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FoPIA-Surefarm 2 Case Study Report BULGARIA

Work Performed by P14, University of National and World Economy (UNWE)

Mariya Peneva, Stela Valchovska

(Mariya Peneva; peneva_mm@yahoo.co.uk)

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

Supplementary Materials C: FoPIA-SURE-Farm 2 Case Study Report Bulgaria

Contents

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1 Introduction

1.1 Main indicators, resilience attributes and challenges

The farming system in the Bulgarian case study is centered around grain farming, which is arable and highly mechanized. The main indicators of the system, identified in FoPIA-Surefarm workshop 1 (Peneva and Valchovska, 2019), were related to five essential functions: "Food production", "Economic viability", "Natural resources", "Biodiversity and habitat", and "Attractiveness of the area" (Meuwissen et al., 2019). They are presented in Table 1. These indicators performed at the average and above average level.

Table 1. Main indicators and their performance and development (Source: Peneva and Valchovska, 2019).

Main indicators	Current level (score 1:5)	Current level (explanation)	Current development
Productivity (t/ha)	**3.6**	The indicator has been perceived as directly related to higher revenues. It has been evaluated high by the farmers. Farmers have managed to increase yields by implementing changes in technology (new varieties, new machines).	Productivity has been developing well for the last fifteen years. However, they have been negatively affected by extreme weather events in the region.
Net farm income	**4.0**	The main factors that influence the income of grain farmers are climate and international market prices. Important part of the farm income comes from the annual single area payment through the Common Agricultural Policy.	The indicator has been increasing between 2007 and 2015. After that the prices on the international grain market have been falling and this has reduced net farm income by about 20%.
Nutrient balance	**3.6**	Farmers are satisfied with the levels of nutrient balance. For most of the last 20 years they have been using fertilisers that have only short-term effects on increasing soil fertility. Using short-term contracts for renting land has prevented them from applying inputs with long-term benefits for the nutrient balance.	The prolonged negative effect of grain farming on the nutrient balance has changed in the recent years. The introduction of green payments, as well as the requirements for crop rotation and inclusion of protein crops have been acknowledged as having positive effect on nutrient balance.
Agri-environmental payments	**3.6**	They have positive effect on farm incomes. However, in some cases farmers find it hard to comply with the requirements.	The overall opinion suggests that using subsidies as a main instrument for supporting the sector is not good.
Diversity of production	**3.2**	It is considered as one of the strategies to overcome negative climate effects and simultaneously ensuring diversification of markets, respectively of the sources of income. Moreover, there are evidences for a beneficial crop rotation including certain varieties.	It is at relatively low level, mainly imposed by the requirement for greening payments under the CAP. There are plenty of possibilities that could be utilised in better optimization of the production, marketing and farm income.
Level of services in rural areas	**2.9**	The level of services is low. Access is inhibited by obsolete infrastructure.	Depopulation and aging affect the level of services and inhibit economies of scale.

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A number of characteristics of the system were examined in order to assess their relevance to enhancing resilience (Peneva and Valchovska, 2019). The most relevant for further investigation of the resilience of the farming system are presented in Table 2. These resilience attributes also depend on the availability and implementation of policy as well as the diversity of responses. The latter is related to strategies of risk management, like pest control, insurance for severe weather events, and flexible payments.

Table 2. Main resilience attributes and their presence in the farming system (Source: Peneva and Valchovska, 2019).

Main resilience attributes	Current level (score 1:5)	Current level (explanation)	Current development
Coupled with local and natural capital (production)	**3.3**	The organization of production and the established traditions are in line with the available soil and water resources. However, actions for the improvement of the existing natural resources are still required.	The main trends are towards increasing soil conservation. In addition, production capacity is developed towards adjustment to climate change through the existing regional characteristics.
Exposed to disturbances	**3.7**	Farmers manage to overcome the constantly occurring economic, social, environmental, and institutional disturbances.	Increasing the adaptability to environmental challenges remains a major issue for the farmers.
Socially self-organized	**3.0**	Farmers organize in networks and structures like associations and unions, but often informally. There is room for improvement of the connections among them and between them and other sectors or sub-sectors.	Farmers recognize the necessity for representation through producer organizations. Especially their capacity for common action on behalf of the farming community with respect to government institutions and public policy development.
Infrastructure for innovation	**3.0**	Farmers know of the existing infrastructure, but this does not facilitate acquisition of new knowledge and adoption of new technologies.	There are well-developed contacts with producers of seeds and chemical. Farmers often invest time and resources by initiating participation in research and experiments aiming to adapt plant varieties or breeds and technologies to the local conditions.

Main challenges for the farming systems that emerged through the analysis of the discussion from the FoPIA-SURE-Farm 1 workshop (Peneva and Valchovska, 2019) are:

- Price fluctuations;
- Climate changes;
- Legislation changes; and
- Labor force (demographic changes).

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1.2 Participation in the workshop

The workshop took place on 16 January 2020 in the city of Dobrich in North-East Bulgaria. It was organized as previous with the assistance of the local directorate of the Ministry of Agriculture, Food and Forestry (MAFF) and the Agriculture Advisory Service. A total of 24 participants were initially invited. A total of 19 participants attended the workshop. The participants included: representatives of the agriculture advisory service (3); representatives of the regional directorate of the MAFF (3); and representatives from the offices of the MAFF at the municipal level (2). Other participants included farmers (8) and representatives of processor (1) as well as consultancy (2).

The proposed main indicators, resilience attributes and challenges as presented in Section 1.1.1. were agreed among the participants. But there were questions about the procedure of developing and evaluation which led to some personal opinions about different levels of estimation. One of the main issues which participants discussed was the agri-environmental payments and the future changes. Most of them agree that they would not like to comment on that since the next planning period everything will be different. Moreover, the farmers' satisfaction of them was rated lower compared to the given assessment. Therefore, in the course of workshop we did not stress on agri-environmental payments.

2 Results

The overview of results is organized in four sub-sections. The first examines to what extent resilience indicators, attributes and challenges can change before the system has to change to a new state. Secondly, the trespassing of critical threshold by the same variables is examined in relation to system decline. The third section presents desired alternative systems, while the fourth investigates possible strategies to achieve the alternative systems.

2.1 Maintaining the status-quo

Workshop participants contributed in identifying the minimum or maximum values of indicators and challenges that would lead to system decline. As a group, they were not united around any level of indicator or challenge. Very few estimations received support by two or more participants. Furthermore, some levels variated by more than twice in size. This overview is focused on the dominating opinion where available. Some numbers were supported not only by the information written on notes, but also by the ongoing discussion, as well as discussions during other parts of the workshop.

2.1.1 Indicators

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Productivity

The boundary condition for this indicator was measured by determining under what level of output the system would go into a decline. Most participants considered the output of wheat. The most supported opinion throughout the workshop was that under 2 t/ha the farming system would go into a decline. This is a quite low output that can be expected during years with severe weather conditions.

One participant considered 4 t/ha to be the threshold level for system decline. It should be noted that such yield may be considered normal if obtained from fields with less fertile soil or by farmers who apply smaller quantities of fertilizers. Another participant had pointed out 5 t/ha. However, this yield is close to the average yield for the country that is considered very good at the level of 5.3 t/ha (MAFF, 2019).

A decrease in productivity in relative terms was also noted down. One participant has summarized several indicators and challenges, including yields, as reaching a threshold level if they decreased by 20%-25%. Another participant has also stated that 20% decrease in productivity was a threshold for the indicator.

Net farm income

The discussion and written information on this indicator were mainly focused on gross rather than net income. This seemed closer to the way participants thought about farm income than calculating a net value. At least one participant mentioned early in the workshop that they would not like to discuss how much they earn. This may have been an additional reason for participants to divert the discussion in the direction of farm revenue.

Less than 1000 euros/ha revenue form cereals was the most often occurring number. This income was justified by a detailed calculation by one participant where the 1000 euros covered the costs of production (600 euros) and land rent (400 euros) while the farmer retained the single area payment subsidy as income. It should be noted that the mentioned level of cost per hectare would include only the seeds, fertilizers, and land cultivations.

Some farmers from other sectors determined the boundary condition from the perspective of their main output. A lavender farmer pointed out threshold level of 2500 euros/ha annual gross income. This is a realistic estimation considering the much higher costs of that production in comparison to cereals.

There was also an opinion that less than 1000 euros net income per month for the whole farm (usually participants talked about the farm family and farm household) was a threshold. This statement is hard to interpret without further information. The same participant has noted that

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the net income should be a positive amount. Another participant was more specific, by pointing out that the minimum net farm income should be 700-800 euros per farm household member per month. If it is recalculated net income per hectare, approximately it is 40-50 euros.

Nutrient balance

According to one grain farmer, the level of humus in the soil was already as low as 1.2-1.4% (without presenting any reliable source of information to be checked, it is based on personal assessment and in discussion we take it very cautiously) and arable agriculture was the main reason for that. Judging by the rate of reduction of humus during the twentieth century, they said that after 30 years more of arable farming the soil will be destroyed.

Notes of participants showed opinions that humus content in the soil of less than 1% was a threshold. Another participant has pointed out nutrient balance of less than 4% humus content. During the discussion, there were statements that famers currently apply a minimum of 800 kg of fertilizers per hectare as the preliminary quantity is from artificial fertilizers and very limited organic (manure). Some of them had previously included protein crops in the crop rotation. However, this was because of the favorable market price rather than their role in contributing to the nutrient balance in soil. At present, they considered the protein crops, like chickpeas, as unlikely choice due to recent fall in market prices.

Diversity of production

This indicator was mostly assessed through qualitative categories. One participant pointed out the necessity for vertical integration of production. Another participant argued the need for increasing the value added at the farm level.

Participants also discussed that the diversity in grain farming was already quite limited as the main crops were cereals, maize, and sunflower. However, one participant pointed out that some farmers diversified their crops and gave example with the cultivation of lavender that has not been typical for the region until recently. Land under lavender cultivation has increased substantially in the North-East in recent years (InteliAgro, 2018). As a result, currently 58% of the national area under lavender cultivation is situated in the case study region.

Level of services in rural areas

This indicator has received relatively small attention from workshop participants. None noted down any estimation for this attribute. Despite during the discussions later, all of them mentioned life conditions as an obligatory condition which influences people's choice to stay and work in farming.

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2.1.2 Resilience attributes

Coupled with local and natural capital (production)

During the workshop, this challenge was not addressed by the participants directly. In general, the overall impression we have from the region, locals (either experts in governance structures or farmers) accept the region as a leading in agricultural production in the country. They do not have doubts about the overall excellent production conditions for the main sub-sector of grain production.

Exposed to disturbances

This challenge did not receive any estimation through the stick notes. The discussion revealed that in case of change in profit tax of up to 100% the farmers will still be able to operate (currently the tax either for physical person and legal entity is 10%). They stressed that what was important was for revenues to exceed costs. The possibility for introduction of land tax was tolerable. Participants pointed out that 5 euros/ha was acceptable. However, a tax of 50 euros/ha would be a boundary condition for the system.

Socially self-organized

Participants demonstrated that they were informed on farmer participation in various organizations. They had noticed that the organizations tended to consolidate in time, i.e. some smaller associations have joined larger ones. Larger organizations lobbied more successfully in favor of their members. However, if the existing organizations broke down, participants did not expect the system to decline. They believed that all farmers would manage to continue their businesses as usual.

In addition, participants considered the current level of co-operation between farmers as insufficient. One participant noted down that larger numbers of formal producer groups should be established. Furthermore, they wrote that there should be organized special meetings between farmers for setting up formal groups.

Infrastructure for innovations

This challenge did not receive any estimation through the stick notes. It also was not subject to discussion at that point of the workshop. At a later stage 'infrastructure for innovations' became subject of extensive discussion. It suggested that the attribute has a role as a boundary condition. Furthermore, it was mentioned that current connections of farmers with the institutions developing innovations were weak.

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2.1.3 Challenges

Price fluctuations

Output prices falling by 20% from the current levels was an opinion supported by several participants. One of them qualified this estimation as a small fluctuation, while another gave a range of 10-20% for the prices as a threshold. Larger price fluctuations were also assumed. Two participants have pointed out that prices falling by 50% from the current levels would be the boundary condition for system decline.

One participant chose to point out a specific price of 100 euros/t of wheat as a boundary condition for the challenge which does not correspond to the relative assessments given by the others – it is a higher decrease of almost 40% decline. While the price of wheat has been mostly on the rise during recent years, the price of lavender oil has seen a substantial dip due to overproduction (InteliAgro, 2018). Prices falling below 25 euros/kg of lavender oil have been pointed out by a lavender farmer as a threshold.

During the discussion a grain farmer expressed an opinion that the price of cereals, and especially wheat, is never going to fall to a critical level for the system. They supported their statement by arguments that the population at world level is constantly rising and the market is global. In addition, they pointed out that competitors from other wheat producing countries could hardly offer the product at a price that is below the costs of the Bulgarian producers.

Climate changes

Drought was the most notable climatic event among the participants at the workshop. It was already an issue for the current winter. Previous experiences of drought were also quite fresh in their memories. There was a widespread agreement that drought affecting the quantity of output can make grain farmers go out of business. However, participants differed in their estimations of the severity of the effects.

According to one participant, drought for more than one year in a row was enough to send the system into a decline. Another participant suggested that drought for two out of five consecutive years. A third participant pointed that drought for five consecutive years was the critical threshold for the challenge. Other participants pointed out ‘drought’ as an event without assigning it any quantitative measurement. Lack of snow and rain was also present as an opinion. Two participants suggested rain of less than 1200 liter/ha and 1500 liter/ha, respectively which is difficult to interpret since it is their personal observations and the measurement is not clear.

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Some participants chose to measure climatic conditions in relative terms. One estimated that 20-25% worsening of the climate conditions was the critical threshold for the challenge without specifying any indicators. Another participant considered 40% worsening in the climatic conditions as a boundary condition. They specified that it applied to rainfall. Other measurements for climate changes included increase in temperatures by 3-4 degrees Celsius suggested by one of the participants. One participant also noted that a change in the seasons, where the four distinct seasons blend into each other, would be a critical threshold for the farming system.

Legislation changes

Increase in administrative burden was pointed out as a threshold without a specific number attached to it. Another participant wrote that introduction of restrictions would be a threshold for decline without detailing what they meant. A legal limit on the area of farmed land was also discussed as a possible legislative restriction. However, participants suggested that it would not make sense to use political measures to restrict farm growth. They found the restriction of subsidies to certain farm size more acceptable.

One participant pointed out that a cap on subsidies in favor of small-scale farms would be a critical threshold for the farming system. However, they agreed that a limit on the size of farms supported by subsidies was necessary. Subsidies were also mentioned in the discussion. Some participants held opinions that the subsidies should be removed as a form of support to farmers. On the other hand, others defended a position that subsidies were necessary, and they had to be diversified to provide more targeted support to different types of farmers.

Labor force (demographic changes)

Quantity and quality of labor force decreasing by 20% was pointed out by two of the participants. Another participant noted 30% decrease in the available work force as a boundary condition. A fourth participant chose to consider the population as a whole rather than the labor force specifically. They pointed out that the total population falling below 3 million people would be a boundary condition for the challenge.

One participant representing the National Agricultural Advisory Service pointed out in the discussion that farmers should not experience lack of qualified employees in the area as a challenge. Their solution was to create large families and engage their own children in farming as it has been traditionally done in the past.

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2.2 System decline

Performance of indicators and resilience attributes was examined in a small-group discussion. Each group of participants focused on the impact of one challenge on indicators and attributes when critical thresholds were exceeded.

2.2.1 Price fluctuations

Price fluctuations were considered in terms of falling output prices that would have negative effect on the farming system and could lead to its collapse. Prices falling beyond critical thresholds were expected to affect all indicators and attributes on the list. The respondents commented that 'productivity' as measured in quantity of output per unit of land was expected to increase. In that situation, farmers would try to compensate for the falling prices by increasing output. They would use more fertilizers and chemicals as well as varieties that provide higher productivity. However, respondents also commented that farmers are trying to produce more anyway, because this would increase their revenues. So, the possibility to increase production because of falling prices would be limited. On the other hand, respondents also commented that constantly falling prices would lead to the farmers reducing their activities by reducing their costs. This suggests a negative impact on productivity. To some extent, it contradicts the logic of aiming to increase productivity. However, the two reactions may depend on the duration of impact of the falling prices.

The impact on 'net farm income' would be negative as it is directly related with the prices of outputs. 'Nutrient balance' in the soil will also be affected negatively. Respondents related that with the increase in productivity. Falling prices can be expected to increase the 'diversity of production'. Respondents commented that grain farmers would consider alternative crops that bring higher revenues if the price of grain falls. They gave an example with lavender. Farmers have been attracted to undertake the new (for them) production because of the substantially higher revenues per hectare. The connection was weakly rather than strongly positive as, according to the respondents, farmers would not stop producing grain completely. Even in view of falling prices, there will always be demand for bread, and wheat respectively.

The 'level of services in rural areas' will be affected negatively by falling output prices. Respondents related this indicator with the incomes of farmers. If the incomes of farmers start falling, the level of services will be falling as well. As a result of falling market prices, the production would also become less 'coupled with local and natural capital'. With more pressure to produce in order to compensate for the falling prices, farmers can be expected to contribute to the depletion of organic matter and increase the use of fertilizers. One farmer commented that there was hardly any opportunity for that already, but they would try to do it anyway. Respondents commented that the effect will be similar to that on the nutrient balance.

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Respondents saw falling output prices as a factor that would constrain farmers' ability to 'respond to disturbances'. If the challenge is combined with disturbances like reduced subsidies or increased profit tax, this will have a strong negative effect on grain farmers. On the other hand, the challenge will have a positive effect on 'social self-organization'. It can be expected to encourage farmers to seek formal or informal co-operation for the benefit of their production. In addition, there is a strong positive effect on farmers' interest towards the 'infrastructure for innovation'. If output prices fall drastically, farmers would be encouraged to look for something new to them that will help them increase their revenues. In this sense, they would approach the organizations that provide innovations.

The discussion also involved some of the challenges that were in the focus of the other groups, like the possible decrease in subsidies or the persistent draught. Respondents highlighted them as more probable to occur than falling output prices. Increasing land rents emerged as a challenge at the end of the discussion. The falling output prices affect them negatively as farmers' ability to pay rent decrease with falling revenues.

2.2.2 Climate changes

The second most important challenge for the farming system in the region, according to the participants in the workshop, was climate change. The corresponding thresholds, beyond which the system would have to change, were defined as drought lasting 3 to 5 years.

The discussion group consisted of four participants and one moderator, discussing the effects of drought on the indicators of functions and on the resilience attributes of the farming system. The participants agreed that although there has been less snow in the region in the recent years, the current climate conditions are still favorable for cereal production, provided that the farmers take good care of their land and duly perform the necessary processing and treatments.

Effects of the challenge on the indicators of functions:

Productivity (t/ha) - The relation between drought lasting 3-5 years and productivity is strongly negative. The longer the drought lasts, the more productivity reduces, regardless of the crop. Nevertheless, there are crops that perform better at dry climate, such as einkorn wheat, spelt and barley.

Net farm income - The participants agreed that the reduced yields caused by a longer dry period could have positive as well as negative effect on net farm income, which is why the relation was defined as neutral. The participants have observed situations, in which cereal crops have obtained lower yields but their selling prices have gotten higher (Usually this is the case when the weather conditions or anything else compromise the production of leading countries (price-makers) either

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in the region of Black see and/or Europe. Bulgaria is a price-taker on the World grain markets and this "discrepancy" is observed in last more than 20 years.); while in other cases, higher yields have brought lower prices, combined with higher costs for collection, transport, drying and processing. From their point of view, the highest net farm income is achieved when the yields are medium.

Nutritional balance (Soil quality) - Although most soil quality and fertility indicators do not depend on moisture (humus content, soil structure, humus horizon, acidity, etc.), rain and soil moisture are crucial for the cereal crops ripening and for the level of groundwater. Therefore, the drought challenge is moderately negatively correlated with soil quality. The participants indicated that a too high level of rain, however, would also have a negative impact on soil fertility, which could be even more severe than the one of drought, because it negatively impacts plant health and biodiversity.

Diversity of production - The participants indicated that a long-lasting dry climate with negative effect on crop productivity would most likely contribute to the introduction of more drought-resistant crop varieties in the region. Possible alternatives include einkorn wheat, spelt and barley among others. The diversity of crops with different profile would also reduce the risks associated with external production factors such as temperature, precipitation, etc. The relation between drought and diversity of production is defined as strongly positive.

Level of services in rural areas - The level of services in rural areas does not seem to be impacted by drought, according to the participants. They explained that regardless of the yield levels, rents do not change much. The prices for other services in agriculture, such as machine processing, do not depend on yields either. This is why they evaluated the effect of drought on level of services in rural areas as neutral.

Effects of the challenge on the resilience attributes:

Coupled with local and natural capital (production) - The participants did not find perceivable negative or positive effects of drought on coupled with local and natural capital (production), which is why they defined the relation as neutral. They gave an example related to sunflower production in a dry year. Due to the drought, they had saved some land processing and fertilization treatments, which resulted in a cleaner and almost organic sunflower production with less pollution on the environment.

Exposed to disturbances - The participants did not determine a specific direction of change in the response diversity caused by severe drought, which is why the effect was defined as neutral. However, they noted that in case of other unexpected challenges, the elaboration of an action plan could be beneficial for coping with the unforeseen critical situation.

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Social self-organization - There is a positive effect of drought on the social connections and collaborations with actors outside the farming system; however, the participants indicated that the severity of the problem should be very high in order for the people in the region to decide to devote combined efforts for coping with the difficult situation.

Infrastructure for innovation - The participants considered the effect of drought on the infrastructure for innovation as moderately positive. They think that the local Dobrudzha Agricultural Institute in the town of General Toshevo, along with other institutions, could be a source of useful and accessible information (for knowledge and skills), especially for farmers with less agricultural experience. However, the participants indicated that the interaction and collaboration with the local agricultural institute has been somehow broken and the institute experts are distant from farmers' reality. Nevertheless, such institutes could support farmers in the case of severe drought with advice on innovative technologies, drought-resistant crop varieties, varieties that are more appropriate for the local conditions or varieties that obtain higher yields. Although trust in the local innovation institutions does not seem to be high, innovations are considered as a very important tool to support farmers in the challenge of climate change in the region.

2.2.3 Legislation changes

Last but not least legislation challenges were discussed in a separate small group of 5 participants. On the first place it was clarified which of legislation changes have the more direct effect. Several elements were mentioned: the land relationship legislation, the requirements for good agricultural and ecological practices, level of subsidies (including different constraints in regard to farm size and overall level of subsidies in at farm level) and taxes etc. Later, the most important relations are discussed as legislation changes influence directly the following indicators related to functions: productivity (e.g. ton/ha), net farm income, diversity of production and related to attributes: coupled with local and natural capital (production), socially self-organized and infrastructure for innovation.

Productivity could be influenced positively even when some restrictions are imposed, e.g. lower level of subsidies. It requires optimization of the production costs (through better combination of production activities, technologies etc.) and one of the participants argue that without subsidies farmers will be more effective and will seek for better solutions to increase farm productivity. In this relation legislative changes may ensure construction and maintenance of the irrigation system which does not exist at the moment. It will have very positive effect on the productivity indicator. In this case two more indicators (as intermediaries between the challenges and indicator productivity), namely cost optimization and level of irrigation.

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Net farm income will be negatively affected by abolishment of the system of subsidies as it is now. But at the same time such a change will change the levels of land price and rent/lease which may result in increase of the farm income. Finally, the effect could be neutral depending of the combination of changes into legislation.

The diversity of production will not be changed in general, even if the subsidy system is changed some farmers could be more effective in crop combination in rotation. Some of them currently just follow the requirements in order to satisfy conditions to receive subsidy.

The effect on the coupled with local and natural capital (production) is both positive and negative. Changes into land relationships legislation may impose positive effect since now the short-term contracts somehow limit farmers' investments and planning in long-term period. If through the legislation long-term contracts with an effects on the owner responsibility (e.g. currently the farmer is responsible for the land management and preservation and the owner has no obligation in that sense. But they have the possibility to rent their land every year to different farmer and in this case the responsibility of the long-term effects is mixed and vague) are introduced, farmers will have better opportunities to develop their farms following local conditions and simultaneously current changes in weather and climate.

The positive effect is expected into socially self-organized indicator if and when there are legislation changes. Usually, this is the case when farmers are very interested to be represented by a non-governmental institution with strong positions and the capacity to negotiate with law-makers and to carry resolutions in favor to farmers. One of crucial changes which will effect positively farmers' cooperation is abolishment of the current subsidy system. Currently, farmers are much more competitors in land acquisition having in mind its limited amount and the stimulus of getting more to receive more subsidies. In any other case farmers should act much more collectively to overcome all the challenges which production system experience.

The only relationship in regard to the infrastructure for innovation is seen in legislation changes which will better re-connect farmers with science and education institutions. Without excellent relationships between two sides, it is not possible to overcome current challenges, said one of the farmers. He very much misses the expert advice and scientific point of view when need to make decision in regard to the production, changes into varieties, technical solutions, technological improvements etc. Currently, he acts in the principle of trial-and-error which costed him a lot. Opposite if the infrastructure is developed the innovation process will run more smoothly and the experiments in a controlled environment will facilitate adaptation of any innovation to the local specificities and each farmers' preferences. The participants see this changes into legislation in development of a common projects, seminars and opening scientific and educational institutions

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to operate on the market of services and providing experiments offering technical and technological solutions, common educational programs, scholarship programs etc.

2.2.4 Labor force (demographic changes)

Reduction in the quantity and quality of available labor force would have a negative effect on 'productivity' in two ways. First, farmers may not be able to meet their labor needs with available labor force and this may delay some necessary cultivations or other works that would result in worsened productivity. Secondly, reduced quality of labor force would have negative effect on the quality of work on the farm and respectively on productivity, i.e. less experienced machine operator will implement cultivations with lower quality.

It would also reduce 'net farm income', which is influenced in a similar way as productivity. However, the relationship with 'nutrient balance' is neutral. Furthermore, if increasing 'diversity of production' by adding a new crop requires additional labor, the effect of this challenge would be negative. I.e. reduction in available labor would not facilitate diversification that requires additional or specialized labor.

If this challenge surpasses the threshold level, the effect on the 'level of services in the area' would be negative. The reduction in available labor is predominantly associated with depopulation of the area, rather than with increased economic opportunities in other sectors. Overall reduction of the population would make many services in the area less viable and subject to discontinuation.

Labor would have neither positive nor negative connection with the indicator representing 'coupled with local and natural capital'. Furthermore, it would influence negatively the capacity of farms to 'react to disturbances'. Labor shortage would create operational issues for the existing organization of production and any disturbances can be expected to add to that. On the other hand, reduction of labor availability can also be expected to have neutral connection with 'social self-organization'.

The threshold level of this challenge would have positive effect on farmers' interactions with the 'infrastructure for innovations'. Depending on the type of crop and current technological level, farmers may seek different technological solutions that will help them overcome the need for labor.

2.3 Alternative systems

Participants were asked to note down three alternative states they envisaged before a system decline will happen. These were summarized by researchers in groups during the workshop. The

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emerging alternative systems were discussed with the participants to verify that they have been captured correctly and reveal their characteristics. As a next stage, participants discussed which boundary conditions had to be realized for the alternative state to happen. They also discussed the actions that were necessary to implement and the approach that could be taken for achieving certain alternative state. This allowed identification of strategies.

Table 3. Perceived performance of indicators and resilience attributes for current and future systems. Impact of boundary conditions. Explanation of signs: → 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.

		Future systems							
Indicator	**Current level**	**Status quo**	**System decline**	**Innovation and technology improvement**	**Processing and increasing value added**	**Crop diversification**	**Exit farming / change of sector**	**Collaboration**	**Moving the farm to a different region**
Productivity (t/ha)	high to moderate	↗	↗|↓	↗	→	→	↓	→	→
Net farm income	moderate to low	↘	↓	↗	↗	↗	↓	↗	↗
Nutrient balance	low	↘	↓	↗|→	→	↗	→	→	→
Diversity of production	low	→	↗	↗	↑	↑	→	→	→
Level of services in rural areas	low	→	↓	→	↗	→	→	→	↓
Coupled with local and natural capital (production)	moderate	→	↓	↗	→	↗	→	↗	→
Exposed to disturbances	moderate	→	↗	↗	↗	↗	→	↗	→
Social self-organisation	low	→	↗	→	→	→	↓	↑	→
Infrastructure for innovation	low	→	↑	↑	↗	↗	→|↗	→	→
Boundary conditions									
AGRONOMIC									
Satisfactory level of productivity		**V**		V	V	V			V
ECONOMIC									
Satisfactory level of income		**V**		V	V	V	V	V	V

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		Future systems							
Indicator	**Current level**	**Status quo**	**System decline**	**Innovation and technology improvement**	**Processing and increasing value added**	**Crop diversification**	**Exit farming / change of sector**	**Collaboration**	**Moving the farm to a different region**
Diversity of production				V	V	**V**			
Gaining market share					**V**				
ENVIRONMENTAL									
Exposed to disturbances		**V**		V	V	V	V	V	V
Coupled with local and natural capital (production)				V		V			V
INSTITUTIONAL									
Public policy		**V**		**V**	**V**	V	V	V	V
Public policy - favouring national production				V	**V**	**V**			
Legislation – land tenure regulation		**V**		**V**	**V**	V		V	
Administrative requirements		V			**V**			**V**	
Access to know how				**V**	V	V	V		
Access to finance				V	**V**				
SOCIAL									
Labour availability		V			**V**				
Acquisition of new knowledge		V		V	**V**	**V**	V		
Access to innovation ideas		V		**V**	V	**V**			
Social self-organisation				V				**V**	

2.3.1 Innovation and technology improvement

This alternative state encompasses various dimensions of change in the employed technology. Three participants had pointed out the more general 'adoption of innovations' as an alternative solution to system decline. On the other hand, two participants have been more specific by suggesting the adoption of new technology that leads to cost reductions as an alternative.

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Another two participants have pointed out change in technology, and change in tilling technology, respectively simultaneously preserving soil quality and satisfactory level of productivity. Further prompts revealed that participants meant innovations in terms of technology, as well as crops, fertilizers, and chemicals.

Given the extensive focus on adoption of advanced technologies, participants were asked if they considered precision agriculture among the alternatives. It turned out that some of them were not aware of the term and needed further explanation. After being given more detail, participants agreed that precision agriculture was an alternative. Similarly, they agreed that no till technologies were among the alternatives in overcoming future pressures for change. Some of these technologies still need to be adapted to the local conditions and natural capital which is part of the grain farming system resilience.

The discussion of the alternative state revealed that participants, representing advisory services, considered the 'infrastructure for innovations' as a weak point for achieving this alternative state. They pointed out that the connection between farmers and the institutions developing innovations was relatively weak. It was revealed that there was lack of communication between the institutions and the farmers regarding ongoing innovation efforts. The farmers had no way to find out what were the current research activities of the institutions, because the latter did not announce them publicly in any suitable way. The institutions also did not tend to announce the results from their research work. This hindered the spread of the innovations among the farmers. But such a future system will strongly influence positive development in the infrastructure for innovation (Table 3).

Respectively, innovation took place at the farm level and was mostly driven by the farmer. Examples included when the farmer was purchasing more advanced machines or started using new varieties. In addition, there was low preparedness of the farmers to adopt and implement the innovations resulting from the work of the institutions. Participants also identified low level of trust of the farmers towards the research institutions. The latter were more inclined to trust their own experience resulting from trials and errors. Participating farmers argued that this experience was also more closely related to the specific characteristics of the farm than work done by research organizations. The findings of the research institutions could not be easily related to the specific farm, which made them harder to utilize.

Another obstacle to the adoption of innovations was the lack of successful examples. A grain farmer pointed out that they would not like to be the first to try out how and if some innovation worked in practice. The farmer would feel more confident if other farmers had already tried and

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demonstrated that the innovation worked well. Thus, the farmers' network is of crucial importance to acquire new knowledge and to have access to new ideas.

This alternative state involves investment as well as adjustment of the organization to accommodate the new elements of technology and innovation. Thus the relevant financing is of crucial importance and proper access to it is of main conditions which should be ensured. The main strategies for achieving this alternative state are knowledge acquisition and business planning. The later may not be at the level of the whole farm, but only in relation to the new elements. But it is expected that the positive change into productivity and net farm income and higher preparedness to disturbances (Table 3) would balance the investment price.

2.3.2 Processing and increasing value added

Two participants proposed this alternative state. A discussion with all participants confirmed it as an opportunity for farmers from the region. A grain farmer representing a diversified farm business involving trade in addition to grain production, mentioned it as an alternative of increasing value added through processing of output. He pointed out the wider positive effects on the local economy in terms of upstream and downstream economic linkages and transactions. Another participant had a more general view for 'increasing of processing'.

During the discussion, participants revealed that they related processing with the current outputs from the system into food products for the end consumer. When prompted with the perspective for biofuel production, participants agreed that it was an alternative. They also pointed out that their main outputs, like maize, were among the inputs in the production of biofuels. Participants were aware of existing practices internationally as well as in Bulgaria. However, they considered biofuel production as an alternative market for their outputs rather than as an alternative business that they could initiate. For farmers the importance of preservation of income level is of high importance.

The participants also pointed out that the processing needed to be related with a market-driven identification of appropriate new product. I.e. it had to consider the needs of consumers to ensure that there was demand for the processed products. They were aware that by undertaking such step, they would face different, and maybe, fiercer competition than within their current activities. Some participants expected legislation changes that would give Bulgarian products an advantage over imported analogues. They also discussed the need for more targeted policy efforts for strengthening the image of Bulgarian products among consumers in the country. Consumer trust in nationally produced food was eroded by the low quality offered by already existing producers.

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This alternative state can be achieved through a strategy involving entrepreneurship and business development. It requires additional efforts in order to run a processing facilities, e.g. new knowledge about legislation in the food industry and new know how of marketing activities. Specific administrative requirements needed to be fulfilled and integrated into the farm processes. But for sure it would improve market performance and the market share of the single farmer. Additionally, access to financing is of crucial importance either through different operational programs and/or rural development program and/or bank and other credit institutions. In some cases, cooperation was considered such as farmers' organizations where processing facilities could be utilized better and the risk to be shared.

2.3.3 Crop diversification

Two participants pointed out crop diversification without giving further detail. One participant specified that diversification towards crops and varieties that are more suitable for a drier climate were a possible future state. There was wide agreement from the rest of the participants on the prospective for such alternative state. It will in conformity with the local conditions and the state of natural capital (Table 3). Thus, the changes follow the changes in the environment and are inevitable. Simultaneously, it is related to the innovations and farmers' access to them as well as to their openness and readiness to be innovative.

When prompted to consider growing of new crops, the participating farmers identified several areas where the alternative would require innovation in their practices. These included: use of new machines due to differences in tilling practices required by the new crops; and acquisition of new knowledge that would help them grow the new crops.

The main issue that the participating farmers saw with the adoption of new crops was the initial planning for the new production. As they had no prior experience with the crop, it was unfamiliar, and they could not anticipate all relevant issues that could arise. Thus, planning of the production of the new crop could be inaccurate.

They also recognized access to finance as a possible issue for implementing crop diversification, especially if the latter required some investment. There were two main ways for access to finance – own finance and bank loans. One participant also mentioned the public policy opportunities for accessing funding. The participants did not recognize any other (new) way of access to finance.

To some extent this alternative state overlaps with 'innovation and technology improvement', because new crops may require new machines and ways of tilling the land. Respectively, undertaking crop diversification also required strategies involving acquisition of new knowledge and adjustment of the organization.

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Thus, we can say that the first two alternative systems are complementary and may be should be considered as a future possible vision of farming system development in the region.

Other possibilities were discussed as well but farmers give them less attention and priority having in mind that there are possible solutions for the single farmer but not for the farming system in the region as a whole.

2.3.4 Exit farming / change of sector

Three of the workshop participants have proposed an alternative state that involves exit from farming and moving to a different sector of the economy without specifying which one. A different participant has suggested a change from farming to tourism by selling all farming assets and buying a hotel by the sea. The opinion of another participant was that emigration was a possible alternative state. All these options are more a change at farm level than at farming system level. But there are some rationales behind, e.g. preservation or even increase of the income level, different opportunities rising by the policies different than agricultural and rural development.

To some extent, this alternative state suggests that a new business will replace the main farming activity. In this respect, it is similar to the 'processing and increasing value added' discussed earlier. It implies new business undertaking and respectively, a strategy involving entrepreneurship and business development. Although productivity and farm income may go down, other main indicators of the system were expected to stay stable (Table 3). This future system as well suppose new knowledge and access to know how and higher level of risk acceptance by the respective actor.

2.3.5 Collaboration

Two participants have identified this alternative future state. One of them did not detail the idea for collaboration. The other had specified that the opportunity was for collaboration with another farmer for achieving lower production costs and utilizing the economies of scale.

The discussion revealed that participants were pessimistic about the prospective for collaboration. They shared a general perception that people (everyone in society) did not tend to take part in collaborative relationships for business purposes. This happened even when there were obvious benefits from collaboration, like opportunities to increase revenues by accessing a different market or achieving higher price of output. Some participants supported their words with examples from personal experience of trying to organize a collaborative initiative with other producers of similar output.

It is an important perspective in Bulgaria in general since the level of cooperation is very low and still is not fully utilized. Cooperation implies positive changes into both better coupling with local

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conditions and natural capital since farmers can better plan production structure and territorial allocation of it and higher capacity of the cooperated farmers to overcome together different disturbances either if it is weather conditions and/or market realization (Table 3).

2.3.6 Moving the farm to a different region

This solution was mentioned by one of the grain farmers who gave examples with farmers moving to the South East of the country. Other regions had lower competition for the farmland, which made access to land easier and at a lower price. In this alternative state, the farmer could continue doing the same, but in a different location. The rest of the participants agreed with the presence of likelihood for this future alternative state. This is also a change that starts at farm level for some farms in the region, which only affects the farming system as a whole moderately. It was expected that productivity would not further increase, income would moderately increase, nutrient balances would not become more negative (Table 3). The other main indicators were expected to stay the same in comparison to the status quo, except for the level of services, which was expected to go down strongly.

2.4 Strategies towards the future

According to the participants each one of the future systems is possible. Participants even indicated that some combinations of strategies are very likely to happen. This will depend on the climate conditions and the policy responses to different challenges in order to facilitate smooth adaptation and/or transition to new realities. Which new strategies will be applied is related to achieving a common vision about the future of the farming system in the region and the place and importance of grain production. The previously mentioned strategies (Peneva and Valchovska, 2019) are relevant as well. But always there are changes into the environment (economic, environmental and institutional mainly) which facilitates the implementation of the certain strategy, namely: increase of the farmed land as a strategy for growth, changes into production technologies and modernization as part of innovation and adaptations needed, or even transformation of the production system (e.g. planting lavender and producing lavender oil), preservation of the current marketing of the products (enriched by the possibility to shorten the value chain through processing) and application of good farming practices (obligatory in any time if the production capacity would be preserved or even improved). During the workshop it became clear that shared common vision may strengthen trust among actors involved (farmers and governance especially) and would facilitate cooperation among them in achieving it. It seems that working together and discussing different future systems when participants agreed upon certain element, each one of them is ready to contribute to this element.

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From the agronomical point of view, the strategy of changes in production technologies and modernization are compulsory in any of the foreseen systems (Table 4). It means that system even at its current status could not exist, e.g. the adaptability is the most probable way of grain farming system development. It has been explicitly pointed out by the participants when two of the future systems (Innovation and technology improvement and Crop diversification) were discussed.

Another very important strategy is related to the previous one and it is perceived from the ecological point of view, namely application of good farming practices as part of the necessity to preserve farming system ability to provide public goods, along with private goods, which is the current and future demand of the society (Table 4). During the discussion, participants expressed their concerns that this requirement is enforced, giving examples of the current policy implementation. But all of the participants were also convinced that without proper management of natural resources there is no future of any farming system. Even one of them said that it is in their favor and that the farmers' society is the most concerned with improved provision of public goods in order to continue the agricultural business.

The third strategy relevant to most of the future systems is stimulating succession and improved attractiveness of the sector (Table 4). Involvement of the next generation of farmers and farm employees is an element of most strategies for achieving alternative states because participants saw it as a way to build human capital with relevant knowledge base for the realities of farming in the region.

Of course, some strategies are more relevant to the future systems. Usually these are related to the current shortages in the system, e.g. soil quality, cooperation and information and knowledge sharing, and lack of cooperation with scientific and research institutions (Table 4).

The system resilience is based on the quality of natural resources and agronomic decisions which allow system existence and growth. Preservation of the soil quality may support the robustness of the farming system but it is also a precondition of proper implementation of adaptations of the system which are imposed by the need to overcome negative effects of climate changes. The policy support and introduction of insurances and their proper implementation impact the resilience of the system in the same way. One of the main strategies leading to adaptation and transformation of the system is the process of stimulation of succession and improved attractiveness of the sector. Actually, the new generation in most of the cases is recognized as a driver of innovations implementation and higher consciousness about environmental issues.

According to the participants' assessment the alternative system "Innovation and technology improvement" is the most desired as well as the most likely future system. It is important that the alternative system "Collaboration" is ranged (by the participants after the discussion of all of the

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possible alternatives) as a second most desired system, but as the least possible. During the workshop in different statements different arguments against cooperation were raised, e.g. lack of trust between farmers, high competition for land as a main sources of production, difficulties in planning of mechanized works under the weather uncertainties etc.

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Supplementary Materials C: FoPIA-SURE-Farm 2 Case Study Report Bulgaria

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**	**Innovation and technology improvement**	**Processing and increasing value added**	**Crop diversification**	**Exit farming / change of sector**	**Collaboration**	**Moving the farm to a different region**
Changes into production technologies and modernization	Agronomic	V	V	**V**	V	**V**		V	V
Diversification of crops	Agronomic	V		V		**V**			
Preservation of soil quality	Environmental			**V**	V	V			
Application of good farming practices	Environmental	V	V	V	V	V	V	V	V
Increase of the farmed land	Economic	**V**	**V**						
Preservation of the marketing of the products	Economic	V			**V**			**V**	
Introduction of insurances	Economic	V		V					
Marketing/production/processing cooperatives	Social				**V**			**V**	
Stimulating succession and improved attractiveness of the sector	Social	V	V	V	V		V		V
Better information exchange and field visits	Social			**V**	V	V		V	V
Policy support	Institutional	V		V	V			V	
Better cooperation with research institutions and universities	Institutional			**V**	V				

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3 Interpretation

3.1 Tipping points

The data overview suggests that changes of 20% in the current levels of indicators (productivity and net income) and challenges (price fluctuations) were enough to lead the system into a decline. This is a relatively small change for most of them.

The results on productivity show that the sensitivity of some farmers to yield reduction is higher than for others, which can be expected. Nevertheless, they allow suggesting that productivity could fall more than twice (i.e. from over 5 t/ha to only 2 t/ha) before it starts causing major changes to grain farming. Net farm income provides a clearer threshold for system decline. The indicator was discussed mostly in terms of revenue and many participants stated that revenue needed to be higher than production costs. This suggests that a net farm income of zero and below would be the tipping point. Nevertheless, the indicator also showed that farming is expected to provide an acceptable level of income that can maintain the farm household. That level depends on the type of production as well as presence of other income sources. Subsidies were especially mentioned as a source of income, explaining why production levels can deviate so much before a critical threshold is reached.

Resilience attributes did not receive quantitative evaluations. They were estimated, to a certain extent, in relative terms. 'Exposed to disturbances' and 'social self-organization' showed stronger role as boundary conditions in comparison to 'coupled with local and natural capital' and 'infrastructure for innovations'. Consecutive discussion of 'infrastructure for innovations' showed that farmers were not in much interaction with existing institutions that stimulate innovation. On the other hand, their approach to adopting innovations was self-initiated and related to social learning. Thus, a the lack of innovativeness at the system level could primarily be seen as the lack of an enabling boundary condition for change, and only secondly as a resilience attribute in itself.

Challenges had clear tipping points. 'Price fluctuations' were not perceived as a threat to grain farming as prices of grain maintained good levels in the recent years. However, other types of production had experienced price falls. This helped identifying a threshold price for grain as well at level of 20% of the current levels.

'Climate changes' were an ongoing challenge and measuring them in frequency of occurrence of weather events was more useful for discussion and interpretation than actual numbers for rainfall and temperatures. Some participants provided measures of rainfall that represented very low amounts and were not formally used in practice. This may be an indication of lack of detailed knowledge on the factor and probably the participants meant another measurement unit. The

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average annual rainfall in the country has not been less than 370 mm during the last thirty years (EEA, 2019). Typically, it has been above 500 mm on average for the country. In addition, in the North East region, the rainfall is less than in other parts of the country. If these amounts are calculated in liters per hectare, they represent much larger numbers than the numbers stated by participants. Most severe are the drought periods of time, especially in specific points of the process of crop growth.

There was a general agreement on the challenge posed by decreasing availability of labor force. However, farmers' needs differed both with respect to skilled and unskilled labor. Higher need was associated with stronger pressure from this challenge. Lack of prospective employees that could fill the labor needs on the farms was a recognizable possibility. In addition, the discussion revealed that future undertakings were hindered by considerations for limited availability of labor. Participants highlighted that allowing foreign workers to help certain sectors in the region was a solution.

3.2 Thresholds exceeded

Productivity received the highest score among all the indicators in regard to their importance (Peneva and Valchovska, 2019) which affects farm economic viability and usually it is related to the higher revenues. The food production of the farming system is important because North East Bulgaria has the highest share of grain and technical crops production in the country. Productivity is a result of natural resources (environment), yield capacity of the crop variety (genetics) and the crucial performance of weather conditions in the different stages of the crop growth (environment), and agricultural practices (management). The natural conditions are in favor of the farming system production structure (it could be said that they predetermine the initial choice which later is effected by the other challenges imposed by policy, demographic situation etc.). The key factor in this relation is climate change and how farmers can adapt to this. Next, the factor of labor availability is important, since all the operations needed to be performed timely and in case of negative weather conditions, these time periods are shortened and the labor intensity is very high. Thus, the productivity could be compromised in case of lack of workers for all the production processes to be performed on time.

The net farm income is also rated among the most important indicators of the farming system. The farm income level is predetermined both by the productivity and price levels. Thus, the income is indirectly influenced by the challenges facing the productivity. The second important is price volatilities. Grain farmers are very much influenced by world prices and there are cases when the low level of productivity led to higher level of net farm income due to the circumstances and level of productivity in the leading cereal producing countries as well as trade conditions on world stock exchanges. The legislation changes could affect the net farm income as well but at lower

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level, e.g. changes into taxation (increase of profit tax, introduction of land taxes etc.), land rent relation regulation etc.

From the resilience attributes, the highest presence has been given to the attribute "exposed to disturbances". It is very important for farmers to accumulate and maintain buffer resources to manage different disturbances in a constantly changing environment. The farming system responses could be in all of the three capacities of resilience – robustness, adaptability and transformability. Therefore, any exceedance of any of the challenges is crucial for farming system preservation/adaptation/transformability. Price fluctuations negatively affect directly the availability and accessibility of monetary resources to stabilize the system to ensure the same level of productivity. In the same direction is the impact of the inadequate level of labor sources. Legislation changes which deepen the negative processes include: less financial resources available for farmers, less protection against disastrous events, labor legislation resulting in too many requirements in hiring seasonal workers etc. And last but not least, the exceedance of weather conditions may impose the highest level of disturbances and they remain the major issue in regard of the farming system resilience.

The other two attributes – socially self-organized and infrastructure for innovation – are recognized as important but currently still at low levels. Improving their levels would primarily be beneficial for the farming system performance, i.e. they serve as boundary conditions, or even strategies. Secondly, they could also build further resilience capacities.

Taking into consideration the discussion during the workshop and the information gathered through other field studies and documentary analysis within the SURE-Farm project, some interacting thresholds are identified (Figure 1). Essential for the level of grains' productivity are weather conditions and in the case of North East Bulgaria drought is very relevant. At field level it reduces the yields, respectively the overall harvest at farm level. Having in mind that the irrigation system in the region is compromised, farmers do not have many buffers to overcome negative effects when productivity drops under the critical 20%. There is still the possibility that if the farm fields are spread on a territory large enough to have different weather conditions, farmer still may decrease the negative consequences. Following that farmer's net income decrease and if the overall net farm income decrease by 50% , the farmer will start to adapt or transform the farm. If the climate changes continue to deepen for a longer period of more than 5 years, it will result in farmer exit. Simultaneously, the farm sector attractiveness will decrease as well as willingness of new generation to continue running farm which at farming system level lead to decrease in farm population and rural population as well. Rural depopulation is a major factor in destroying different services' systems, e.g. school closure, temporary health services offered several days in a week, infrastructure deterioration etc. and usually these negative processes are managed by

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the institutions led by economical effectiveness. Inevitably, the grain farming system preservation at this level requires political measure and stimulus for innovations for adaptation and/or transformation. If it becomes impossible for the system to preserve its current levels, the level of uncultivated land will increase leading to loss of efficiency for the society as well as from ecological point of view the land quality may be compromised in a long-term period.

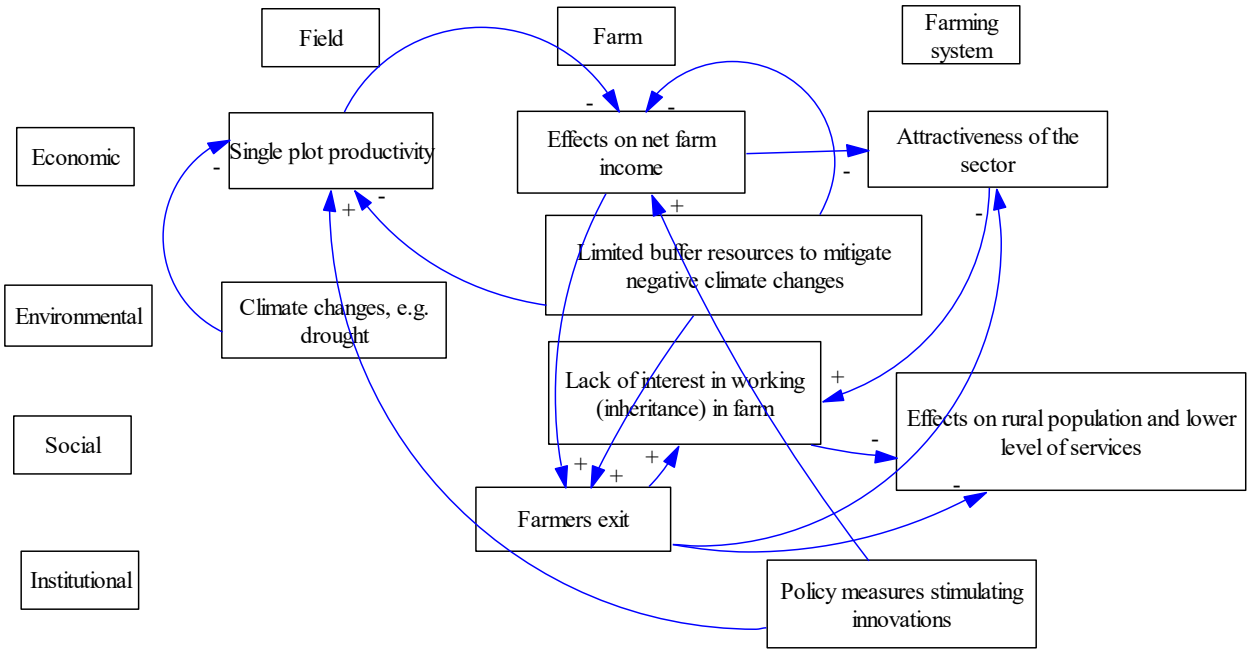

Figure 1. Interacting thresholds in the farming system in North East Bulgaria.

3.3 Alternative systems

The overview of the discussed alternative systems suggested that participants were in favor of farmers maintaining largely the same production by adding crops or machines. Radical changes were considered at an abstract level, but not translated in alternative systems (except the exit of farming sector, which would imply a system decline). The participants were aware of the possibility for farmers to implement change by entering different business or occupation, e.g. business in tourism, migration etc. They had an opinion on the different dimensions of these new undertakings which means that option has been considered and discussed. Furthermore, some of the participants showed detailed knowledge of business planning and helped identifying a

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number of additional boundary conditions that were relevant to the start-up of new activity (Table 3), e.g. running enterprise in processing industry.

Innovations at a general level were perceived as solutions to most of the worsening indicator levels and challenges. The diversity of possible developments encompassed by the adoption of innovation does not allow identifying one possible alternative system. Nevertheless, it suggests that the current farming system would change into a certain extent. Interaction with the innovation infrastructure represented by educational and research institutions was the most important strategy for this alternative state. While it was at a level that needs development, farmers suggested that their own, individual capacity for adoption of innovations could help them moving towards that alternative state.

Exiting farming by changing business sector, or a different occupation, or emigrating from the country for economic reasons was not a desirable alternative state. Participants were aware of such examples of colleagues switching to tourism. This was an easily identifiable alternative with the proximity of the seaside to the region. In addition, tourism was commonly identified as an employment alternative to agriculture. Emigration as an alternative may have been pointed out as an extreme solution. Nevertheless, examples were common as the reduced availability of labor was attributed to increased emigration from the region to countries with better economic opportunities.

The consideration of moving farming to a different region reveals a situation where the system would change but not by too much from the perspective of the farmers. This solution could let them produce the crops they already knew well in ways they were already knowledgeable of, but in a different area. Furthermore, they would be able to use the same agricultural machines in the new location. The alternative could help adaptation to reduced policy support or even reduced availability of labor at the regional level if other regions were not affected by similar trends. However, this alternative is not useful in case of factors that would affect the whole country, like climate change, for example.

3.4 Causal loop diagram

Several closed feedback loops are identified in the studied grain farming system in North East Bulgaria, as presented in Figure 2.

The most important **reinforcing feedback** loop is that after 2007 the EU CAP implementation granted farmers the possibility to receive subsidies at levels higher than before. Thus, the grain farming system in the region continues to grow (the beginning could be pointed at the beginning

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of this century when the restructuring process and land restitution ended and the process of private farms accelerated) utilizing the subsidies investing in new machineries, technologies (increased level of inputs, fertilizers and chemical substances) and varieties (highly productive hybrids, mainly imported varieties, not improved domestic varieties). Following that the productivity performance of the farming system has increased and yields rose at higher levels after the transformation at national level towards a market economy. And for 6-8 years (approx. until 2013) the yields became higher and comparable with those of the leading grain producer countries. Increased productivity forced farmers to look for better marketing of their production and the collaboration with trade companies has developed. During the workshop it was considered as disadvantage, that stimulated the power of the intermediaries and trade companies. Therefore, some of them (those which became large enough) started their own trade enterprises which increased their share in the price (the profitability) and allow them to continue to grow.

Simultaneously, the competition in agricultural sector increased, mainly for acquisition of land. This process characterizes the important balancing feedback loop when the access to land as a production factor is limited and recently it is even depleted (it is zero-sum situation because one farmer can increase their cultivated land only at the size equivalent to another farm decrease, so the net change in cultivated land is zero). During the workshop it was clarified that the business as it is after the introduction of subsidies has become more attractive as new farms were set up and the existing ones increased their size. The limited amount of land alongside with the development of monoculture production structure which led to soil exhaustion affect the system negatively. Both process limited the speed of growth and it is obvious that the biophysical characteristics and natural resources capacities limited further development only through traditional pathways of economic growth.

Therefore, many farmers started to implement new strategies introducing innovation both in production technologies and crop varieties. This process is speed up by the policy measures directed to nature protection and natural resources preservation, CAP greening measures forced farmers to introduce protein crops, and to have ecologically focused areas in their farms. Thus, the second reinforcing feedback loop is identified. During the workshop farmers confirmed that these trends are accelerating and many of them started to change the production system in their farm (which influence the whole farming system in the region) because it is part of their long-term strategy for development. They realize that their income (despite it is very much influenced by the price volatility) in the long-term is in positive relation with the preservation and increase of the soil quality as well as adaptations which make the overall system more resilient. Moreover, these changes are reinforced by the negative consequences from the climate changes and different strategies to mitigate the negative effects on the net farm income.

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The reinforcing feedback loops led and lead the system in positive direction of development. The factors and actions undertaken by the actors characterizing these loops contribute in different ways to the system productivity, respectively net farm income and economic viability of the system as a whole. The stochastic processes which bring uncertainty in the system are related to the price volatility and extreme weather events. There are very limited options (as have been discussed in previous sections) for farmers to limit the negative consequences of these stochastic events.

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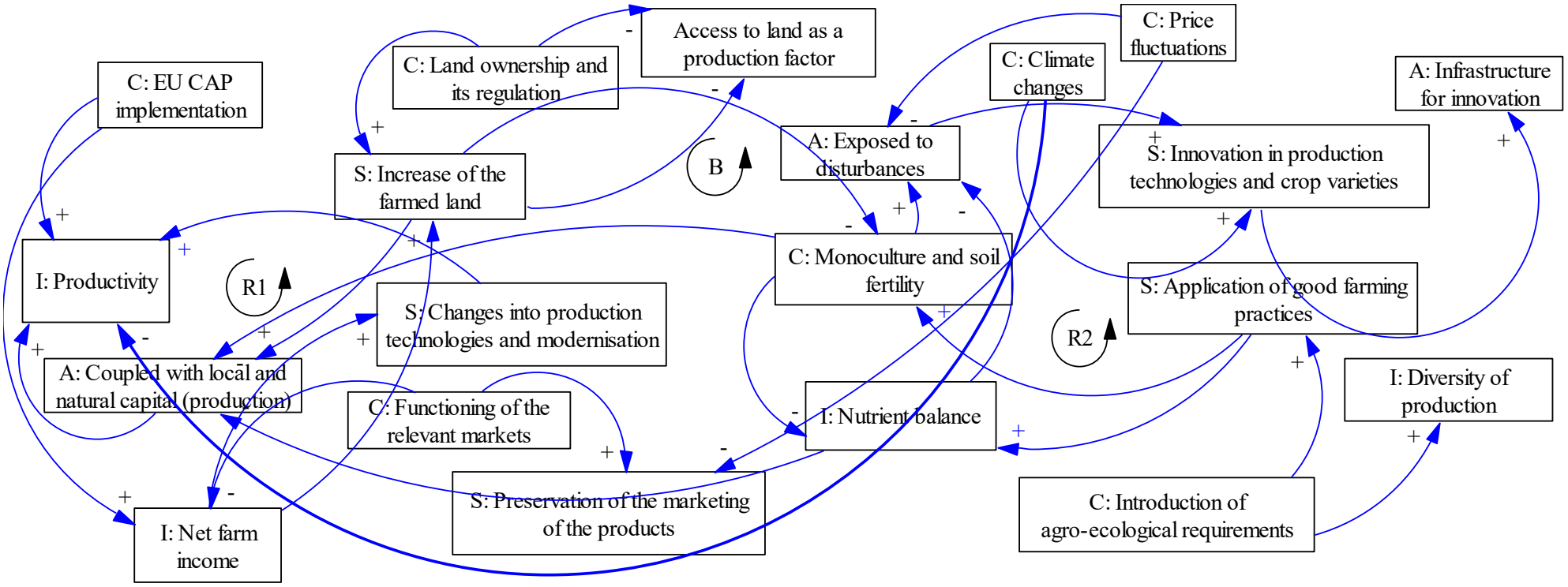

Figure 2. Causal loop diagram of the farming system in the North East Bulgaria. A + implies a positive cause-effect relationship and a - implies a negative cause-effect relationship. B stands for a balancing feedback loop and R stands for a reinforcing feedback loop. I indicates an important system indicator 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.

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Supplementary Materials C: FoPIA-SURE-Farm 2 Case Study Report Bulgaria

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3.5 Linking alternative systems to scenarios

The assessment is performed only for the four of the six mentioned alternative systems, which were chosen as most possible to happen and simultaneously represent faring system resilience: “Innovation and technology improvement”, “Processing and increasing value added”, “Crop diversification”, “Collaboration”. Maintaining the status quo in the future depends on stopping climate changes (which is out of the opportunities only by one farming system) and preservation of the soil quality as well as the level of price volatility since farming system could not influence the world market and prices. Therefore, the alternatives “Innovation and technology improvement” and “Crop diversification”, according to the participants’ explanations, are the pathways to mitigate climate changes and at the same time preserve land productivity. In regard to the “Collaboration” system it would be maintained again in combining farmers’ efforts to overcome negative consequences by the climate changes giving them higher power within the food supply chain and opportunities to optimize their production costs, respectively realize higher revenue and be more flexible in time of low price levels. In this regard the alternative system “Processing and increasing value added” allows realization of a better market position and integration within the food supply chain. Labor force availability as well as the educational level of farm workers are of crucial importance for the realization of each one of the systems – the status quo and alternative ones. In that sense the alternative “Innovation and technology improvement” was listed by the participants in the workshop as an alternative which may overcome labor force shortages. The same is the situation with the rural areas vitality and the level of services which may prevent (or even reverse) the negative trends of aging and depopulation. Both should be stopped to ensure rural development without which grain farming system cannot be resilient in a long-term perspective. Some of the participants said even that the country development is hindered by the negative processes in the rural areas constituting a larger part of the territory. Another important indicator is the level of development of infrastructure for innovations which is considered as crucial for the two of the alternative systems: “Innovation and technology improvement” and “Processing and increasing value added” as well as for the maintenance of the status quo (one of the farmers explained the need of the interrelations and interactions between farmers and educational and research institutes because even if s/he wants to use specific hybrid it must be tested and adapted to the local circumstances or if s/he invest in new machineries students must be aware of their exploitation etc.). It should be mentioned that for each one of the systems the legislation basis and the policy implementation may determine the final realization and success of the actions taken by the farming system actors to adapt/transform it in more resilient way.

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Each one of the systems is in a different level of compatibility with the developed and proposed Eur-Agri-SSPs which represent different shared socio-economic pathways for European agriculture as it is presented in Table 6.

The highest compatibility of the future systems is with scenario SSP1 (agriculture encouraged for sustainability). All the assessments are reflecting moderate compatibility except one for the alternative system "Processing and increasing value added" which is categorized as a strong one. Despite of the very small differences between the compatibility scores, the advantage of the system should be recognized. Some of the arguments in this direction is that this is the alternative system which requires more effective cooperation between the sectors and actors having in mind the consumer preferences and taking into consideration societal demand. It is also aligned with the process of shortening and increasing the transparency of the food supply chain since the number of intermediaries decreases and the collaboration between farmers and consumers are high. It is not a surprise that this scenario has been given such high assessment because it represents very much the current efforts of the public and private sectors to introduce and mainstream environmental friendly practices and standards, introducing public payments for ecosystem services, pressure for decrease of the artificial inputs level etc. Moreover, improving soil quality is aligned with increased attention for the maintenance of natural resources in SSP1. During the workshop many participants stated that these are the aims which they support but still the way of their implementation does not lead to achieving them. Moreover, some of the policy instrument in some regions led to negative effects, e.g. the requirement of leaving fallow land in some parts of the region led to increase of the chemical inputs in the next years to prevent weed spread or some crop rotation requirements increased inputs for pest controls etc. Therefore, the suggested alternative systems need to be implemented after specification of the regional/local realities and environmental conditions.

Table 6. Compatibility of alternative systems with different Euri-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	0,63	0,29	-0,76	0,09	0,12
Innovation and technology improvement	0,65	0,24	-0,74	0,33	0,30
Processing and increasing value added	0,68	0,29	-0,77	0,32	0,32
Crop diversification	0,63	0,10	-0,76	0,11	0,12
Collaboration	0,65	0,14	-0,84	0,13	0,18

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The less compatible scenario is the SSP3 (agriculture controlled within national boundaries) since the main characteristics of the discussed system's preconditions are quite opposite to the scenario, e.g. neglecting environmental standards (even farmers during the workshop agreed that they are needed), nationalization of the processes and supply chain (entrepreneurial behavior is well developed and farming system actors see state regulation and stimulating functions but not as a main player in market economy), technological development could not be stopped as it is considered as a main solution to the challenges, actually the response to the current challenges is not considered in this scenario at all.

For the rest of scenarios – SSP2 (agriculture kept on established paths), SSP4 (agriculture moved towards inequality) and SSP5 (agriculture boosted by technology), the assessment revealed weak compatibility of the discussed systems. If the priorities are given to the alternative systems "Innovation and technology improvement" and "Processing and increasing value added", the system could be better prepared for the realization of the SSP4 and SSP5 since both of them are based on the technological uptake increasing investments in economic growth.

In general, as it is pointed out, the participants in the workshop do not consider it possible that only one alternative system will be achieved in the future. There are many challenges outside of the system which are not constant and even some of them cannot be predicted and imagined. There are as well many changes happening in the faming system internally. Therefore, the future of the system could not be seen as one-directional. It is more about the different directions and actions needed under different circumstances to preserve the system capacity to ensure private and public goods. It is the system resilience to respond to changing environments and internal processes.

3.6 Strategies

During the workshop discussion it was acknowledged that single strategy could be not assign to a single system. Moreover, it is obvious that strategies applied in the past (and which led to current farming system status) are relevant and are possible to be implemented under the realization of different alternative future systems. We should not forget also that there is an interrelation between the systems and most probably the future system will possess elements of the different strategies identified during the workshop. It is visible also from Table 4 where the relevance of the different strategies towards realization of different systems is assessed.

There is general consensus achieved among the workshop participants that changes into production technologies and technical modernization are necessary in response to the challenges

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and therefore it is an essential element in realization of each one of the alternative systems. The huge effect towards better productivity, respectively higher net farm income, is expected. In that sense the farmers adaptability and transformability would be increased as well as their preparedness for managing the system under different constantly occurring disturbances in different dimensions (economic, institutional etc.). In case of the "Innovation and technology improvement" it is a core strategy which will determine application of the rest of the listed strategies, e.g. soil quality preservation, information exchange and better cooperation with education and research institution as well as relevant policy instruments which facilitate the needed investments and changes into the status quo. At the same time "Preservation of soil quality" is a strategy important to be implemented because the perceived economic viability (satisfactory level of net farm income as a result of better productivity and market opportunities) is precondition for successful realization of each of the alternative systems but it is still key factor for system robustness and status quo preservation.

Equally important is the strategy of "Stimulating succession and improved attractiveness of the sector" because any future system realization depends on the human capital and capacity to realize it. It is interrelated with the strategy of "Better cooperation with research institutions and universities". The workshop discussion clearly identified that through this process of learning and exchanging information and experience, farmers changed their behavior and are more open and successful in changing their activities in accordance of the changing circumstances and environment. So, the alternative systems realization depends also of farmers' attitudes towards uncertainty and their risk perceptions which may be increased by the young and better educated and equipped farmers.

4 Conclusion

In the process of studying the grain farming system in North East Bulgaria in the SURE-Farm project, the farming system resilience is assessed to be medium showing relatively high capacity to keep status quo. Under the current circumstances (mainly climate changes, international market developments and changes into agricultural policy) adaptability has also been stimulated. The FoPIA-SURE-Farm 2 workshop findings are in line with these conclusions. One of the key finding revealed in a process of analyzing workshop results is that the grain farming system is very important in the context of the regional and national development of the agriculture and rural areas. The sector is a key player in natural resources usage (having both negative and positive effects) since any other organization (as production structures and specialization) would be less effective in economic terms. FS supports overall developments but still there are many changes

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(adaptations and/or transformations) which need to be taken to improve its social and ecological performance. The recent processes (in agricultural production, farm demographics, governance and risk management) are driven by different challenges (environmental, institutional, social, economic) and farming system performance is reinforced by different strategies all of them targeting different resilience indicators and attributes and seeking for their preservation and even improvements. Among the most important discussed here are the productivity and preservation of the profitability (net farm income) of the farming system as well as the quality of soil indicator. The current developments in the mentioned indicators support the improvements in the grain farming system robustness. But the future alternative systems embrace adaptability of the system as it main resilience capacity. The relatively tight thresholds given to the different challenges and indicators suggest that system is not possible to continue operating in a robust capacity for a long-term period. The proposed strategies suggest the need of adaptation of the system towards increase of its capacity to cope with emerging uncertainties and disturbances. The alternatives ”Exit farming / change of sector” and “Moving the farm to a different region” would imply a negative transformation of the system. The transformability is a possible future capacity of the system, provided system performance, especially profitability, is improved first. Improving system performance is mainly perceived to be realized in the following alternative: “Processing and increasing value added”.

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