to trade with external countries. On the contrary, the Only-French market is comparable to the scenario in the sense that the internal trade is reduced and food self-sufficiency is promoted, in fact the alternative system is conceived in the context of the COVID-19 pandemic that would put value on the production totally internal to the country. In addition, the production is largely based on permanent grassland, characterized by a low feed-food competition and adding a net contribution to the nutrition of the population of the country. The Tourism scenario, will be compatible with the Eur-Agri-SPP3 scenario in the sense that the production will be based locally, however, the movement of people (and of tourists) will be likely negatively affected by the regional rivalry restrictions. However, all the four system exhibit incompatibility with the SSP3 scenario, with a weaker incompatibility for the Only-French-market and the Tourism.

### 3.3.4 Eur-Agri-SSP4 scenario “Inequality”

The Eur-Agri-SSP4 scenario is mostly based on the consumption of meat for the elites (that can afford high prices) therefore, the Bourbonnais can fit into this scenario if production is lowered and the price is kept high. In its current state, the system could fit, however the willingness to pay for the high-quality beef is very low in general. The Eur-Agri-SSP4 scenario also envisages a liberal trade of the animal products, and this is matching the current reality of the Bourbonnais system

The compatibility of the All-export scenario is considered higher than in the other alternative systems because international trade will be advantaged and the system would be completely based on the international market. The production will be lowered in this scenario, but this would fit, because the consumption will be only for the elites. The compatibility of the Only-French-market scenario is to be considered weak because, even though the system is not dedicated to the export, it has a production strongly based on the added value of the quality and of the landscape preservation, therefore an elite consumption (willing to pay the right price)



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would sustain a system like this. The Tourism scenario will also be weakly compatible because of the tourism will select a group of consumer interested in the landscape and in the beef quality.

### 3.3.5 Eur-Agri-SSP5 “Technology”

The Bourbonnais is a very specialized system, whose limitations are found in its low economic viability, low population and consumer expectation. Given most of these limitations are removed from the context, in this scenario (e.g., there is a low environmental awareness), the status quo would be able to persist and to boost its production for both the internal and external market. In addition, the system would also be sustained by the high liberalization of the international trade.

The compatibility of the All-export scenario is moderately high because its economical viability would be sustained by the liberal market exchanges. The environmental impact of transport will not be internalized and prices will be kept very accessible for buyers. The compatibility of the Only-French-market is considered weak because the Only-French-market scenario considers a system coupled with the natural capital, with a production only for the French market and therefore not relying on exports and on a boosted production. The compatibility of the Tourism scenario is to be considered weak because, if the production remains local, the tourism would move people on the region and would probably also promote consumption of the Bourbonnais beef outside the country, causing exports.

*Table 10. Compatibility of alternative systems with different Eur-Agri-SSPs. Where values -1 to -0.66: strong incompatibility, -0.66 to -0.33: moderate incompatibility, -0.33 – 0: weak incompatibility, 0-0.33 weak compatibility, 0.33-0.66: moderate compatibility, and 0.66-1: strong compatibility.*

Systems	SSP1	SSP2	SSP3	SSP4	SSP5
Status quo	0.69	0.39	-0.68	0.17	0.27
only-export	0.41	0.45	-0.73	0.51	0.39
only-French-market	0.70	0.40	-0.60	-0.14	0.17
tourism	0.57	0.40	-0.56	-0.12	0.25

## 4 Conclusion

According to the desk study based on expert assessment, the resilience attributes “Reasonably profitable” and “Socially self-organized” are slightly increasing. This signal denotes that the system is getting a bit further from the most dangerous thresholds, which are those one related to economic viability. The decreasing resilience attribute is “Coupled with the natural capital”, however, the system is not really deemed to be close to a critical threshold under that aspect. By analyzing the proximity of the system to threshold, we can say that the system is far from critical threshold from the point of view of food production and of natural resources and close to a critical threshold for economic viability. However the current trend shows that economic viability is at moment slightly improving, therefore we can say that the system shows signs of robustness.

In the context of this study, we also deemed that the system is adapting to more recurrent droughts, shifting the production from quantity to quality, diversifying the production (not only cattle raised on grass, but also cultivation of temporary grasslands, cereals, and agroforestry) and adopting more and more risk management strategies to cope with droughts. We can then say by adapting to recurrent droughts, the system is getting more and more robust to single events of droughts.

The two alternative systems “only-export” and “only-French-market” constitute an adaptation of the current system for better facing challenges of droughts, economic viability, and social distrust towards farming practices. Both of them correspond to a specialization of the system in a market niche in the context of beef production. However, the “only-export” alternative system is more fragile as it would relate to a continuous demand of weanlings from abroad and would not invest in diversification. However, the “only-French-market” alternative system would bring to a diversification of the system in other forms of agriculture, spanning from cereal cultivation to agroforestry, and in other activities, such as the valorization of the landscape. In other words, the “only-French-market” scenario would constitute a specialization in a market niche for beef production, but would imply a diversification in other sectors. The “Tourism” alternative system, instead would constitute a complete transformation of the system. At moment there are no sign in the current system going in this direction, and, in order to better assess them, it would be useful to submit the scenario to stakeholders.