Project acronym: SURE-Farm
Project no.: 727520

Start date of project: June 2017
Duration: 4 years

FoPIA-Surefarm 2 Case Study Report Sweden

Work Performed by P6, Sveriges Lantbruksuniversitet

Gordana Manevska Tasevska and Jens Rommel

(Gordana Manevska-Tasevska; gordana.tasevska@slu.se)

Due date	31/May/2019 (part of D5.5)
Version/Date	Final 27/May/2020
Work Package	WP5
Task	T5.3
Task lead	INRAE
Dissemination level	Public

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

Supplementary Materials K. FoPIA-SURE-Farm 2 Case Study Report Sweden

Contents

Please cite this report as:

Manevska Tasevska, G., Rommel, J. 2020, 'FoPIA-SURE-Farm 2 Case Study Report Sweden'. 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

1 Introduction

1.1 Main indicators, resilience attributes and challenges

We investigate the egg and broiler production system in Sweden. The system is undergoing continuous adaptation driven by continuous change in consumer preferences (animal welfare, food quality), continuous change in regulation which also requires technology adoption, as well as stricter standards applying to domestic products than imported products, making it more difficult for Swedish producers to be competitive on international markets. The main functions of the farming system are providing affordable and healthy food, economic viability, and maintaining natural resources in a good condition. Taking good care of animal health and welfare is also among the main functions and is considered a precondition for delivering healthy food. Indicators that are most representative for these main functions (function indicators) are presented in Table 1. On a scale of 1-5, with 1 being very low to 5 being perfect, the performance of the function indicators ranges from 2.8 for viable income, 3 (FoPIA-SURE-Farm 1) and 4 (FoPIA-SURE-Farm 2) for animal health and welfare, 3.6 for delivering healthy products, to 3.9 for maintaining the natural resources in good condition.

Table 1. Main indicators and their performance and development. Source: Gordana Manevska-Tasevska et al. (2019).

Main indicators	Current average level (score 1 – 5)*	Current level (explanation)	Current development
Ensure viable income	**2.8**	High pressure for continuous adaptation in the technology and regulations	Status quo
Deliver healthy and affordable food products	**3.6**	High quality products are delivered. High production costs increase the sale price, thus make the products less affordable for some consumers	Status quo
Maintain natural resources in good conditions	**3.9**	Well maintained, regulations are followed	Constant development in line with new requirements
Animal health and welfare	**3.0 (4.0)****	Well maintained, regulations are followed	Constant development in line with new requirements

* 1 = very low, 2 = low, 3 = medium, 4 = good and 5 = perfect. **New value suggested from FoPIA 2.

Main resilience attributes of the system relate to system reserves (reasonably profitable), diversity (both response and functional), openness and infrastructure for innovation. On a scale of 1 to 5, with 1 being not present to 5 being perfectly present, the presence indices of the resilience attributes range from 2 for reasonably profitable and response diversity, 3 for infrastructure for innovation, to 4 for functional diversity and openness (to changes and learning). The perceived presence of the resilience attributes are presented in Table 2.

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

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

Main resilience attributes	Current level (score 1:5)*	Current level (explanation)	Current development
Response diversity	**2**	Farmers depend on other actors in the chain. Few companies contract several farmers on long-term contracts.	Status quo
Reasonably profitable	**2**	Policy instruments do not buffer resources. Stakeholders see certain policy decisions as unrealistic, affecting the profitability of farms negatively.	Production is coupled with local and natural capital; Knowledge is shared/farms do not depend on a single person.
Functional diversity	**4**	It is applied mostly at farm level. Functional diversity is seen as a risk management strategy not to depend on a single income. However, each unit is expected to be profitable for its self.	Social learning is highly supportive.
Openness	**4**	Farmers are open to adapt to new challenges, take actions.	Social learning is highly supportive.
Infrastructure for innovation	**3**	Stakeholders evaluate the infrastructure for innovation as moderate. Policy is supporting infrastructure for innovation, but the gap between the innovators to the final users is big.	The relationship between farmers and the branch organization is stable. Stakeholders see certain policy decisions as not realistic.

* 1 = not applied, 2 = slightly applied, 3 = moderately applied 4 = adequately applied and 5 = perfectly applied.

Workshop participants agreed with the proposed main function indicators and resilience attributes, as well as with their performance (except for animal welfare) as previously assessed (SURE-Farm FoPIA 1). Representatives of the broiler production emphasized the need for adding one more challenge, namely competition with products from the rest of the EU market, where production standards are lower than in Sweden. Bureaucracy was also mentioned to be a large burden. During the workshop these last two mentioned challenges were discussed together with the challenge “High standards and strict regulation”.

Main challenges for the farming systems as identified in the workshop are:

- High standards and strict regulation for product quality (both for egg and broiler producers)
- Competition with products from the rest of the EU market, where the requirements for standards are lower than in Sweden (for both, egg and broiler producers, but broiler producers argue to be more severely affected)
- Fast change in technology and challenges arising from adopting new technology/adapting to new conditions (for both, egg and broiler producers)

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

- Changes in consumers preferences requiring adaptation (for both, egg and broiler producers)

1.2 Participation in the workshop

The participatory assessment workshop was organized on 30th January 2020 in Linköping, for representatives for the egg production, and on 3th February 2020 in Stockholm, for representatives of the broiler production. In total, 9 participants attended the workshop (seven for egg production and two for broiler production). The stakeholder group participating in the two workshops included five farmers (the group was mixed in terms of farm history and farming experience, however all farmers were egg producers), one representative from the Swedish farmers' organization (chairman of regional unit, working on rural development issues), two high ranking representatives from the eggs- and broiler branch organizations Svenska ägg and Svensk fågel (one each) and one representative from the broiler branch organization Svensk fågel, with expertise in animal welfare, production, insurance issues, etc. While farmers represented the producers' perspective, the branch- and the farmers' organization representatives provided a broader overview of the value chain, rural development and the policy perspective. Both genders were equally represented (5 female and 4 male participants). The gender of the moderators organizing the workshop was also balanced (one male, one female). The workshop was not recorded, members of the research team moderated the events and took notes. During the workshop a selection of presented indicators, attributes and challenges was taken for further discussion.

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

2.1.1 Introduction

Thresholds for the system to keep the status-quo were discussed for the function indicators, resilience attributes and challenges. During the discussion, participants focused on the economic performance and how it relates to the remaining indicators/attributes/challenges.

2.1.2 Indicators and attributes

Ensure satisfactory income/being reasonably profitable

To ensure satisfactory income and be reasonably profitable were the most frequently selected indicators/attributes by the stakeholders. Satisfactory income and being reasonably profitable were discussed as one indicator, i.e., the overall economic performance of the farm. It was mentioned that the economic performance of the farm is a precondition which largely relates with the performance of the remaining indicators/attributes and the challenges, or as one participant puts it: *"Everything starts with the economic performance of the farm."*

Selecting a threshold was not an easy task for the stakeholders, and they did not felt comfortable to specify a threshold value. During the plenary discussion, stakeholders agreed that covering the farm costs, and extra income for further investments would enable the farm to adapt and would thus be a prerequisite for the production. One participant of the egg production workshop mentioned a "5% operating margin" as a threshold value (operating margin = operating profit after depreciation/net sales). Other stakeholders (farmers) of that workshop agreed with the proposed threshold. Moreover, it was argued that the life-style expectancy of the new generation differs from the expectations of their parents. New generations are willing to secure income for more employees on the farms (part/fulltime depending of the farm size), so that they can have some free time.

Deliver healthy and affordable food products

Stakeholders emphasized that they are willing to provide high quality products. Broiler producers face tough competition from imported poultry meat produced under weaker regulation/standards. Egg producers also operate under higher standards, but imports are quite strictly regulated. Imported eggs must be certified salmonella free which imposes and additional cost to importers, offering some protection for domestic producers. Stakeholders agreed that all egg and broiler producers in the EU should follow common health/animal welfare/environmental practices for production, as a threshold. However, at the moment, Swedish producers feel punished for their efforts to deliver high quality products: *"EU does not have mechanisms to*

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

support high quality production." In other words, stakeholders would hope for a greater harmony of EU regulation with national regulation.

Infrastructure for innovation

Participants indicated that infrastructure for innovation needs improvements. Although agricultural policy is supporting infrastructure for innovation, the gap between innovators and end users is perceived as large. The relationship between farmers and the branch organization is good, and it facilitates knowledge sharing. Thresholds were not identified for this resilience attribute.

2.1.3 Challenges

High standards and strict regulation for product quality

This challenge is to a large extent related to the indicator "deliver healthy and affordable food products." Stakeholders emphasized that they do not oppose strict regulation *per se.* Rather, there is the perception that there is no level playing field, as EU competitors are not subject to the same regulation and enforcement. It was repeatedly emphasized that changes in standards and regulation must happen in greater harmony with the EU level in order to limit competition that was perceived as unfair. Swedish decision-makers were criticized for imposing extra requirements that also increase the bureaucratic burdens. Some changes in the regulations were viewed as over-reaching and too general, without a careful consideration of the impact and the respective costs and benefits. It was also stressed that better collaboration among the stakeholders (research/production/industry/market/policy) is needed. The same applies to the "delivery of healthy and affordable food products." The threshold is that egg and broiler producers in the EU follow common health/animal welfare/environmental practices for production. Stakeholders representing farmers think that primary producers are the most affected. Stakeholders representing the branch organizations view the problem as one of the whole value chain, as changes in standards and regulation are imposed on other actors as well (production, packing, transport, slaughtering, processing, sale etc.).

Rapid changes in technology

Rapid changes in technology emerge from changes in regulation but also from changes in consumer preferences. Changes in consumer demands are viewed as erratic and unpredictable by stakeholders. They are driven by long-term trends, but short and mid-term demand also reacts to social media, the overall economic development and income of Sweden etc. The amortization period of invested capital was discussed as a threshold. Ten years on equipment/machinery and 20 years on buildings were viewed as useful. In the plenary discussion it was also mentioned that changes in the technology and experimenting are possible at small scale.

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

2.2 System decline

2.2.1 Introduction

In three groups (two groups for the egg production, and one group for the broiler production) participants discussed two challenges, namely high standards and strict regulations and fast changes in technologies, and their impact on main indicators and resilience attributes, in case thresholds were exceeded.

2.2.2 Performance of indicators and resilience attributes

High standards and strict regulation for product quality

High standards and strict regulation aim at improving product quality, animal health-, welfare-, environment- and climate conditions. Such changes are part of policy making decisions, where possibility of the producers to impact the outcome is rather limited. The general opinion is that high standards add value to the domestic production, and stakeholders are not against high standards. However, "unrealistic standards and regulation" implemented within "unrealistic time frame" cause problems with adaptation to mounting bureaucracy, and they are negatively related (--) with production costs. In the discussion, production costs were used as a "by-pass"/mediator challenge that relates to the performance of the resilience indicators and the resilience attributes.

In the discussion, high production costs were negatively related (--) to the purchasing power of domestic consumers and, thus, the demand for domestically produced products. A moderately negative relation (-) was expected for the income (resilience indicator) and profitability (resilience attribute) of the production. Stakeholders explained that high standards can have a moderately positive (+) effect on the product quality at state level, but the effect at farm level was evaluated as moderately negative (-), because low profitability and low income prevent farmers to produce high quality products.

On the other hand, changes in standards and regulation facilitate resilience attributes related to functional diversification and technology adoption. Stakeholders' opinion was that decisions for diversification lead to *"stå på flera ben"* which roughly translates into *"*standing on more than one leg." This can be viewed as a risk management strategy, but the expectation is that any additional unit of production should be profitable for itself. The effect of changes in standards and regulation on adoptions of new technology was also evaluated as moderately positive (+), at least for producers with good system reserves and income. In other words, there is an upside of the constant changes in that it helps the sector to come up with flexible solutions for other problems as well.

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

Fast changes in technology

The need for fast adaptation in technology stems from changes in the regulation (discussed as a first challenge) and consumer preferences. That is, the two challenges (high standards and regulation for product quality and rapid change of technology) are crucially interlinked.

Following the stakeholder discussion, viable income and system reserves i.e. profitability are crucial resilience indicators for changes in technology to take place (as investments are needed, but liquidity goals must also be maintained). If the challenge performance overweighs the performance of the indicator, i.e. the adaptation is too fast, the effect on income/profitability is expected to be negative (--). The effect on product quality will be dual, negative (--) for farmers facing economic problems to strongly positive (++) for viable farms.

With respect to resilience attributes, profitable farms or, more generally, farms that do well economically are also the one that can easily adopt new technologies. The relation between economic performance and technology adoption was evaluated as moderately positive (+). Changes in technology and decisions for adaptation to new technology were discussed as moderately positive (+) for the resource use and the environment. The need for rapid technical change will also stimulate research and innovation projects (strongly positive (++)).

Stakeholders do not oppose strict regulation and new technology. One strategy to maintain the system implies even to push for stricter regulations elsewhere in the EU. Stakeholders agreed that all producers in the EU should follow common health/animal welfare/environmental practices for production, and that the EU must develop better tools to support quality and high value production.

2.3 Alternative systems

2.3.1 Introduction

Alternative systems were selected in an open discussion with all workshop participants. During the discussion, stakeholders selected and focused on three alternative systems: large farms, higher self-sufficiency of fodder, and robots. Each of the selected alternative systems was discussed by the whole group. Stakeholders' opinion was that 2030 is not a long-run perspective, so within that time perspective, they see system changes to be more associated with robustness and adaptation than with transformation. The discussion suggests that the alternative systems will mainly impose structural change in the system. New alternative systems can maintain and moderately improve the main functions and the resilience attributes of the farming system (Table 3). However, a negative impact is expected for producers (farms/slaughter houses/packaging companies) that cannot keep pace.

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

Boundary conditions such as appropriate balance between the production costs and the farm gate prices, access to skilled labor, access to land and capital, knowledge management, specified for maintaining the status quo, were found to be a prerequisite for all of the alternative systems. Effective bureaucracy was mainly discussed in context of procedure for expanding the farm size and access to land in order to be self-sufficient for fodder. Technological innovation was directly related with related automatization i.e. use of robots in the production process.

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.

Indicator	Current level	Status quo	System decline	Alternative, future system		
				Large farms	Self-sufficiency fodder	Robots
Viable income	Low/Moderate	→	↘|↓|↑	↗|↓	↗|↓	↗|↘
Healthy and affordable products	Moderate/High	↗	↗|↘	→	→	↗
Maintain natural resources in good conditions	High	↗	↘|↗	→	→	→
Animal health and welfare	Moderate	↗		→|↘		↗
Response diversity	Low	→			↗	
Reasonably profitable	Low	→	↘|↓|↑	↗|↓	↗|↓	↗|↓
Functional diversity	High	→		↗	↗	
Openness	High	↗	↗|↑	→	→	→
Infrastructure for innovation	Moderate	↗	↗|↑	↗	↗	↗
Farm size	High	↑	↗|↑	↗	↗	↗
Boundary conditions	**Domain**					
Balance between production costs and farm gate prices	**Economic**	V		V		V
Access to land/ capital	**Economic**	V		V	V	V
Knowledge management	**Social**	V		V	V	V
Qualified labor	**Social**	V		V	V	V
Effective bureaucracy	**Institutional**	V		V	V	
Technological innovation	**Economic**	V		V		V

2.3.2 Large farms

This alternative system was mainly discussed from farmers' perspective, especially egg producers. On several occasions, farmers emphasized that the pressure for increasing farm size is larger for primary producers. They also emphasized that Swedish farms are family farms, and not all farmers have a business concept of being a large producer, thus structural change can occur.

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

The discussion on this alternative system started with two questions: *"How large do we need to be?"*, and "*what do we need to increase, the land or buildings?"*. The increase in size was discussed both in terms of: i) increasing the size of the buildings i.e. increased egg production, but also in terms of ii) functional diversity, with an accent on self-sufficiency level for fodder production, i.e. increase of land. Both issues were discussed in parallel but the discussion for the two alternative systems are presented separately.

In general, stakeholders expect that farms have to grow in order to improve the productivity. Both egg and broiler farms operate under constant pressure for the need of technological change. Moreover, broiler farms have a constant pressure of low prices for imported products, therefore investments in technology and increase in size are necessary for the profitability of the farms. Large farms applying modern technologies for production and monitoring will contribute to high product quality (animal health, and welfare), but it can also be a constraint if the farm does not have a capacity (labor and technology) to monitor large production.

Boundary conditions for this alternative system were strongly related with the profitability of the farm, i.e., access to qualified labor, access to land, ground water and capital, and a functioning and efficient bureaucracy. Stakeholders see profitability as a precondition for investments. It was mentioned that not all farms will be able to follow that trend, thus there will probably be fewer farms in the future. Large farms will need access to qualified labor, which can also be a constraint. Farmers also discussed the irregular need for part-time labor, posing difficulties for labor planning. Cost for labor are high, and farms need to have proper planning to find a balance between the permanent and the part-time labor. Increases in size imply access to land, access to ground water, and investments in new buildings which require bureaucratic processes for building permission and environmental/climate related regulation and permissions. Stakeholders asked for more efficient bureaucratic processes which will speed-up the procedures for access to credits, and thus the investment. Large farms can also expand in activities positively contributing to functional diversity. Large farms can easily diversify in order to be more self-sufficient for fodder, or diversify the income sources, such as from bio-energy production, forest, etc. As previously stated, stakeholders recognize functional diversity as a risk management strategy for unpredicted shocks, commonly communicated as *"stå på flera ben"* ("stand on several legs", translated). As to how far such diversification at the farm level leads to more diversification at the farming system level is an open questions though. While farms may become more resilient from diversification, the impact on farming system resilience is more uncertain.

2.3.3 Self-sufficiency for fodder

For large farms, self-sufficiency in fodder was discussed from farmers' perspective, especially egg producers. The main argument for the potential benefit of this alternative system were the high

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

and volatile fodder prices affecting the economic performance of the farms. Fodder costs were identified by the farmers as the highest costs of the production.

According to the stakeholders, this alternative system ensures more stable economic performance of the farms due to the lower risks originating from the volatile prices of the fodder. Self-sufficiency in fodder increases the response and functional diversity of the farms and the need for applying new technologies, i.e. support innovation infrastructure. Functional diversity is ensured with the multiple production lines (poultry products, cereals/crops to be used for fodder production) on the farms.

The existence of this system was directly linked to the possibility of increases in farm size. Several boundaries were identified for the expansion of this system. First the access to land. Egg and broiler farms are located in productive regions competing for land with other farms, thus farm expansion with a purpose for own fodder production is not always possible. Second, fodder production, especially for concentrates, needs specific technology and knowledge, but also investments in buildings. Similar to the first discussed strategy, stable economic performance and access to capital are a prerequisite for the farmer to apply the system.

2.3.4 Robots

Robots are already used in the production system, and the use of artificial intelligence is expected to increase in the future. The application of robots was seen by the stakeholders as a process of adaptation, rather than as a system transformation. Robots are expected to be more extensively used in processing, such as determining the sex of an egg embryo, packing, transporting lines, slaughtering, sorting carcasses, etc. Farm producers emphasized that some farm activities can be replaced with robots, e.g., transporting lines, feeding, ventilation etc., but the contact between the farmer and the animals has to exist. Stakeholders strongly believe that a successful farmer has to have *"djuroga"* ("animal eye", translated), i.e., ability to pay attention and detect when things are not as they should before the real problem comes/escalates. It was argued that robots lack that kind of human intuition.

Stakeholders indicated that they see robots as inevitable change, for securing better productivity (e.g., labor) and efficiency, but also for minimizing the possibility for contamination and speeding diseases, and thus having high quality products.

Boundary conditions for this alternative system were mainly related to profitability, the size and the infrastructure for innovation. Stakeholders see profitability as an initial step for investments, and even for smooth generation change within the family. Farmers with unsatisfactory economic performance are not willing/do not have possibilities to invest in advanced technology such as robots. Investments in advanced technology also exhibit economies of scale. Both egg and broiler

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

sectors are ready to increase in size and advance in new technology/robots if there is a market for their products. Regarding infrastructure for innovation, stakeholders emphasized that the need for advanced technology in the sector stimulates innovative solutions, but the gap between the innovators and the final users must to decrease.

2.4 Strategies towards the future

Stakeholders agreed that all of the proposed alternative systems are realistic and compatible. For instance, farms are to a large extent forced to expand to achieve economies of scale and compete with the cheaper products from imports. Larger farms have a greater potential to diversify, i.e., produce their own fodder. Larger farms also need more advanced technology, e.g., technological innovations and robots to coordinate the activities in a more efficient way – to avoid problems from shortage of adequate labor, but also to increase productivity. Robots were also seen to be necessary for other parts of the value chain, e.g., processors. This may have implications for upstream partners as well.

Alternative systems can maintain and/or moderately improve the main functions and the resilience attributes, but a negative impact is expected for farmers who cannot adopt the new system. Boundary conditions relate to economic performance, the need of good knowledge and skills, access to skilled labor, as well as access to land and capital.

Strategies for improved performance of the alternative systems are related to the boundaries, and economic performance, good knowledge and skills and capital in particular. Specific strategies for access to land and skilled labor were not discussed. Same as for the existence of the current system, proper knowledge management and technology adaptation were emphasized as core strategies (see Table 4). Stakeholders discussed: *"different kind of knowledge – wide competence is required", including technical knowledge for the production operations, optimization of the different activities, optimization of labor, new trends, legislation and requirements to be followed, etc.* For that purpose, stakeholders (e.g. farmers, branch organization representatives, farmers' organization, etc.) act jointly, help each other and cooperate. Branch organizations take large responsibility to help the knowledge sharing process, protect the farming system from inadequate policy decisions, external pressure etc. Policy support encouraging high quality products is highly appreciated. Current policy and regulations were criticized as ignorant to the extra costs arising from practicing high quality- environmentally- and climate friendly production.

Stakeholders stated that experimentation exists, it is a permanent process at different levels of the value chain, but it has to be done on smaller scale, especially when new production technology is about to take place. It was also emphasized that such changes need gradual shift; stakeholders

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

talked about *"smart adaptations/transformation"* following market signals and the directives for the changes that take place in the other EU countries.

Strategies for the alternative states of the farming system are expected to have positive effects on both, the main indicators and the resilience attributes. Acquiring proper knowledge and skills is needed for proper economic- and production planning, thus improved economic performance, production of high quality products in line with the requested regulation, diversification, openness to new knowledge and cooperation i.e. social self-organization, work- and application of innovative solutions i.e. infrastructure for innovations and openness. As mentioned previously, negative impact is expected for farmers unable to follow the new systems.

Same as for the alternative systems, proposed strategies are expected to contribute to the robustness and the adaptability of the farming system. The proposed time dimension, until 2030, was not seen to be long enough for significant transformations of the farming systems.

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

		Current system	**Future systems**			
Strategy	**Domain**		**Status quo**	**Large farms**	**Self-sufficiency fodder**	**Robots**
Knowledge Management	Agronomic	**V**	**V**	**V**	**V**	**V**
	Economic	**V**	**V**	**V**	**V**	**V**
	Institutional	**V**	**V**	**V**		
Technology adaptation	Agronomic	**V**	**V**	**V**	**V**	**V**
	Economic	**V**	**V**	**V**	**V**	**V**
Farm size	Agronomic			V	V	V
Farm size	Economic	V		V	V	V
Farm size	Institutional	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

We tried to engage participants in a discussion on tipping points, but they perceived this as highly speculative, and the discussion did not yield any substantive results, hence suggested critical thresholds should be interpreted with care. The educated guess of 5% profit margin suggest that the farming system might be close to a critical thresholds as current profit margins are about 5% (including direct and rural development payments). The fact that currently there is no level playing field for Swedish poultry farmers suggest that the system is beyond a critical threshold, forcing the system to adapt. The educated guesses for the speed of technology change are related to pay-off times of equipment (10 years) and buildings (20 years). Currently, major production changes, under influence of legislation and consumer preference, have changed at a similar pace, suggesting that the system is close to a critical threshold at least at national level. At EU level, critical thresholds are not satisfied, which causes problems for the broiler sector in Sweden in the perception of stakeholders. The compulsory certification for salmonella free-eggs requested for importing eggs in Sweden (and not requested for Nordic countries) to some extent acts as a buffer for the egg sector. It should be noted that the critical thresholds are primarily affecting less profitable farms, rather than the farming system as a whole.

3.2 Thresholds exceeded

During the discussion stakeholders identified thresholds for the economic performance (satisfactory income and reasonably profitable) and delivery of healthy and affordable food products. Figure 1 represents how the identified thresholds interact in the farming system.

To ensure good economic performance (satisfactory income and be reasonably profitable) was the most frequently selected indicator/attribute by the stakeholders. Stakeholders' agreed that a "5% operating margin" as a threshold value is an acceptable threshold margin (operating margin = operating profit after depreciation/net sales). Good economic performance implied covering the farm costs, and making extra income for additional investments. Failing to maintain the economic performance disable the farm/farming system to adapt to new technologies and regulations thus is a prerequisite for the production to persist. Low economic performance decreases the interest in farming, and it is not seen as an attractive decision for the successors. Failing to maintain the economic performance impacts the remaining indicators/attributes. For instance, low economic performance decreases the interest/possibility for taking activities that maintain the natural resources in good conditions, secure animal health and welfare. Experimentation with innovative approaches is less likely employed. Farm diversification might be positively affected, as farmers may see other attractive possibilities in alternative production.

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

Overall, exceedance this threshold i.e. "5% operating margin" is perceived to have strong negative impact on the farming system, both in terms of the system's ability to persist i.e. the robustness and the adaptability. That undesirable state will affect the supply of high quality poultry products and technology adaptations to satisfy animal welfare, -health and environmental requirements for maintaining the natural resources in good conditions, experimentation in innovative approaches. Low economic performance might initiate farming system transformation, and provision of alternative goods.

Another important indicator is a delivery of healthy and affordable food products. Throughout the workshop, participants indicated that production of healthy food products are not an issue to be discussed. As agreed by the stakeholders, common health/animal welfare/environmental practices for production (threshold 1) and mechanisms to support high quality production (threshold 2) at EU level are needed. Both thresholds have an institutional character. The current state is that these thresholds are not met, and institutional involvement is necessary. Differences in the regulations for product quality including considerations on animal welfare, health, and environment across the EU decreases the price competitiveness of the Swedish production, thus prevent the Swedish producers to grow and export. Given the price constraints both the egg and the broilers productions are oriented for the domestic market. Higher production prices make the products less affordable for the consumers. Exceedance of thresholds have lower impact on the domestic demand, thus the expectation is that the farming system will not change significantly. In 2019, the self-sufficiency indices for eggs and broilers were 97.5% and 71.6%; the share of exported eggs and broilers, was 17% and 18% respectively (Jordbruksverket, 2020). Yet, the domestic demand seemed to be more affected for the broiler sector, as cheaper imported chicken produced under weaker regulation can enter the market. Latest figures (2019) show that, in Sweden, 40% of the total broilers consumption is from imports and 16% for eggs respectively (Jordbruksverket, 2020). Swedish egg producers benefit from the requirement that eggs imported to Sweden need to be salmonella-certified (Regulation NR 1688/2005). In regard to threshold 2, i.e., existence of inadequate mechanisms to support high quality production. It was emphasized by the stakeholders that such inadequate treatment of high value products discourages the adoption of regulations for high quality products in general.

Overall, exceedance of these thresholds i.e. not existence of: i) common health/animal welfare/environmental practices for production and ii) mechanisms to support high quality production (threshold 2) at EU level, is perceived to have moderate negative effect on the farming system performance, predominantly with low price competitiveness at the EU market (egg and broilers production), and constraints in price competitiveness for the broilers production for the domestic market.

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

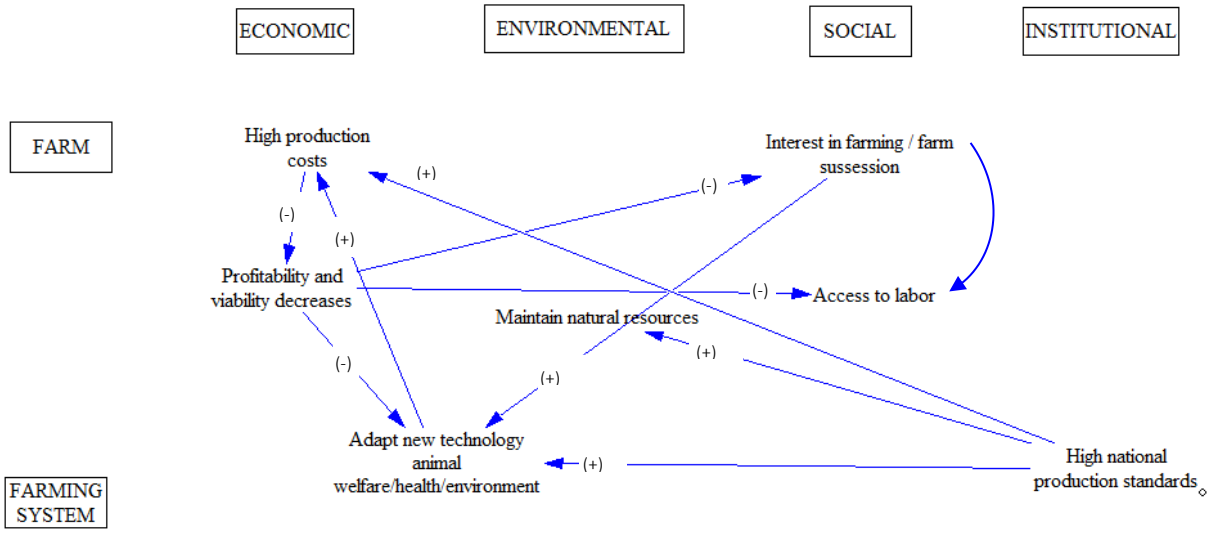

Figure 1. Interacting thresholds in the farming system under pressure from high standards and strict regulations..

3.3 Alternative systems

The main functions and the resilience attributes are expected to be maintained or moderately improved in all alternative systems. (Table 1).

Viable income and reasonably profitable are important in all proposed alternative systems, both for maintaining the production i.e. robustness and various adaptations i.e. adaptability. With the proposed alternative systems, these indicators are expected to be moderately improved. Both alternative systems (large farms and robots) are needed for better productivity, and thereby lower cost per unit of product. Better income can be attained with improved product quality which is interlinked with technologies applying better health- and animal welfare practices. Negative impact is expected for farmers unable to follow the new system.

Animal welfare can be maintained and even moderately improved on “Large farms”, and moderately improved with “Robots”. Large farms, and farms applying modern technologies for production and monitoring (e.g. robots) contribute to good product quality (animal health, and welfare), and thus better income. However, negative impact is expected for farmers unable to follow the new system.

Farms that are “Self-Sufficient for fodder”, can moderately improve functional and response diversity, whereas “Large farms” can have a moderate positive impact on the functional diversity. To diversify farms need to be large enough, both in terms of assets and capital. Farms self-sufficient with fodder also have a better position in term of bargaining power from the producers selling fodder, thus their performance in terms of response diversity is higher.

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

The current state of Maintaining natural resources in good condition, and openness is high. Both attributes are relevant for the new systems, but no change from the current status is expected.

The alternative system "Large farms" is important for both, the robustness and the adaptability of the current system. "Self-sufficiency for fodder" and Robotization" production process are more related with adaptability. For the alterative systems "Large farms" and "Self-sufficiency", main changes need to be undertaken at farm level, whereas "Robotization" of the production process is relevant for both, the primary production and the processors.

3.4 Causal loop diagram

Figure 2 presents a causal loop diagram that shows how different challenges and system indicators can interact with positive or negative results.

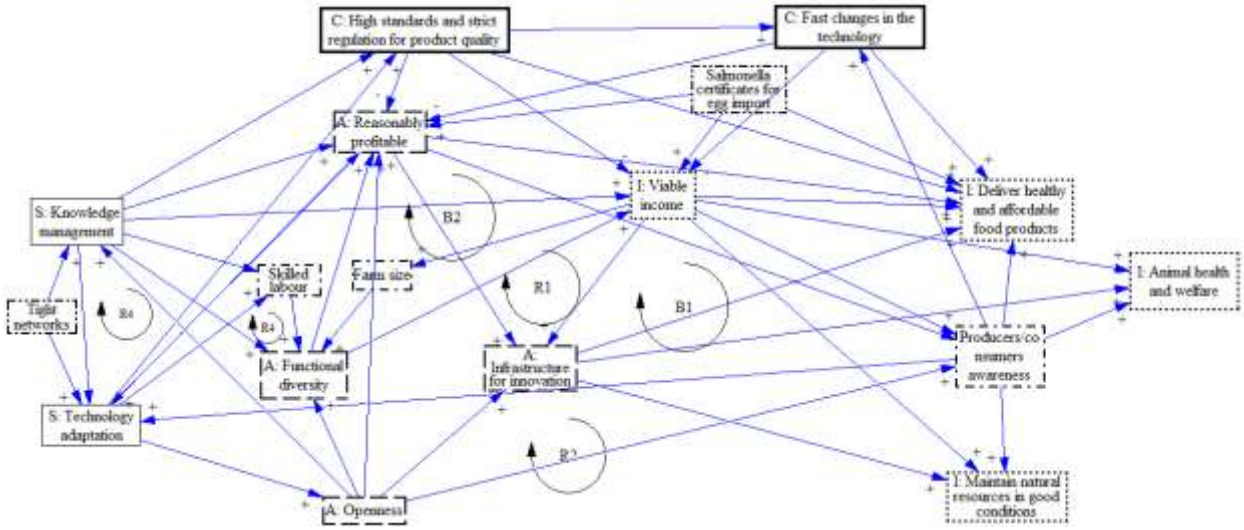

Figure 2. Causal loop diagram of the farming system in egg and broiler production in Sweden. A + implies a positive cause-effect relationship and a - implies a negative cause-effect relationship. B stands for a balancing feedback loop and R stands for a reinforcing feedback loop. I indicates an important system indicator related to the system's functions. C indicates a system challenge. A indicates an indicator related to a resilience attribute. S indicates a strategy applied to maintain current functionality of the system.

Several balancing and reinforcing feedback loops were identified. Viable income (I) (B1) and reasonably profitable (A) (B2) balance the negative impact from the challenges originating from the requirements for high standards (C) and/or fast technological changes (C), and reinforce the producers' awareness for high quality products, and the adaptation of new technology (S). It was clear from the workshop, low quality products with a negative impact on the environment are not an option. It is rather that such standards should be imposed to the rest of the EU countries. However, workshop participants emphasized that the economic performance, i.e viable income (i), and or reasonable profitability (A) of the farm is a precondition which largely relates with the

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

performance of the remaining indicators/attributes and the challenges (citation: *"Everything starts with the economic performance of the farm."*

Viable income is also a part of the reinforcing loop (R1), where it appears as a stimulating factor for increasing the size of the farms, and thereby provides possibility for improving the functional diversity (A). The functional diversity mostly refers to farm diversification in terms of own fodder production, which was discussed to be a precondition for the future viability of the farms.

It's important to mention that during the workshop the requirement for salmonella certification for eggs imported to Sweden was emphasized as an important variable securing the resilience of the egg production. Although the requirement for salmonella certification is not a part of the feedback loops, it influences both, the viable income (I), and the profitability of the farms, and hence B1, B2 and R1.

Openness (A) to new knowledge and cooperation, i.e. social self-organization, work- and application of innovative solutions is among the reinforcing attributes (R2) that also appeared to help be important for the functional diversity (A), and further, for viability of the income (I), the producers awareness, and finally the strategy for technology adaptation (S).

Availability to skilled labor (R3) also supports farmers' decisions to diversify the activities, i.e. reinforces the functional diversity (A), which again improves the viability of the income (i), the awareness of the producers for quality products, and the technology adaptation (S). Similar reinforcing loop was also identified via the economic performance attribute reasonably profitable (A).

Another important factor mentioned during the workshop was the tight networks that exists in the egg and the broiler sector. Same as for the salmonella certificate, tight networks are not a part of a feedback loop, but are facilitators of for the strategies for knowledge management (S) and technology adaptation (S), which are included in multiple feedback loops, e.g. B1, B2, R2, etc.. Majority of the identified balancing/reinforcing feedback loops are in line with the alternative systems.

For maintaining the current- and the alternative systems, good balance between the production costs and farm gate prices, access to land and /capital, knowledge management, qualified labor, effective bureaucracy and technological innovation are necessary. Based on the workshop results, economic performance (viable income and reasonably profitable) are of greatest importance, conditioning the existence of the system. Farm size was also mentioned as a limitation, and as inevitable structural change in the future. Furthermore, it was pointed out that delivering healthy products, taking care of high animal welfare, and maintaining natural resources are well accepted

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

practices within the current system, and that path will continue within the alternative systems. Indicators and boundary conditions of the current- and alternative systems are presented in Table 3.

Agriculture encouraged for sustainability (SPP1, Appendix B) is moderately and strong compatible with the needs for maintaining the current- and the alternative systems (Table 5). Sustainable development is best described by short supply chains, local markets, environmental/climate regulations and standards (all characteristics of SPP1) which is high on the national agenda and supported by preferences from the consumers. The egg sector is self-sufficient (97.5% in 2019, (Jordbruksverket, 2020), and representatives of the broiler sector claimed that they are ready to increase the self-sufficiency by increased production, but imported broilers meat produced under lower environmental conditions decreases the competitiveness of the domestic broiler production. The respective self-sufficiency index of the broiler sector is 71.6% (Jordbruksverket, 2020). Among the alternative strategies self-sufficiency for fodder has strongest compatibility (0.83) pointing towards closed production cycle, with low dependence on external inputs. The alternative systems large farms is approaching strong compatibility (0.61).

Table 5. 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.

	Scenarios				
Systems	**SSP1**	**SSP2**	**SSP3**	**SSP4**	**SSP5**
Status quo	0.55	0.40	0.44	0.00	0.19
Large farms	0.61	0.43	0.50	0.15	0.09
Self-sufficiency fodder	0.86	0.44	0.58	0.08	0.26
Robots	0.50	0.63	0.63	0.50	0.38

Agriculture kept on established paths (SPP2, Appendix B) is moderately compatible both with the status-quo- and the alternative systems (Table 5). The European agricultural policy is aiming at international competitiveness, productivity and efficiency (all characteristics of SPP2) which is in line with structural changes such as increasing the farm size, diversification. Own production of fodder is an example of farm diversification. Slow progress in implementing environmental standards and policy instruments at EU level, contradicts the national standards/regulation and consumer demand for high quality products in Sweden. Such conditions make the local product less competitive, due to increased production costs, and consequently decreased viability of the system. Uncertain viability of the system decrease the number of smaller less efficient farms, and makes pressure to the system to expand and especially apply advanced technology in order to achieve scale efficiency.

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

Agriculture controlled within national boundaries (SPP3, Appendix B) shows moderate compatibility with the status-quo- and the alternative systems (Table 5). SPP3, is about national governments in the EU to keep agricultural production standards low. That is strongly against the strict regulation and consumers' preferences for high quality local products. Such conditions lead to desirable self-sufficiency.

Agriculture moved towards inequality (SPP4, Appendix B) has mixed effects (Table 5). Moderate incompatibility was found for status-quo and weak incompatibility for large farms and self-sufficiency for fodder. In Sweden, the status quo of the system is not driven by the wealthy upper-class (as assumed in SPP4). However, business oriented farming which is another characteristic of SPP4 is often related with large farms. A possible explanation for moderate compatibility for robots is the SPP4's characteristic to stimulate technology development and technological uptake of efficient technologies.

Agriculture boosted by technology (SPP5, Appendix B) has weak to moderate compatibility with the status quo and alternative systems (Table 5). The possible explanation for the weak compatibility is the trade liberalization, the globally connected supply chains, which will decrease the competitiveness of the system even further, especially for the egg producers, if import barriers for salmonella free eggs are removed. The alternative systems "Robots" has moderate compatibility, and is with line with the SPP5 characteristics "accelerated technological progress" and "high-tech affinity"

3.5 Strategies

Proper knowledge management and technology were emphasized as core strategies for both the egg and the broiler production in the past, the existence of the current system, and even for future adaptations for the system to continue to develop. The identified strategies are also common for proposed alternative systems. Production specific strategies related to egg and broiler production were not discussed.

Proper knowledge management and technology adaptation are primarily linked with the system challenges such as high standards and strict regulation for product quality and fast changes in the technology, originating both from the consumers' and societal needs (Figure 2). As both the regulations and the societal needs are developing constantly, the knowledge management and the adaptation of the technology are an ongoing process.

Given the character of the challenges, and the identified alternative systems (large farms, self-sufficiency in fodder, robots) proper knowledge management and up-to-date technology

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

implementation bring: i) competence and technical knowledge for the production operations, optimization of the different activities, optimization of labor, new trends, legislation and requirements, ii) delivery of healthy products.

In regard to attributes, these strategies are interlinked with the farmers openness to search for possibilities for development, both in terms of knowledge (via networking, official knowledge, vocational training), and technological advances or alternative systems that can be applied on the farms. The attribute openness is further linked and positively associated with the economic performance, functional diversity, infrastructure for innovation, product quality and maintaining the natural resources in a good condition (Figure 2).

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

4 Conclusion

Alternative systems can maintain and/or moderately improve the main functions and the resilience attributes. Stakeholders agreed that all of the proposed alternative systems (large farms, self-sufficiency for fodder and robots in the production) are realistic, and interconnected. Farms are forced to expand to achieve economies of scale and compete with the cheaper products from imports to achieve satisfactory economic performance. Larger farms have a greater potential to move towards own fodder production, they are also in a greater need and have a greater capability to adopt new technologies such as robots to coordinate production more efficiently.

As all alternative systems require substantial investments, hence, good economic performance is a precondition for all states. Negative impacts are expected for farmers who cannot follow the new system. Unsatisfactory economic performance disables sub-components of the system (i.e. the individual farms) to maintain the production i.e. robustness, upgrade to new technology for animal welfare, health and maintain the natural resources. More profitable farms can compensate the resulting loss in production by scale enlargement. However, the number of farmers in the system will be reduced. The effects of other critical thresholds of the farming system such as i) common regulation for animal welfare/health and economic requirements; and ii) mechanisms to support high quality production are also interlinked leading to lower price competitiveness of the Swedish poultry products both on the EU market (for egg and broiler production) and the domestic market (for broiler production). In the long-term, these challenges may eventually lead to economic infeasibility of farms that currently are profitable.

Similar to the existence of the current system, proper knowledge management and technology adaptation were emphasized as core strategies to continue to develop. Such strategies are expected to bring competence and technical knowledge for the production operations, optimization of the different activities, optimization of labor, new trends, legislation and requirements etc.

Both, the alternative systems, and the proposed strategies are expected to contribute to the robustness and the adaptability capacity of the farming system. Robustness will be mainly attained with the improved economic performance, whereas the adaptability is related with good economic performance, adjustments in size, diversification, technology, knowledge etc. The proposed time dimension, until 2030, was not seen to be long enough for significant transformations of the farming systems.

Stakeholders agreed that all of the proposed alternative systems are realistic and compatible and have a high likelihood. This indicates that the Swedish egg and broiler sectors are moderately

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

adjusted with keeping the established paths (SPP2) for a sustainable production (SPP1) which is well accepted within the national borders (SPP3). That holds unless the national and EU regulation/standards are identical.

5 References

Gordana Manevska-Tasevska, Jens Rommel, Helena Hansson, Carl-Johan Lagerkvist, Andrea Pettit, & Larson, S. (2019). D5.3 Current resilience - Case study report Sweden. Horizon 2020, Project no.: 727520.

Jordbruksverket. (2020). *Marknadsbalanser kött, mjölk och ägg*. Retrieved from Jönköping: http://www.jordbruksverket.se/amnesomraden/handelmarknad/kottmjolkochagg/marknadsbalanserkottmjolkochagg.4.298d9b5152ce44f1843e7b7.html

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