Project acronym: SURE-Farm
Project no.: 727520

Start date of project: June 2017
Duration: 4 years

FoPIA-Surefarm 2 Case Study Report Italy

Work Performed by P10, UNITUS

C. Zinnanti, S. Senni, S. Severini.

(Contact person: severini@unitus.it)

Due date	31/May/2020 (part of D5.5)
Version/Date	Final 27/May/2020
Work Package	WP5
Task	T5.3
Task lead	INRAE
Dissemination level	Public

Supplementary Materials G. FoPIA-SURE-Farm 2 Case Study Report Italy

Contents

Please cite this report as:

Zinnanti, C., Senni, S., Severini S., 2020, 'FoPIA-SURE-Farm 2 Case Study Report Italy'. In: Accatino, et al. D5.5 Impacts of future scenarios on the resilience of farming systems across the EU assessed with quantitative and qualitative methods. Sustainable and resilient EU farming systems (SURE-Farm) project report.

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

Supplementary Materials G. FoPIA-SURE-Farm 2 Case Study Report Italy

1 Introduction

1.1 Main indicators, resilience attributes and challenges

The farming system (FS) in Viterbo province, in central Italy, is highly specialized in hazelnut farming. The local hazelnut market is unstable and strongly exposed to Turkish production, the main competitor. The presence of cooperatives of farms (often organized in producer's organizations - POs) is crucial in terms of both economic and social influences on/from farms: they represent the main form of socio-economic organization inside the FS, but they are also essential in connecting producers to confectionary industries and downstream markets. The main functions of the FS are providing economic viability, affordable and healthy food raw material and ensuring a good quality of life in the system area. In contrast, there is a growing concern about the potential negative impact of agriculture on the environment due to its single-crop specialization and because of the limited number of organic hazelnut farms. Indicators that are most representative of these main functions (function indicators) are presented in Table 1.

Table 1. Main indicators and their performance and development. Source: Severini et al. 2019.

Main indicators	Current level (score 1:5)	Current level (explanation)	Current development
Gross Saleable Production (€)	**4.1**	For both indicators: The system has been affected by Turkish production. The high mechanization has reduced production costs and contributed to the quality of the hazelnuts. Growing interest: entry of large confectionery industries, associated with the introduction of strict quality parameters, RDP and CAP incentives, relations with the industry.	There is an increasing trend but threatened by Turkish production which is more competitive in price and quantities (not in quality). In 2014 it peaked due to the reduction in the Turkish hazelnut production, thus prices have risen.
Gross Margin (€/ha)	**4.0**		
Organic farming (Ha)	**2.5**	It is linked to the CAP funding availability	The surface area is increasing albeit with a fluctuating trend between 2008 and 2012
Retention of young people	**3.0**	The system has generated employment, allowing the skilled workforce to be included in it.	Stable

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

The general resilience of the FS is mostly reached by the attributes as presented in Table 2. While the FS is socially self-organized and supporting rural life, the FS has been characterized as not fully coupled with local and natural capital especially because water quality and quality are expected to deteriorate because of the growing pressure of agriculture on this and other natural resources. Finally, policies have paid, so far, a not very relevant role in the development of the FS that has been driven mostly by the favourable market conditions.

Table 2. Main resilience attributes and their presence in the farming system. Source: Severini et al. 2019...

Main resilience attributes	Current level (score 1:5)	Current level (explanation)	Current development
Socially self-organized	**3.6**	Farmers can organize themselves into networks and institutions such as co-ops, community associations, advisory networks and clusters with the processing industry	The ability to co-operate is still weak. Stakeholders feel the need for a good advisory network to improve the system.
Coupled with local and natural capital	**2.3**	Soil fertility, water resources, and existing nature are maintained.	Water availability in terms of quality and quantity is reducing.
Support rural life	**3.4**	Rural life is supported by the presence of people from all generations and supported by enough facilities in the FS area which enjoys certain proximity to the metropolitan area of Rome.	Hazelnut economy is an important driver to support rural life in this farming system. Unfortunately, the system does not enjoy a high percentage of young people.
Infrastructure for innovation	**3.0**	Existing infrastructure facilitates knowledge and adoption of cutting-edge technologies (e.g. digital).	Technical and technological innovation is the basis for the development of the system.
Diverse policies	**2.3**	Both first and second pillar of the CAP stimulate all three capacities of resilience, i.e. robustness, adaptability, transformability	The role of policies has not been relevant so far, as the development of the FS is mostly driven by positive market conditions.

Main challenges for the farming system are:

- Variation in hazelnut prices;
- *Phytopathologies*;
- Extreme weather events (drought);
- Greater eco-friendly requirements;

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

- Common Agriculture Policy (CAP) support.

These challenges will be explained in detail later in this Report.

1.2 Participation in the workshop

The participants chosen for the workshop belonged to six different categories: *Farms*, *Government*, NGOs, *Industry*, *Research* and *Advice*. Persons participating in the workshop were 14, 5 of which were *farmers*. Other participants belonged to *NGOs* (2), *advise* (3) including agronomists, *government* (2), *industry* (1) and *research* (1). Participants agreed with the use of the main function indicators and resilience attributes listed in the FoPIA SURE-Farm 1 report. Concerning the challenges identified in FoPIA SURE-Farm 1, some changes have been made. The team debated with the participants in the workshop on the challenges identified in FoPIA SURE-Farm 1 considering both shocks and long-term pressures, as well as economic, environmental, social, and institutional challenges. In FoPIA SURE-Farm 2, the team and participants agreed to cluster those challenges into four issues: hazelnut price; extreme weather events (drought); greater eco-friendly requirements; concentration of the confectionery industry. Participants considered the performance scoring adopted in FoPIA SURE-Farm 1 sometimes constraining their task. This is because, despite the importance of the indicators, the scoring was restrictive and lacking in precision. In assessing performance, a set of specific units of measures has been agreed on for the function indicators. Instead, a basic scoring scale (from 1 to 5) was used for the challenges that the FS faces.

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

2 Results

2.1 Maintaining the status-quo

In order to keep the status quo of the FS as it is, participants provided minimum and, in some cases, maximum levels of indicators, resilience attributes and challenges beyond which the system could decline or change significantly.

2.1.1 Indicators

Gross Saleable Production (€)

Participants in the workshop agreed to jointly consider "hazelnut production", "hazelnut quality" and "price evolution" as a unique indicator "Gross Saleable Production" (gross revenue - €) that, to some extent, summarizes the three single indicators with reference to the absolute dimension of the FS.

Gross Saleable Production was mainly discussed as a percentage variation (% of reduction/increase) compared to the current level value (around 125 million €) already identified in FoPIA SURE-Farm 1. The stakeholders agreed to consider the minimum level of reduction (%) as the threshold of system decline and have agreed that this is the most important aspect to consider. Nevertheless, maximum values of increase (%) have been also considered because, even if in positive terms, improving the profitability of the crop could be also a reason for the change of the entire FS toward an even more specialized and intensive FS. Estimates showed that to maintain the status quo, the Gross Saleable Production might decline by 19.6% on average with respect to the current level. In detail, more than half of the participants (8) identified a minimum threshold of reduction of 10-15% indicating that the system is close to a trigger point for future changes.

Gross Margin (€/ha)

Participants in the workshop agree that Gross Margin values between 5,000 and 8,000 €/ha allow the status quo of the system. Again, the critical condition arises when the gross margin levels go below the value of 5,000 €/ha. In this case, profitability decreases as well as the intensity in the production. The most affected will be small farms because larger farms have lower unit production costs. Such contraction could reduce the volume of production of hazelnut in the area and, in turn, this could have negative consequences overall the FS.

Organic farming (Ha)

The indicator "Organic farming" has been discussed in terms of an increase of areas under organic production that may substantially change the FS status quo. The current level of organic farming is so limited that its reduction is not expected to affect the FS. On average, all participants indicated a range between 20% and 30% may do so. However, three participants mentioned a maximum level of the organic surface until 50% before the FS changes.

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

Retention of young people

To discuss the retention of young people in the FS, the unit of measure chosen was the percentage of reduction/increase of young people (under 35 years old) compared with the actual level. On average, to maintain the status quo of the system, participants considered a reduction of no less than 20% of young people in agriculture to have a sizable impact on the FS. The impact comes from the fact that young generations are more inclined to invest, to adopt technical and technological innovations and to be involved in post-farm activities. All participants agree that the renewal of the system's operators is a key issue for the resilience of the FS.

2.1.2 Resilience attributes

Discussing resilience attributes, participants agreed to use the following scoring system from 1 to 5, where: 1 – very low; 2 – low; 3 – medium; 4 – high; 5 – very high.

Socially self-organized

Comparing with the current level of this attribute (3.6) identified in FoPIA SURE-Farm 1, the participants asserted that the system could maintain the status quo if its level of self-organization is maintained above the score of 2. This is because the current role of community associations (as well as institutional networks among local authorities), advisory networks and co-ops are very high. Hence, the FS can afford significant reduction without being affected strongly by the reduction of self-organization within this range. However, if the value goes below this level, the FS will undergo a transformation that is perceived as reducing its resilience. This is due to the key role of the strong link among farmers and the other stakeholders and institutions previously mentioned that makes the FS deeply interconnected.

Coupled with local and natural capital

The current level of the "coupled with local and natural capital" resilience attribute appears relatively low being equal to 2.6. In particular, the relationship with natural capital is not excellent due to the limited production of public goods. This has negative effects on the quality of the environment, the health of the population and biodiversity. The participants indicated a minimum level just below the current one, up to which this indicator can move. Indeed, twelve participants indicated a minimum of no less than 2. This shows that the system is not able to withstand further significant deterioration of local and natural capital without experiencing significant changes.

Support rural life

The workshop participants agreed that the core system currently supports the well-being of all rural life positively: the current score is 3.4. To maintain the status quo, this attribute should not be lower than 2.7 (almost average) otherwise the system declines. Also for this attribute, the system in the current state could be not able to cope with a decline in terms of support to rural life.

Infrastructure for innovation

All participants agreed that the infrastructures for innovation are crucial in order to maintain the status quo. Indeed, the minimum level indicated by the stakeholders is not far away from the current level. This suggests that innovations are considered very important for the FS. The stakeholders expressed a strong interest in new infrastructures for innovation because these are considered essential to improve the whole system.

Diverse policies

Conflicting points of view among participants exist on the role of policies. Adjusting policies to the needs of the system is considered an important resilience attribute provided that the current level is low (2.3). Indeed, participants agree that this level should be improved to keep the system as it is.

2.1.3 Challenges

Starting from the challenges identified in FoPIA SURE-Farm 1 for the Viterbo FS, the following challenges were summarized and thus discussed to observe prerequisites to maintain the status quo.

Variation in hazelnut prices

The high competitiveness of hazelnuts produced in other countries (commercialized in high quantities and at competitive prices) has put a severe strain on the remuneration of Italian hazelnuts making them exposed to fluctuations in international markets.

At the current state, hazelnuts registered a medium price of 7.20 €/kg in the Viterbo's FS. This is the price for standard-quality unshelled hazelnuts. Note that the price received by the farmers, who sell hazelnut with shell, is strongly influenced by the technical conversion rate from a product with the shell to a product without shell (usually approximately 45%). However, the price is also influenced by additional technical characteristics including the relative occurrence of empty (due to hazelnut weevil), aborted nuts (due to bugs) and hazelnut which have been damaged by insects. These factors cause an unpleasant taste and odour, both of which render the nuts less suitable for processing. The confectionary industry is constantly requiring a higher quality standard and differentiates the price according to these quality parameters. This provides a strong incentive for farmers to adopt all practices that increase the quality of the product including irrigation and chemical treatments against insects.

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

Participants agreed that a price range of 5.1 – 9.7 €/kg (about +/- 30%) is needed to maintain the system in the status quo. Particular important is the minimum level: in this regard, four participants mentioned that a price lower than 4 €/kg could push toward a restructuring of the system especially because this will push some farm, in particular the small ones, to exit. This will have negative consequences already discussed in a previous section of the report.

Phytopathologies

Among the different *phytopathologies*, bug infestations have been taken into account because of the damage they cause and related economic consequences on farm profitability. Bugs are potentially dangerous because they carry out the life cycle only in the nut, damaging the fruit that will suffer a qualitative depreciation. *Phytopathologies* were discussed in terms of the percentage of hazelnuts damaged by bugs (gen. *Halyomorpha*). Considering the current level of 10% of hazelnuts damaged by bugs, participants believed that the system could change if that percentage goes beyond the 18% on average. It is interesting to note that more than half of the participants indicated a maximum score of over 20%. Increasing the percentage level of bug's infestation, the farming system could decline. Indeed, a high level of infestation requires farmers to more extensively use chemical control. This should have negative consequences on the environment, especially water quality, and on the health of the population living in the area.

Extreme weather events: drought

Extreme events have recently increased in intensity due to climate change. This has large negative impacts on agricultural production and, to a lower extent, the viability of the FS. In the future, drought could increasingly be a problem for agriculture. The new climate scenarios show a slight decrease in cumulative precipitation in late spring and summer and, more markedly, an increase in the length of drought periods. In the long term, the increase in extreme weather events such as heat and drought carries a higher risk of yield losses. This leads to growing pressure on water resources: larger irrigation volumes will be necessary as well as longer irrigation seasons. In addition, many farms will feel the need to equip the cultivated surface with an irrigation system.

During the workshop, the threshold used to express the drought challenge was "*occur each x years*". Considering the current level of one event (drought) every fifteen years, participants agreed that an extreme event every two years could induce the farming system to change.

Common Agriculture Policy (CAP) support

The hazelnut FS receives support from the CAP, in particular from the Common Markets Organization (CMO) and the Rural Development Programme (RDP). This is because the support provided by CAP direct payments (i.e., Pillar 1), which is very important for extensive crops such as rainfed cereals, is not so important for this high value crop. The challenge referring to CAP subsidies was expressed as a percentage of reduction with respect to the current level of the

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

overall support provided by the two mentioned groups of policies. Most of the participants asserted that a reduction of no more than 30% respect to the current level could maintain the status quo of the system. This suggests that even not negligible reductions are not able to threaten the survival of the FS as it is. Indeed, it is interesting to note that two participants affirmed a lack of interest in policy support to maintain the status quo of this strongly market-oriented FS.

Greater eco-friendly requirements

The emphasis placed by society on environmental issues became a challenge for the FS. This could induce local authorities to introduce more stringent regulations limiting farming practices. Examples are restrictions on the use of irrigation and chemicals for pest control. This is expected to have negative effects on yield level and, even more, on product quality. This is therefore likely to have negative consequences on farm economic results. The extent of the challenge due to the imposition of greater eco-friendly requirements was expressed by mean of a Likert scale from 1 to 5 (where 1 - very limited; 2 - limited; 3 - medium; 4 - robust; 5 - very robust). Participants showed that only limited eco-friendly requests could maintain the status quo.

2.2 System decline

2.2.1 Introduction

In small groups, participants discussed one challenge and its impact on main indicators and resilience attributes (as previously described), in case thresholds would be exceeded. The challenges to be discussed within the groups were chosen by the participants among those listed above. One participant proposed to include a new challenge, the “concentration of the confectionery industry”. In summary, the challenges discussed among the four groups were:

- Hazelnut prices decline;
- Extreme weather events: drought;
- Greater eco-friendly requirements;
- Concentration of the confectionery industry.

2.2.2 Performance of indicators and resilience attributes

Hazelnut prices decline

The indicators related to economic viability (i.e. “gross margin” and “gross saleable production”) are positively correlated with the price level. However, there are also correlations between the price level and environmental and social indicators. If the prices collapse there will be negative consequences including possible abandonment of the crop. Participants found no correlation

This Project has received funds from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement No. 727520

between price and rural development policies. A price fall would be dramatic for the sector and would negatively affect all indicators.

Extreme weather events: drought

If the critical thresholds are exceeded, drought will have a relevant negative impact on the FS. Group members have discussed this challenge that occurs when levels go beyond the maximum thresholds of the current level. The impact of drought on the "Gross Saleable Production" varies depending on the specific location within the case-study area. In some areas, repeated drought for successive years can lead not only to a production decrement with a strong negative impact on farm economic results but also to the death of the planted trees leading to a decline of the asset value. In the 1950s, in a municipality particularly suited to hazelnut production, repeated years of drought and the absence of underground water tables sufficient to meet requirements, led to the abandonment of the cultivation and to the transition to become woods. This scenario could reappear in the warmer areas of the FS. The gross margin would also be negatively impacted by higher costs related to irrigation, energy, and infrastructure. If the drought thresholds were exceeded, the organic area would not change unless the new conversions to organic land are rewarded by the administrations in some way. In areas where the "Gross Saleable Production" is high, its decrease can dissuade young people from continuing hazelnut cultivation. There will be new services (e.g. agro-meteorological alarms, telematics management, and evapotranspiration calculation). The whole structure should adapt to the reduction of "Gross Saleable Production". Such a decrease in the "Gross Saleable Production" has a negative impact on the resilience attribute of 'support for rural life' since all services related to this activity would be missing hazelnut production being a support to share capital. In case the drought exceeds the thresholds, today's technologies level is not ready to respond to these resilience needs. Hence, farms will have to equip themselves with tools useful, for example, to the evapotranspiration calculation. Participants expressed concern about policies failing to adapt promptly to the changing environmental conditions.

Greater eco-friendly requirements

The group working on the challenge "Demand for greater eco-compatibility" identified a negative correlation with both "Gross Saleable Production" and "Gross Margin" when the challenge exceeded the current threshold. In the former case, a slight negative impact on the gross saleable production in the short time frame could be related to the difficulty of making the market accepting the higher price for a sustainable product. In the second case, the impact on "Gross Margin" is higher as the farm business could be affected by less input in the management of the crop. The demand for eco-friendliness beyond the current thresholds has a positive impact on the organic area under hazelnut as well as on the involvement of young people in sustainable agriculture: the latter being more attractive than conventional farming. As participants consider the system to be well organized, increased demand for eco-compatibility would not have a major impact on the decline of the FS. On the contrary, it would have a positive impact on the link between natural and local capital, leading to an increase in the latter, with consequent support for rural development. However, rural development could be hampered by a possible reduction in inputs. In this sense, exceeding the demand thresholds has antithetical effects on rural development. The positive impact of this challenge on infrastructure for innovation and modernization of facilities is strong. Some argued that the quantity and quality of the product would be compensated by the improvement of the technology infrastructures. Policy support is considered by stakeholders able to enhance the process of technical innovation fostering resilience.

Concentration of the confectionary industry

In the analysis of the challenges that could change the status quo and lead the system into decline, participants proposed to consider the "concentration of the confectionery industry". This challenge concerns the growth of the market power of multinational companies to whom hazelnuts are sold. It is referred to as the confectionary industries operating in the international market and currently located in the northern part of the country (e.g. Ferrero Commerciale Italia s.r.l. and A. Loacker s.p.a). Strategic decisions of these, especially in terms of procurement of raw hazelnut, can have relevant implications for the FS.

This is found to have a cross-cutting role because affecting several aspects. As well as influencing prices, for example, it imposes production protocols that affect the production practices and costs, as well as the eco-compatibility of the system. The increased concentration of the industry could have negative effects on price levels and, in turn, an immediate impact on “Gross Margin” and “Gross Saleable Production”. In the view of participants, the industry is almost indifferent to organic products due to their small share of turnover and because their marketing strategies do not care, so far, about an organic processed product. Participants agreed that the industry is not interested also in retention of young people even though young people are driven by the desire to invest, to grow by proposing new ideas and bringing cultivation up to date with new technology and innovation. Regarding the resilience attributes, the increased concentration of industry fostering a greater organization of the FS could benefit the infrastructure for innovation. Members of this group considered that policies to date have been particularly targeted at the needs of the agri-food industry rather than targeting the farmer’s needs.

This Project has received funds from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement No. 727520

2.3 Results: alternative systems

2.3.1 Introduction

The participants did not propose radical changes to the system because they do not see a viable alternative to hazelnut production which is expected to remain in the next future the most important crop. The debate has shown that the FS decline may differ according to the challenge considered. For this reason, the item “system decline” has been declined in four headings into Table 3, one for each challenge.

During a plenary session, stakeholders identified and discussed some future alternative configurations of the FS. The ideas they provided led to four different possible alternatives (see Table 3) that were labeled so:

- technological innovation;
- sustained demand (high and stable prices);
- product valorization;
- eco-friendly agriculture.

These desirable alternative states generally can improve functions and attributes that now do not perform at the desired level to realize a sustainable and resilient FS.

This Project has received funds from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement No. 727520

Supplementary Materials G. FoPIA-SURE-Farm 2 Case Study Report Italy

Table 3. 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.

			Challenges causing system decline				Future systems			
Indicator	**Current level**	**Status quo**	**Hazelnut prices decline**	**Extreme weather events: drought**	**Greater eco-friendly requirements**	**Concentration of the confectionary industry**	**Sustained demand (high and stable prices)**	**Product valorization**	**Technological innovation**	**Eco-friendly agriculture**
Gross Saleable Production	High	↗	↘	↘	↘|→	↘	↗	↗	↗	↘|↗
Gross Margin	High	→	↘	↘	↘|→	↘	↗	↗	↗	↘|↗
Organic farming (Ha)	Low	↗	→	↘	↗	→	↘	→	↗	↑
Retention of young people	Moderate	↗	→	↘	↗	→	↗	↗	↗	↗
Socially self-organized	Moderate	→	↘	↘	→	↗	↗	↗	↗	↑
Coupled with local and natural capital	Low	↗	↘	↘	↗	↓	↑	↗	↑	↑
Supports rural life	Moderate	↗	↘	↘	→	→	↗	↗	↗	↗
Infrastructure for innovation	Moderate	↗	→	↘	↗	↗	↗	↗	↑	↗
Diverse policies	Low	→	→	↘	↗	→	→	↗	↗	↑
Boundary conditions	**Dimension**									
Growing demand	Economic	V					**V**			
Prices linked to the real cost	Economic								**V**	**V**
Hazelnut prices decline	Economic	V					**V**			
Concentration of the confectionary industry	Economic	V					**V**			
New markets	Economic						**V**	**V**		
Short supply chain	Economic							**V**		V
Brands with high local value	Environmental							**V**		V
Extreme weather events: drought	Environmental	V								V
Greater eco-friendly requirements	Environmental	V								V
Cultural changes	Social	V						**V**		**V**
Research	Social								**V**	**V**
More young people in the system	Social	V							**V**	
Information flow	Social								**V**	
CAP support	Institutional	V							**V**	**V**
Duty-Free Markets	Institutional						**V**			

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

Sustained demand (high and stable prices)

Increasing demand would generate, *ceteris paribus*, a price increase with positive repercussions on the profitability of the cultivation and consequently on farmers' income (Table 3). This alternative system may have positive effects on keeping young people in the system but, on the contrary, reduces the interest in organic and eco-friendly farming practices. Such an alternative system should improve system organization, the infrastructure for innovation and support rural life. These have positive consequences for the resilience of the system because it increases robustness and adaptability capacities. On the contrary, it reduces its link with the natural and local capital because the production intensification and specialization could have negative consequences on the environmental function.

Participants highlight the removal of trade restrictions as a boundary condition to make the alternative state of the system happen and the promotion of product placement in markets where demand is growing such as China, as a strategy to reach this result.

Product valorization

The valorization of typical agri-food products is a complex process involving a plurality of actors, who have specific interests and therefore potentially pursue different and sometimes conflicting individual objectives and strategies. According to participants, product valorization could be pursued in two (not alternative) ways. On the one hand, some referred to the development of geographical indication that could overcome the problems currently faced by the PDO "Nocciola Romana" that is currently underutilized. On the other hand, some other participants mentioned the potential role of developing locally processed and differentiated products to be directly sold to retailers. In this alternative system, there is a general improvement in the performance of the indicators. The "Gross Saleable Production" and "Gross Margin" increase because one effect of this alternative future state of the system is the increase in the competitiveness of the local production and better placement of the products in the market (Table 3). This generates a more attractive employment market for young people. The impact of the valorization of the local product on the organic surface is considered indifferent. The valorization of the product might help to close the supply chain and to open up new market channels. The enhancement of the local production can have positive effects on direct links with the local and natural capital supporting rural life at the same time from a regional and employment point of view. The valorization of local production can be a driving force to improve the infrastructures. Participants of this group consider concerted planning among all stakeholders of the system as the main strategy to adopt involving farmers, industry and government to increase the product value. Boundary conditions, in this sense, are represented by high-value brands of the area: the protection of the intrinsic and extrinsic quality of local production is not enough today. Also, a market alternative through the closure of the supply chains is needed.

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

Technical Innovation

The "technical innovation" alternative system includes changing system processes or products towards the improvement of technical innovation infrastructures. The hazelnut system in Viterbo is now highly mechanized: it has introduced technological innovations in the previous decades. Although it is not a backward system, the participants still consider technological innovation a driving strategy to FS improvement.

Participants of this group indicate high-performance levels of the indicators "Gross Saleable Production" and "Gross Margin" because the adoption of technological innovation can increase the efficiency of technical means, reduce costs and increase production value. In this sense, young people would find it more interesting to participate actively in the production. An innovative system in technology is more organized thanks to structural centralization. A greater link between natural and local capital could allow the diversification of roles and skills. As the demand for technological infrastructure increases, production costs may decrease. This has a positive impact on the overall quality of life. Participants argue that support policies do not adapt to needs promptly; therefore, they are unable to drive innovation to promote change due to slow bureaucratic procedures. Also, participants in this group assert that enhancing the training and the cooperation among stakeholders (including farmers, industries, advises, NGOs and government) are the main strategies to be enforced in this alternative system. Some of the participants mentioned a lack of information referring to an asymmetric distribution of the information along the value chain. According to them, farmers are left with an incomplete amount of information negatively affecting their bargaining power.

Eco-friendly agriculture

Considering the increase in constraints resulting from the efforts for the conservation of the natural resources, an eco-friendly alternative state of the system is desirable. Participants of this group argued that the performance indicators "Gross Saleable Production" and "Gross margin" may decline at the beginning because this can have negative consequences on yield and product quality causing a reduction of farm revenues. However, this is likely to happen at the offset of the change provided by the limited experience farmers have on eco-friendly practices. They also suggested that, if the move toward more eco-friendly practices is properly communicated to consumers, it might be possible to observe an increase in product prices. This could be able to offset the effect of lower revenues. The organization of the system, as well as the organic area with hazelnut cultivations, could be improved because this last is in line with the criteria of eco-friendly agriculture. The latter are considered very attractive to young people. Resilience attributes improve their overall performance level in the future alternative system.

A necessary condition for the realization of this alternative system is certainly a cultural change that would affect all stakeholders. The contribution provided by the research, which interacts with the POs suggesting good practices given this transition, is important as well as the economic support to all actors of the system (although the product can be sold at a higher price, the costs to be incurred are higher and therefore government support to accompany the transition is needed).

According to participants, all concrete strategies to implement the alternative system require public support targeted to key operators of the system. Moreover, it is needed to encourage the introduction of third parties of collective actors in charge of control and technical support. In detail, participants indicate the introduction of consortia (e.g. managed by POs) capable of providing consultancy and control for public administrations.

2.4 Strategies towards the future

Stakeholders involved in the workshop do not have a shared vision for the future of the farming system. The drawn alternative states of the future system are not independent anyway. It is interesting to underline that eco-friendly agriculture could be facilitated by technological innovations. Simultaneously, a system based on eco-friendly activities could valorize its products by resorting to the short value chain. Hence, there is a very positive evaluation of the potential benefits deriving from innovations because of the awareness of having already benefited from technological innovation in the past.

Making an overview of strategies, most of them are extremely important to trigger future alternative systems and some are necessary to maintain the status quo. However, while for the latter, mechanization, consortia for technical advisory and cooperation among stakeholders are useful, the required strategies are not the same for alternative future states (Table 4).

Some strategies, among the current already implemented and the ones proposed for the future, are relevant only for one alternative future system. For example, agro-environmental policies and control of environmental requirements are essential for the “eco-friendly agriculture” future system and the strategy of open international markets is needed for the “sustained demand (high and stable prices)” alternative system. Nevertheless, several strategies cross the different alternative states of the system. Realizing consortia for technical advice mixed with increasing CAP support could encourage both “eco-friendly agriculture” and “technological innovation” alternative systems. In addition, promotional policies could be effective for both “sustained demand (high and stable prices) and “product valorization” alternative states of the system. On the contrary, participants highlighted the feasibility of broad-spectrum strategies such as improving mechanization. However, even more important are the value chain activities that are shared as a key strategy by all participants in any alternative system hypothesized. Indeed, participants during the plenary session argued that the interaction among stakeholders in the supply chain and their constant training activity are strategies able to generate positive effects on the system. The latter strategy results in a no-regret strategy because of the cross-cutting nature of the four alternative systems. Moreover, it makes no compromises with the objectives of any alternative future state of the system.

Table 4 reveals the strong interrelation between some sets of strategies of two alternative systems as "technological innovation" and eco-friendly agriculture".

Although in the past, mechanization led to the modernization of the entire system, today the system requires stakeholders trained in the activities of the sector and able to vertically collaborate *intra* value chain. Even today, the need for EU public support represents the strategy capable of strengthening the system in the face of external changes/shocks.

Most of the strategies (such as mechanization, open international markets and promotional policies) have their biggest impact on the profitability of the system (e.g. Gross Saleable Production and Gross Margin indicators). Exceptions are the agro-environmental policies and the control of environmental requirements that have a pushing role in the expansion of organic surfaces and a negative or neutral impact on profitability. Such strategies for increasing profitability could be very interesting for young people.

Value chain activities, including cooperation among stakeholders, seems to be a fundamental resilience attribute able to guarantee an excellent organization of the system (as identified in FoPIA SURE-Farm 1). Promotional policies are linked to this and CAP support results complementary to value chain activities. Quite important are the strategies with environmental purposes (e.g. agro-environmental policies and control of environmental requirements) that need training activities. Besides, while on the one hand strategies of open international markets increase profitability, on the other hand, they decrease the link between local and natural capital.

Several categories of stakeholders should be involved in implementing strategies for alternative future states. In particular, farmers and POs are the main actors engaged in several strategies. Among these is mechanization, follow training activities, cooperation into the value chain. The latter strategy needs the interaction among several categories of stakeholders: industries, in detail, plays a leading role in the collaboration among all operators; followed by POs who are also particularly involved in open international markets strategies and creating consortia for technical advice. Alongside this is the role of technical advice in leading training activities and the control

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

of environmental requirements. The role of the government could be explained in policy support provision, especially regarding agro-environmental and technological innovation measures (e.g. allowing the renewal of infrastructure and mechanization).

Although all alternative future states were considered desirable by all participants, stakeholders found systems labelled as “Technological innovation” and “Sustained demand (high and stable prices)” more desirable. While the former is, according to the participants, the more likely to be realized, the “sustained demand (high and stable prices)” was considered less likely to happen.

This Project has received funds from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement No. 727520

Supplementary Materials G. FoPIA-SURE-Farm 2 Case Study Report Italy

Table 4. Current strategies and future strategies for different future systems. Current strategies are based on FoPIA-SURE-Farm 1.

			Future systems				
Strategy	**Domain**	**Current system**	**Status quo**	**Sustained demand (high and stable prices)**	**Product valorization**	**Technological innovation**	**Eco-friendly agriculture**
Mechanization	Agronomic	V	V	V		V	V
Agro-environmental policies	Environmental	V					V
Open international markets	Economic			V			
Control of environmental requirements	Institutional						V
Consortia for technical advise	Institutional	V	V			V	V
Promotional policies	Institutional			V	V		
CAP support	Institutional	V				V	V
Training activity	Social					V	
Value chain activities – cooperation among stakeholders	Social	V	V	V	V	V	V

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

3 Interpretation

3.1 Tipping points

Generally, the farming system is found to be close to the tipping points, particularly in terms of Gross Saleable Production and Gross Margin. These thresholds should be understood as dangerous only if long-term, repeated economic losses are taken into account. Indeed, since the hazelnut is a perennial crop, economic collapses over one or two consecutive years are usually not catastrophic given the robustness of the whole system.

In recent years, due to the market trend which has witnessed quite volatile demand and very volatile prices, participants do not trust the farming system's ability to adapt itself to extremely difficult conditions for the next ten years. Even in the face of challenges such as extreme weather events that are increasing due to climate change, participants are *sceptical*. At the same time, they cannot imagine this FS without hazelnuts (i.e. they do not see opportunities for future radical transformations of the system).

Regarding resilience attributes, participants believe the system is organized but not such as to be equipped with adequate innovation facilities and infrastructure. This is particularly critical to help meeting the eco-friendliness requirements. Therefore, participants argue that investments should continue to be made mainly in innovation technology.

3.2 Thresholds exceeded

The FS undergoes changes when the thresholds of indicators, resilience attributes and challenges are exceeded.

Based on the workshop and literature, some interacting thresholds (Kinzig et al., 2006) could be defined (Figure 1). Figure 1 reports the cascading scales effects starting from four challenges (in circle boxes): greater eco-friendly requirements, extreme events such as drought, price changes and the concentration of the confectionery industry. Thresholds of systems parameters can interact across domains and levels of integration resulting in an abstract of a usual information richer Causal Loop Diagram (CLD) (Kinzig et al., 2006).

The concentration of industry is often seen as a threat because of the high degree of negotiating power it holds defining so many parameters in the marketing of the product (prices and quality standards). At the same time, the challenge of price variability is closely related to profitability and, in turns to the economic viability of the whole FS.

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

If the challenges dictated by climate change, such as drought, exceed the maximum frequency tolerated by the system, the yields of the hazelnut crop will decline. This leads to the system's profitability decline and the economic viability consequently decreases. This is because hazelnut is the "engine" of the FS and it is the only crop currently capable to support adequately rural life, for lack of profitable alternatives. In this sense, crop diversification became equal to reduce the average profitability of the FS. At the same time, decreasing profitability may lead young people to exit from the system. Reductions of hazelnut prices will have a very similar impact on so far highlighted indicators.

If profitability declines because of the reduction in prices and yields, the system could potentially follow a crop diversification strategy. This latter is a non-desirable alternative state of the system from the participants' point of view. Any other crop is less profitable than hazelnut in the Viterbo's FS, and therefore diversifying would mean reducing the average income value for many farmers. A few producers firmly believe in crop diversification in terms of biodiversity and eco-friendliness. They are often producers who do not like to depend on a single product and a single buyer of their product. With crop diversification, they want to gain even greater degrees of entrepreneurial freedom. However, widespread forms of varietal "diversification" exist within the same hazelnut species. Many producers plant different varieties of hazelnuts to be a little more robust against adverse environmental conditions because different varieties do not react the same to these conditions.

The greater eco-friendly requirement is a new challenge for the system. On the one hand, it could lead the system to incur higher production costs due to the adoption of eco-friendly practices (e.g., pest integrated management or ground cover to replace the use of chemicals) which somehow could limit yields and reduce profitability (with effects on the economic viability of the FS). On the other hand, however, the shift to more eco-friendly production patterns could be managed in a way to benefit the system. This will be the case if the shift in production techniques is promoted, consumers are informed and asked to pay for a higher price. This strategy, if correctly implemented, could have a twofold positive effect: it allows increasing the economic viability of the system and the provision of public goods provided by the FS (Figure 1).

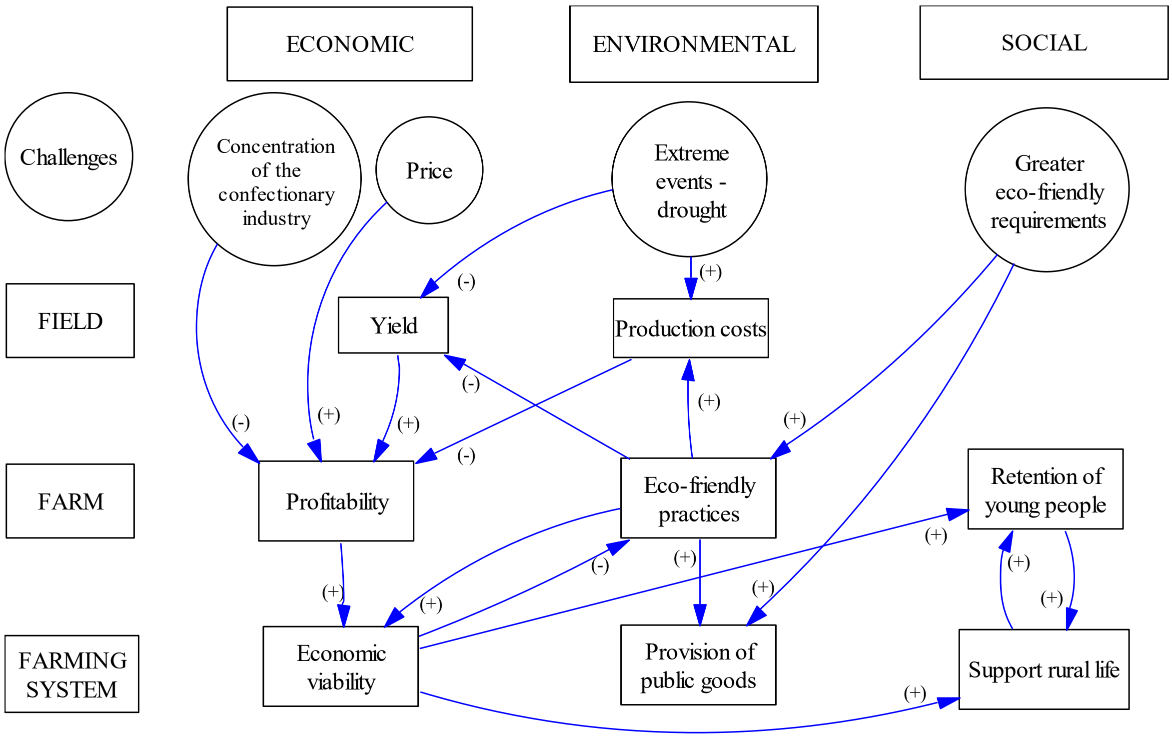

Figure 1. Interacting thresholds in the farming system. Diagram adapted by the framework of Kinzig et al. 2006. Circle boxes indicate the challenges.

3.3 Alternative systems

The proposed alternative future states are adaptations from the current system. This is because stakeholders have not identified future states without hazelnut. Hence, there are no relevant switches in system functions and/or large changes in the performance of the main indicators and attributes.

Performance of main indicators is expected to moderately improve in all alternative states of the system, except for "eco-friendly agriculture". In this case, gross saleable production and gross margin could also decline, especially in the beginning when farmers incur higher management costs (Table 1). As emerged in FoPIA SURE-Farm 1, all attributes have a positive impact on resilience capacities. Most attributes showed a more positive correlation with robustness, which then decreases for adaptability and transformability. However, "Socially self-organized", "Infrastructure for innovation" and "Support rural life" were an exception because these have the most value for adaptability. Simultaneously, "Coupled with local and natural capital" has a strong positive impact on robustness and adaptability and a medium or weak impact on transformability.

All these resilience capacities (robustness, adaptability and transformability) could aptly improve markedly when the current state shift toward the alternative systems.

3.4 Causal loop diagram

The international market can be influenced by the concentration of the confectionery industry. This results in a lower price control for the FS and could lead, *ceteris paribus*, to a relevant reduction of the hazelnut prices. This negatively affects the gross margin and, hence, worsens rural life and the whole organization of the system. Young people could be discouraged by such a situation, increasing the incentive for moving away from the system. The reduction of the price and gross margin also reduces the economic size of the system resulting in a decline of the gross saleable production. While this results in a worsening of the economic conditions of farmers and the whole FS, at the same time it could have positive effects on the environment *via* increasing diversification. Such a shift could improve the use of resources such as water in terms of quantity used and quality. Note that water quantity and quality are linked through a reinforcing loop. This is because decreasing quantity, in general, decreases the quality too. In the end, this could have a positive impact on the link between local and natural capital.

Increasing extreme events such as droughts could affect yields in terms of decreasing levels and increasing variability over time. This turns to have a negative impact on farm profitability. Persistent periods of drought adversely affect also water availability and quality by striking the link between local and natural capital.

The demand for greater eco-friendly requirements will increase production costs affecting negatively the Gross Margin and the Gross Saleable Production. This new condition could lead to qualitative improvements in the use of water and an increase in organic surfaces. Both will ameliorate the link between local and natural capital. Clearly, the implementation of such a configuration of the system could potentially be facilitated by support policies (if tailored to the needs of the sector) as well as the development of innovation infrastructures that guarantee a better organization of the system. A well-organized system acts as a stimulus for maintaining young people who might prefer to stay in or enter agriculture and related activities. Note that factors increasing the retention of young people in the system play a reinforcing role. This is because the presence of young people is seen as a stimulus for a better organization of the system.

Describing how the regime shifts towards alternative systems in our case study, we start by the sustained demand (high and stable prices) alternative state of the system. In the face of strong

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

demand, prices, *ceteris paribus*, would tend to rise: while this will have positive economic consequences, this would come up against the sustainable use of natural resources such as water, soil fertility and unpolluted air.

The specialization and economic dimension of FS are growing steadily as the result of an expansion of the hazelnut area. This evolution is due to the positive trend in the prices of hazelnut in comparison with the declining prices of alternative agricultural commodities that can be produced in the area.

Economic profitability, as well as the patrimonial value of hazelnut plantation (for which a land with hazelnut obtain a much higher land value), are the major driver of this growth and intensification of the hazelnut crop. This brings increasing pressure on the environment. Hence the need for public intervention to protect natural resources. For example, increasing public support could be essential to maintain or increase organic agriculture and/or integrated pest management.

Greater eco-friendly requirements push towards wider use of integrated management of *phytopatologies,* increasing of the organic areas and use of cover crops to reduce soil erosion and related runoff of chemicals into water bodies. Reduced water use (in contrast with the usual reliance on irrigation to increase hazelnut size, yields and product quality) and reduced nutrient application could be used in this regard too. All these eco-friendly practices contribute to improving coupling with local and natural capital into the FS.

In this regard, the relationship between water quality and water availability are directly influenced by two challenges: greater eco-friendly requirements and extreme weather events such as drought. This causes a reinforcing feedback loop (R1 in Figure 2).

Even if, on the one hand, all of the previous indicators benefit from the public support, on the other hand, entail an increase in the production costs (especially in the short period). Therefore, increasing production costs could be a limit to the development of eco-friendly agriculture. In this way, two balancing feedback loops (B1 and B2) are shown among the previously mentioned factors (see Figure 2).

The public support seems important in this context because enabling to sustain the high production costs. Furthermore, the technical training activity depicts a reinforcing feedback loop (R2) in this regard linked to integrated pest management. Moreover, infrastructure for innovation would be needed to set up and facilitate the configuration of the "eco-friendly agriculture" alternative state of the system. This is due to the support that infrastructure for innovation could give to eco-friendly practices to sustain the rural life and, ultimately, contribute to better organize

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

the FS (a new reinforcing feedback loop is showed – R3). In this way, such configuration provides an incentive for the responsible resources use and to enable future generations to remain in the system due to its attractiveness (see the reinforcing feedback loop – R4).

Production costs together with yields variability (due to increasing weather events) and price variability are the main causes leading to variation in gross margin. The latter, that is responsible to support rural life, is strictly linked to the system organization. Similarly is the other economic indicator of gross saleable production. It can contribute to a better organization of the system and then support rural life if the policies were tailored to the needs of the system.

However, the greater eco-friendly requirements sometimes result limited by the increasing concentration of the confectionery industry that requires products with increasingly high standardized technological quality. These results could be difficult to achieve in a type of eco-sustainable agriculture that increasingly requires to reduce the efficient but eco-devastating chemical treatments.

Definitely, several limits regard an eco-friendly future state of the system: high pest chemical control to obtain high-quality products, high production costs, greater variability of the production and, therefore, of the economic results along time.

Regarding the alternative state of the system “Innovation technology”, innovation infrastructure would be needed to allow both reasonable profits and satisfactory management of the natural and local resources.

The shift toward the “Product valorization” alternative state of the system requires cooperation between stakeholders in the system (in particular farmers and local industry) and innovation infrastructure. This could generate a positive impact on local relations and so on rural life.

This Project has received funds from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement No. 727520

Supplementary Materials G. FoPIA-SURE-Farm 2 Case Study Report Italy

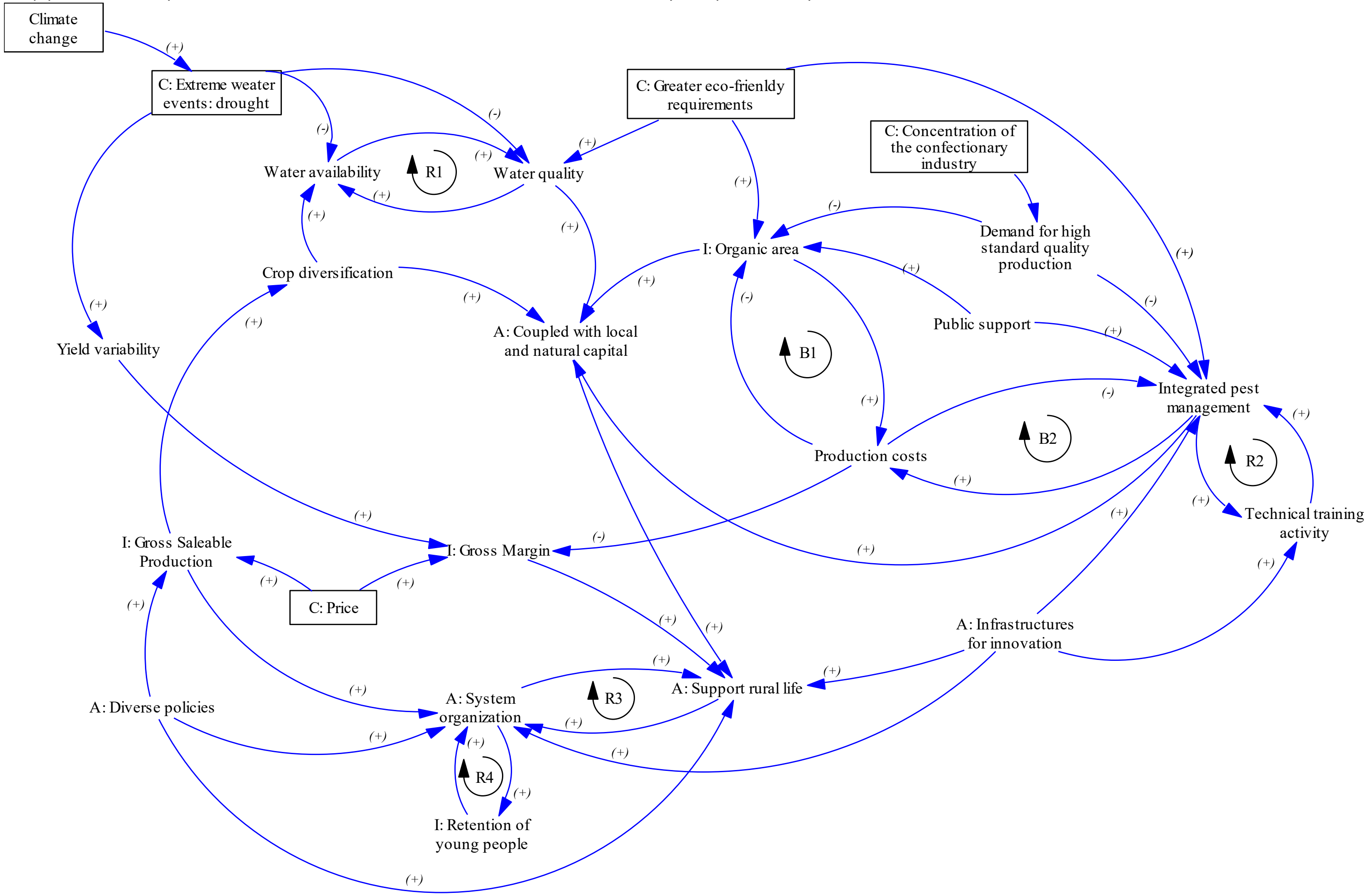

Figure 2. Causal loop diagram of the farming system in Viterbo – Italy. A + implies a positive cause-effect relationship and a - implies a negative cause-effect relationship. B stands for a balancing feedback loop and R stands for a reinforcing feedback loop. I indicates an important system indicator related to the system's functions. C indicates a system challenge. A indicates an indicator related to a resilience attribute..

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

3.5 Linking alternative systems to scenarios

Maintaining the status quo in the future and shifting to the alternative future states of the system will be facilitated by certain conditions that are reported below.

According to the results of the workshop, maintaining the status quo requires the price level to stay above the minimum level identified during the workshop. Additional threats are the increasing frequency of extreme weather events (especially droughts) and a growing concentration of the downstream confectionary industry. A shift in this direction has been identified as potentially having negative consequences on the organization of the system and the level of product prices. According to these factors, maintaining the status quo in the future seems likely even if some changes, mostly to increase its environmental compatibility, are needed. Some of the future states can be more appropriate. Because of this, we turn to describe the conditions needed to shift to the identified alternative states of the system.

The future state "Sustained demand" requires both maintaining high economic growth and strong market integration, including sustained international trade flows ensured by trade agreements. Policies and institutions should ensure political stability, effective institutions and multilevel cooperation.

The future state "Product valorization" also requires high economic growth. However, in this case, a diversity of agricultural supply chains to foster product diversification and valorization is also needed. In addition, it can be useful to foster multilevel cooperation. Because of the need for investments in the supply chain, policies supporting these changes are also very important.

The future state "Technological innovation" will benefit from the development of innovation infrastructures targeted to agriculture (e.g.: mechanization) and to rural areas (e.g: digital infrastructures). However, the development of skills and knowledge of people engaged in agriculture will also be a key element to facilitate the shift. Clearly, this development is correlated with the age of the farming population and its education level. Both factors will influence the pace of the acceptance and uptake of new technologies.

The last future state, the one based on "Eco-friendly agriculture", requires conditions that are often the same as in the case of the previous future state. In particular, it will be fostered by the development of innovation infrastructures, skills and knowledge of farmers. However, in this case, it is also important that the farming population and consumers recognize the added value of eco-friendly products and technologies. In this case, policy support can be very useful especially at the beginning of the shift to cover the costs related to the adaptation process. Furthermore, this alternative state of the system will require more efficient use of available resources. Finally,

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

because of the need to limit the use of agro-chemicals, the new state will be attainable only if there will not be an outbreak of invasive species (especially the bug - gen. *Halyomorpha* -and new plant diseases). Policies could be also important to communicate effectively to down-stream industries and consumers the added value of the products obtained by eco-friendly agriculture.

It is important to note that many requirements for both the states "Technological innovation" and "Eco-friendliness" are the same. This underlines the many complementarities existing among the conditions required to increase the likelihood of both alternative states.

The conditions facilitating the shift to the alternative future states of the system could vary according to the realization of the Eur-Agri-SSP scenarios (see Mitter et al., 2019 and Appendix B). Each scenario will have a differentiated impact on the system. Hence, each scenario could facilitate or constraint the shift to the identified alternative system. The role of each scenario in this regard is presented below.

In the Eur-Agri-SSP1 scenario, agriculture is encouraged for sustainability because social and environmental awareness increases steadily. This could result in tightened environmental constraints limiting production and increasing production costs. This could lead to reduced profitability and economic viability pushing the system near to boundary conditions if the system does not adjust. Because of this, the occurrence of this scenario can push the system toward a relevant change. However, in the presence of adequate policy support and valorization of the eco-friendly production, this change can have a less negative impact.

In the Eur-Agri-SSP2 scenario, agriculture is kept on established paths because European development follows historical patterns. This results in slow but steady social, environmental and technological progress. The impact of this scenario on the system is perceived as limited because having not relevant consequences on the level of food production, economic performance and other important functions. However, this is not going to address the growing demand for a higher eco-compatibility of agricultural production and the maintenance of natural resources. Hence, while this scenario does not seem to push the system towards boundary conditions, it does not support the changes the system needs.

In the Eur-Agri-SSP3 scenario, agriculture is controlled within national boundaries and there is limited cooperation between national and European entities, more severe European and international trade restrictions, and the renationalization of the agricultural policy. In contrast with previous, this scenario could have adverse effects on international trade. Because a large share of the confectionery industries (including the largest buyer of hazelnut in Italy) trade within the international markets, this could slow down the demand for their products, resulting also in a

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

reduction of the demand for hazelnut. This could have negative implications for the system especially if this will push the price below the critical level identified by stakeholders.

In the Eur-Agri-SSP4 scenario, agriculture moves towards inequality, increasing social disparities between and within rural and urban areas. This leads to a business-oriented strategy that will have consequences in terms of growing control over the agricultural supply chains and in favour of large and industrialized farms. This is going to make the system less linked with local resources, less oriented to preserve natural resources and constraining the attempts to developing processing activities and product valorization in the study area.

In the Eur-Agri-SSP5 scenario, agriculture is boosted by technology and trade liberalization. because agricultural supply chains will be globally connected and technological progress, accelerated. Consequently, this is expected to boost structural change. This scenario could have a very positive effect and several negative consequences. A positive consequence is that the growing globalization will open up a new and fast-growing market to the consumption of confectionery products based on hazelnut. This could be the case of China, India and Russia, which will have a pivotal role in determining the overall world demand for confectionery products and, as a consequence, of hazelnut. Hence, this is expected to cause an increase in hazelnut prices. Under these circumstances, this will result in a further increase in production and economic performance. However, this shift will also have negative consequences particularly on the maintenance of natural resources that, as already said, is already close to the boundary conditions for the system. Furthermore, this shift does not seem to support the development of high added value and locally developed products.

To summarize, a synthetic representation of the implication of the considered scenarios on the maintenance of the status quo is reported in the first line of Table 5. The scenarios that are more compatible with the maintenance of the status quo are Eur-Agri-SSP1 and Eur-Agri-SSP5. In contrast, scenarios Eur-Agri-SSP2 and Eur-Agri-SSP4 are found to be only slightly compatible with the maintenance of the status quo. Finally, the scenario SSP3 is found very incompatible with the maintenance of the status quo.

So far, we have described the considered Eur-Agri-SSP scenarios and how these may affect the system. Now we turn to assess how the shift to the alternative future states of the system will be facilitated or constrained under the different Eur-Agri-SSP scenarios.

The alternative state that refers to a sustained demand (high and stable prices), could be very much facilitated in the case the Eur-Agri-SSP5 scenario will occur. Indeed, if agriculture will be boosted by technology, this will result in the development of strong demand for hazelnut. In addition, Eur-Agri-SSP2 and Eur-Agri-SSP4 scenarios seem compatible with the new state of the

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

system, even if at a lower extent than the Eur-Agri-SSP5 scenario. Eur-Agri-SSP1 scenario, where agriculture is encouraged to pursue a higher sustainability level is only partially compatible with a situation of sustained demand because this requires undifferentiated hazelnut with no interest in the link of production with natural resources. Finally, the Eur-Agri-SSP3 scenario, in which agriculture is moved towards inequality, does not seem compatible with the new alternative state of the system.

The alternative state of the system relying on product valorization will benefit from scenario SSP1 because the demand for high-quality food increases slowly but it generates the best environment in which a strategy based on increasing the quality and value-added of hazelnut production will develop. In contrast, the shift to this alternative state of the system will be constrained by the Eur-Agri-SSP3 scenario and, to a lesser extent, by the Eur-Agri-SSP4 scenario. This latter scenario is expected to reduce the role of product differentiation, the development of alternative supply chains and the role of small farms that are all key factors for the valorization of local production.

Shifting to an alternative state of the system based on technological innovation will also be very compatible with the Eur-Agri-SSP1 scenario. This is because, the increased social and environmental awareness associated with this scenario will contribute to technology development towards low carbon emissions, higher resource use efficiency and reduced use of chemical pesticides in agriculture. Even in this case, the Eur-Agri- SSP3 scenario will be the least compatible with this alternative state of the system.

Finally, shifting to the alternative state “Eco-friendly agriculture” could be facilitated in the case Eur-Agri-SSP1 or Eur-Agri-SSP2 scenarios will occur. The latter scenario will be compatible with the new alternative state of the system because the demand for high-quality food and bio-based materials increases slowly. An eco-friendly agriculture alternative system might perform well in terms of increasing both public payments for environmental regulation and maintenance and increasing environmental awareness, resource use efficiency, and environmental health. However, the shift to more eco-friendly production practices is expected to be slow because of the technical problems to be addressed.

On a more general ground, it is important to mention that the Eur-Agri-SSP1 scenario seems very compatible with three out of the four alternative states. This is important because participants have agreed that combining the three alternative systems such as “Product valorization”, “Technological innovation” and “Eco-friendly agriculture” is possible. In particular, short supply chains with internalized external costs in agricultural commodity prices would be preferred. In contrast, the Eur-Agri-SSP3 scenario seems to be the worst for all alternative states. Finally, the Eur-Agri-SSP4 scenario is also not very compatible with two important elements of this combination of states. Its realization will not support a shift towards a system based on both product valorization and technological innovation.

Table 5. Compatibility of alternative systems with different Euri-Agri-SSPs (Mitter et al., 2019). 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.

	Scenarios				
Systems	**SSP1**	**SSP2**	**SSP3**	**SSP4**	**SSP5**
Mantaining status quo	0.35	0.22	-0.62	0.19	0.31
Sustained demand (high and stable prices)	0.15	0.51	-0.49	0.64	0.75
Product valorization	0.67	0.23	-0.82	-0.31	0.12
Technological innovation	0.70	0.15	-0.72	-0.10	0.06
Eco-friendly agriculture	0.63	0.60	-0.61	0.24	0.29

Hence, the occurrence of the Eur-Agri-SSP1 scenario could increase the likelihood of shifting toward alternative states: product valorization, technological innovation and eco-friendliness agriculture or even a mix of these. In contrast, the occurrence of the Eur-Agri-SSP2 scenario, Eur-Agri-SSP4 and Eur-Agri-SSP5 scenarios are expected to increase the likelihood of shifting toward a system based on high production levels such as the one envisaged by the alternative state “Sustained demand”.

Finally, note that most of the stakeholders have agreed that the sector will face an intense technological innovation and that this will take into account the need for reducing the environmental impact of the agricultural practices too.

3.6 Strategies

In terms of strategies, creating POs (to create value-chains and to provide technical advisory) and mechanization were the most important strategies in the past. These are also very important to maintain the status quo but also to shift to a system oriented toward “sustained demand”. The stakeholders have stressed the importance to support value-chain activities mostly by cooperation among stakeholders and that this strategy supports the shift to all the identified alternative future states of the system. Hence, it seems relatively safe to invest in this strategy. In particular, this strategy could be useful for improving the system organization and, in this way, to reinforce the infrastructure for innovation as well as to increase local capital.

This Project has received funds from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement No. 727520

Promotional policies have been indicated as key for reaching both states sustained demand and product valorization. This strategy could be very important if it will be decided to develop a successful geographical indication and locally processed and differentiated products to be directly sold to retailers. If the promotion policies will be successful, these could have positive effects on product prices and, in this way, on crop gross margin and the overall value of the production generated by the system.

In contrast, a larger set of strategies seem useful and needed to shift to the alternative systems "technological innovation" and "eco-friendly agriculture". Apart from value chain activities and mechanization, there is scope for strategies aimed at developing consortia for technical advisory and for increasing CAP support to facilitate the shift of the system to these two states. In addition, training activities have been identified as key for technological innovation, while agri-environment policies and control are important to allow for the shift to eco-friendly agriculture. Agri-environmental policies have been defined as the key to increase diversification and to embrace organic farming. In turn, this will make the system more coupled with natural capital (e.g. improving water quality).

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

4 Conclusions

Current situation: presence of resilience attributes, critical aspects and challenges

Currently, the farming system in Viterbo appears overall resilient. As a general behavior, most attributes and indicators showed a more positive correlation with robustness, less with adaptability and even less with transformability. Given the good economic results, the farming system performs well for two functions (food production and economic viability), and it has a medium performance for most of the other functions (quality of life, natural resources, biodiversity and habitat, the attractiveness of the area). The system has high resilience against specific kinds of disturbances because of its organization, redundancy and large availability of financial resources. This is reaffirmed in the evaluation of the resilience capacities, being robustness the strongest one. However, the low level of crop diversity in the system may be considered a potential weak feature. Indeed, the positive economic results allow the FS to be capable of withstanding losses both in production and economic terms, due to internal and external pressures that may occur in specific years.

The system has developed over the years driven by the hazelnut market positive trend and by the changes of upstream and downstream industries. For example, the past contribution of mechanization to the resilience capacities (robustness, adaptability and transformability) appears to be different depending on the point of view adopted: positive and strong for all capacities when related to the indicator "Retention of young people in the area", whereas concerning "Gross Saleable Production" it has a highly positive relationship with system robustness and less with adaptability and transformability. An improvement in adaptability and transformability capacities could result from a higher level of cooperation and of integrated value chain activities, which would also further improve robustness. Transformability capacity results limited because of the perennial feature of Corylus avellana (Hazelnut) on one side and because there are very few alternative crops ensuring a comparable level of profitability, on the other side.

Looking at the future of the system: faced challenges, alternative system configurations and strategies

With the background of the current situation in mind, the workshop allowed us to have a deep view of the possible futures of the system. Some critical aspects have emerged from the workshop: the system is not very coupled with local capital. This is because it is strongly affected by the strategic decisions of the downstream multinational confectionery industries and by the growing international competition. The system is also weakly coupled with the natural capital given the limited provision of public goods. While some recognized the value of cultivation in terms of carbon dioxide sequestration, soil protection, most worries concern the low biodiversity

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

and the use of chemicals pesticides and fertilizers. This is causing a greater eco-compatibility request addressed to farmers by non-farming local population and NGO's environmentally oriented.

The growing pressure from public opinion could result in the introduction of more binding environmental constraints, as it was started from a few municipalities. Considering the current evolution of climate change events, characterized by an increase in temperature and changes in precipitation patterns and quantities, extreme events as drought are becoming very common and able to activate trickle-down negative effects. Drought is also putting pressure on water availability as well as decreasing the quality of this resource. This affects hazelnut production in terms of both yields and product quality.

However, the price level and its variability continue to be the main challenge affecting the well-being of all operators in the farming system. A reduction of unprocessed hazelnut prices could be caused by the strong competitiveness of international markets (where a growing number of producers are stepping-in). Finally, market conditions could be strongly affected by the strategic decisions of the high and growing concentration of downstream confectionary companies that control a very large share of the world demand for unprocessed hazelnut. Negative evolutions of the hazelnut prices paid to Italian farmers are expected to reduce farm Gross Margin and, more in general, to make the system less profitable than in the past.

Participants have identified some future alternative states of the system even if they do not have a completely shared vision of the FS future. However, none of them can imagine the system without a strong presence of hazelnut. Hence, the proposed alternative states are not radical transformations of it but more or less deep variation. However, alternative future states of the system often require not negligible changes with respect to the current situation.

Among the alternative future states wished by the participants, there was a technological innovation system, eco-friendly agriculture, a system able to valorize the hazelnut production and, finally, a future with sustained demand characterized by high and stable prices.

The current system results already innovative. The recourse to technology has been the strategy that in the past has allowed high mechanization and unit costs reduction. Therefore, it is hoped to continue in this direction to improve the whole system. In addition, the current system is already sensitive to agri-environmental issues. Nevertheless, it is hoped to focus even more on safeguarding the environment and landscape assets as well as all-natural resources threatened by climate change and the intensification of agriculture. Moving in this direction, a future system able to valorize the hazelnut production could open new markets and foster local processing activities to keep more value-added in the area. Finally, a system characterized by stable prices with a reduction of price volatility that characterized so far the hazelnut market is whished by the participants.

Some alternative states of the system proposed by participants were found to be partially interrelated. This is the case of eco-friendly agriculture and technological innovation. The drawn alternative states of the future system so are not independent.

In this perspective, product valorization based on eco-friendly and locally transformed products could ensure the system to be more coupled with local and natural capital. Technical and in particular technological innovation may both reduce production costs and reduce the environmental impact of production. This type of innovation has played and will play a role in improving product quality and therefore revenue, as well as reducing costs.

The workshop has shed light on possible strategies to shift to the new configuration of the system. Current strategies continue to be needed to improve resilience in the future. The new strategies proposed by participants could also facilitate the shift to the alternative states of the system toward the future. Among these, cooperation among stakeholders into the local value chain seems to be a key strategy shared by all participants and able to address the current state toward the potential future scenario. This strategy could counterbalance the observed tendency toward a growing concentration of the downstream confectionary industry. This is feared to potentially increase its market power, to reduce hazelnut prices at the farm gate and, more important, to increase the vulnerability of the system in case of changes in marketing strategies of the confectionary industry (e.g., increasing purchase in other countries). This strategy is also relevant in the view of product valorization and technical advisory. However, with respect to the past, stronger efforts should be done to implement this strategy. Product valorization, linked to the use of Geographical Indications and locally processed products, could play a role in reducing the dependency of the system from the external food-industrial demand. Furthermore, shifting to more eco-friendly production practices could also be a tail of the diversification strategy, if consumers will be correctly informed about this shift. Given the complexity and extent of the required changes, the long-term resilience of the system can only be pursued through a collective strategy that involves all the system's actors, including those at the post-farm level.

Mechanization continues to play a key role. Even if all the system benefitted in the past from mechanization, technological innovation is still necessary but in a renewed form. It should not be just a replacement or an increase in the number of machinery, but an improvement of technologies to reach higher quality and more eco-friendly productions.

In this regard, policy support can still be a key tool able to facilitate both product valorization and mechanization. However, an improvement is needed also in this regard. Stakeholders stressed the need for support that should be timely and effectively targeted to the needs because policy intervention has not always had such characteristics in the past. This is important especially in the view of an "eco-friendly agriculture" alternative future state.

Last, but not least, alternative states of the system have been discussed considering the SSP scenarios because future states can be facilitated by certain conditions of such scenarios. Some of the alternative systems are suitable to respond to the changes caused by the possible future scenarios identified in the literature. In particular, a system based on "Eco-friendly agriculture", "Product valorization" and "Technological innovation" results compatible with both the two scenarios Eur-Agri-SSP1 - Agriculture encouraged for sustainability and Eur-Agri-SSP2 - Agriculture kept on established paths. In contrast, the occurrence of other scenarios will limit the proposed shift of the system as it is especially the case of SSP3 because it characterized by the self-sufficient principle of individual countries making the interaction between national and European entities less efficient. In particular, in the event of the latter scenario occur, none of the desired alternative states could come into effect.

A final consideration should be added. At the time this report is being completed, all activities in the FS area are facing a profound crisis due to the COVID-19. This kind of challenge was unpredictable just a month ago. Some very preliminary economic impact assessments, at the country level, suggest that agriculture, as an aggregate sector, will probably perform better than all the other economic activities - except for the pharmaceutical sector. Nevertheless, hazelnut economics depends on its results strongly from the international demand for the confectionery industry that may be affected by the effects of the pandemic. Therefore, deep uncertainties about the future are appearing at the economic horizon of our specialized farming system.

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520

5 References

Kinzig, A.P., Ryan, P., Etienne, M., Allison, H., Elmqvist, T., Walker, B.H., 2006. Resilience and regime shifts: Assessing cascading effects. Ecol. Soc. 11. https://doi.org/10.5751/ES-01678-110120

Mitter, H., Techen, A., Sinabell, F., Helming, K., Kok., K., Priess, J., Bodirsky, B., Holman, I., Lehtonen, H., Leip, A., Le Mouël, C., Lotze-Campen, H., Mathijs, E., Mehdi, B., Michetti, M., Mittenzwei, K., Mora, O., Øistad, K., Øygarden, L., Reidsma, P., Schaldach, R., Schmid, E., Webber, H., Schönhart, M., 2019. Developing a protocol for establishing new storylines that extend the Shared Socio-economic Pathways and inform integrated assessments of European agricultural systems.

Severini, S., Paolini, G., Nera, E., Antonioli, F., Senni, S., 2019, 'FoPIA-Surefarm Case-study Report Italy'. In: Paas, W., Accatino, F., Antonioli, F., Appel, F., Bardaji, I., Coopmans, I., Courtney, P., Gavrilescu, C., Heinrich, F., Krupin, V., Manevska-Tasevska, G., Neumeister, D., Peneva, M., Rommel, J., Severini, S., Soriano, B., Tudor, M., Urquhart, J., Wauters, E., Zawalinska, K., Meuwissen, M., Reidsma, P. D5.2 Participatory impact assessment of sustainability and resilience of EU farming systems. Sustainable and resilient EU farming systems (SURE-Farm) project report.

This Project has received funds from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 727520