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FoPIA-Surefarm Case-study Report Germany

Work Performed by Partner 12, IAMO

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Abstract

European agriculture is facing multiple economic, environmental, institutional and social challenges which are threatening the stability of production. This also applies for the Altmark region, which is located in the North of the German federal state "Sachsen-Anhalt". Those shocks and long-term pressures are for instance the availability of qualified and educated working force, climate change, which is causing dry summers and wet winters, the relatively low equity capital share of farmers and the continuously changing political regulations, among other.

The Framework for Participatory Impact Assessment (FoPIA) is one of the integrated assessments (IA) tools and used to determine the integrated impact of resilience-enhancing strategies on the German farming system. This country report is presenting the results of the FoPIA workshop for the German case study (CS) about large-scale corporate arable farms in the Altmark region. In the FoPIA workshop 12 participants from different stakeholder groups of the farming system were present. Five farmers, four representatives from policies and NGO's and three from research and consultancy participated. The participants were asked during the workshop to define the importance and performance of functions and indicators of the farming system. Secondly, the indicators "gross margin", "wages" and "animal welfare" were chosen to assess the strategies in the past 18 years and how those and the defined general resilience attributes contribute to the resilience capacities (robustness, adaptability and transformability). During the workshop there were several moments to realize an open discussion between the participants for better insights.

The main findings are that the private goods are more important than the public goods but perform equally good in the German CS. Economic viability is perceived most important by farmers, while the food production is scored most important by research and consultancies. The overall most important function of the farming system is the food production, with the provision of cereals and milk, which is performing rather good. The second most important function is economic viability which is poorly performing and scored lower in performance by farmers compared to the other stakeholders. This function is defined with the outstanding important indicator gross margin. Lastly, the third most important function is the natural resources, which is defined as public good and is performing overall best due to the good performance of soil and water quality. This characterizes a farming system, which is conserving natural resources, also because of the extensive management due to rather unfavorable climate and soil conditions. Researcher and consultants score the performance of public goods better than the other stakeholders. The overall worst performing indicator is wages, which is often mentioned to risk the system in the resilience. Many of the chosen resilience enhancing strategies contribute to

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robustness and adaptability of the farming system. Spatial heterogeneity of the production system contributes to adaptability, while strategies for cost saving purposes increases rather the robustness of the system. Different policy measures contribute to all three different resilient capacities. The general resilience attributes are scored rather medium and low in application and contribute to the robustness of the system and hinder the transformation. The farming system is both robust and adaptable in particular processes but is locked-in and hinder transformation due to the economic margin and infrastructure issues.

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1 Introduction

1.1 Case-study

The region of the German case study (CS) is called "Altmark". It is located in the North of the German federal state "Sachsen-Anhalt," which is in the East of Germany, and consists of the two districts "Stendal" and "Altmarkkreis Salzwedel". The structure of the agricultural production system reflects the large-scale agricultural structures of East German agriculture but also comprises small farm structures. Thus, farm size is heterogeneous (Appel and Balmann, 2018). Most of the utilized agricultural area is used by mixed farms, while the highest number of farms are the arable farms. In average the mixed farms are lager farms compared to the arable farm. In terms of utilized agricultural area, cooperate farms have the highest share but in terms of the number of farms, the family farms comprise half the share. This is reflected in the fact that most of the cooperative farms have a large farm size. Compared to other districts in the federal state the Altmark has with 27% a high share of grassland, the soils are rather poor, and the yields of the arable crops are rather low. Altmark also comprises almost half of the cow population of the federal state.

The farming system is facing different economic, environmental, social and institutional shocks and long-term pressures. Those main challenges of the farming system in the Altmark region are captured in Table 1.

Table 1: Shocks and long-term pressures of the farming system divided by the 4 dimensions.

Challenges	Economic	Environmental	Social	Institutional
Shocks (permanent and non-permanent)	Fluctuating market prices of agricultural products	Weather extremes		Shift from coupled to decoupled CAP payment
Long-term pressure	Farmers have a relatively low own capital	Access to Water (unequal distribution of right to use the water canals)	Decreasing number of availability of wage labourers / successors	Continuously changing political regulations

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Infrastructure of value chain of organic products	Sandy soils	
Low economic performance per hectare	climate change, dry summers and wet winters	Bad internet connection
Low wages		Availability of qualified and educated working force

1.2 Workshop

The workshop was conducted at the 9th of January in community Zethlingen in the Altmark region. Stakeholders from NGO's, politics, research, consultancy and farms where invited to the FoPIA workshop. From all stakeholder groups people participated in the workshop. The participants were grouped into 3 sub-groups, which are "farmers", "politicians and NGO's" and "researchers and consultants". The distribution of the participants into the sub groups is presented in Table 2. The whole participants list can be found in the appendix in Table A1.

Table 2: Division of the participants into the sub-groups with further description of stakeholders

Stakeholder group	Amount	Description
Farmers	5	3 conventional and 1 organic and one student/farmer
Politicians and NGO's	4	1 from the green party and one from the SPD and 2 people from NGO's
Researchers and consultants	3	1 consultant and 1 consultant from a local credit union and 1 from applied science

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2 Farming system

Figure 1 presents the social delineation of the farming system after adaption. During the workshop the participants adapted the actors of the farming system in the visualisation through their expertise knowledge. In total 7 actors have been added to the pre-defined farming system visualisation, which are marked in green colour in the text and the visualisation. The actor "local grocery store" was moved from one circle to another, which is indicated by a green arrow in the visualisation.

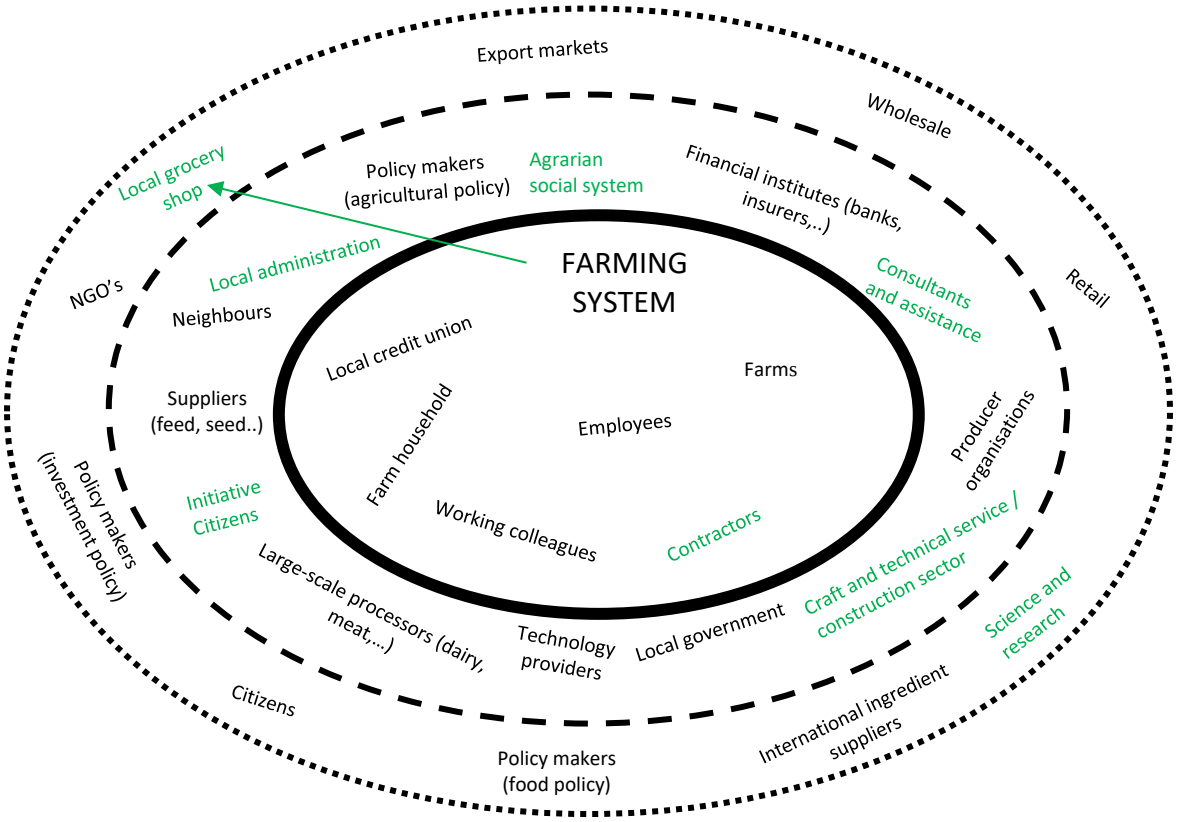

Figure 1. Updated farming system visualisation after feedback from participants. Updates are presented in green. Actors which moved between circles are indicated by a green arrow.

In the inner circle are the actors which influence the farming system and are equally influenced by the farming system. Next to the actor's "farm", the "farming household", the "employees", "contractors", "colleagues" also the "local credit union" is part of the inner circle, since it is influenced by the economic performance of the farming system. "Local credit union" is providing the system with loans, but its performance depends on the investment of the farming system into credits. "Farms" and the "farm household" are providing jobs in the farming systems which are executed by the "employees" and "contractors". "Contractors", which are service providers, are

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next to the family members and employees, an important part for the business of the farming system (e. g. for large-scale producers, suppliers). Service providers are essential because they deliver a certain quality of service and know-how and therefore belong to the inner circle.

The second circle is characterizing the actors which are influencing the farming system Altmark but are only scarcely influenced by it. In the Altmark region actors like "seed and feed suppliers", "technology providers", the "construction sector" and "large-scale processors" are providing the farming systems with inputs and refinement. Quoting on of the participants: the "craft and technical service and construction sector" play a big role in the rural areas for generating income. This is important, because the industry itself in the Altmark is not that strong to generate income. In case agriculture would not exist, the craft and construction sector could not survive either." This means that the agricultural sector supplies the construction sector with work contracts to support the sector. Also, the agrarian system relies on the construction sector as one service to execute work (see Figure 1). "Policy makers" in agricultural politics, the "local government" and "administration" are steering the farming system through a given legal framework. An additional actor next to the local government, which has to be distinguished, is the "local administration". This actor is acting on a community level and responsible for permits e.g. gives orders to block streets and roads et cetera. The producer organisation ("German Farmers' Federation") has influence through representation of interests on policy makers. "Consultancy and assistance" also have been added to the visualisation of the farming system. This actor has the function to give advice for funds, reconstruction, assessments of the farms among other tasks. Quoting one of the participants: "The agrarian social system", like health insurance, pension insurance for farmers is an actor in the farming system, which is influencing the farm performance". The system covers the farmer in case he or she is not able to work because of sickness and physical inability etc. The participants of the workshop suggested to add the actor "initiative citizens". This actor has to be distinguished to the actor of "citizens" because they are representing a more active role. Those initiations, which the citizens are conducting are e.g. discussion rounds about agricultural topics. Those initiatives are influenced by present issues and the agricultural discourses. Initiative citizens also have to be distinguished to the actor "NGO's" because they are less structured and organized.

In the third circle actors with an indirect influence on the farming system are listed. "Wholesalers" and "retailers" are actors of the third circle, which are important for the Altmark region. Other actors are "policy makers" in national politics and actors, who are purchasing the products outside Germany and suppling ingredients from abroad. Also, "non-governmental organisation" and "citizens", which are aligned with agricultural topics as are influencing the farming system. "Scientists" are missing, as an actor. Not the fundamental research but the applied research. In general science and research has still to be added to the visualisation of the farming system"; was also mentioned by one of the participants. Applied science delivers new ideas for innovation in a

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farming system. Lastly the participants agreed on take out the "local grocery shops" from the inner circle to the outer circle. It is very difficult for the farmers to use the supermarket as a selling platform to earn sufficient money because of the price competition. Also, direct marketing is not reached easily by the farmers because of the rural structures and lack of sufficient demand.

3 Functions

On average between the stakeholder groups there is a slight preference observed to allocate importance to private goods. This preference is biggest for the stakeholder group *researcher and consultants* and smallest for *politicians and NGO's*.

To score the importance of the functions 100 points where used between all eight functions. The function "food production" is scored highest with 20 points on average between the stakeholders (see Appendix B, Table A2). The function "economic viability" follows with 17 points on average and "natural resources" with 14 points on average. The function "animal health and welfare" is scored lowest with 9 points on average. Standard deviation is highest for "economic viability", followed by "food production", indicating different points of view among participants (Table A2). For the function "food production" there is a high scoring (30) from the stakeholder group of *research and consultant* (Figure 2). Their score is more than double compared to the one from the *farmers (14)*, but the standard deviation is also highest for *researchers and consultants* (Table A2). For the function of "economic viability" the score from the *farmers* is by far highest with 27 points. Also, here the standard deviation for *farmers* is rather high. "Animal health and welfare" is scored highest by *politicians and NGO's*.

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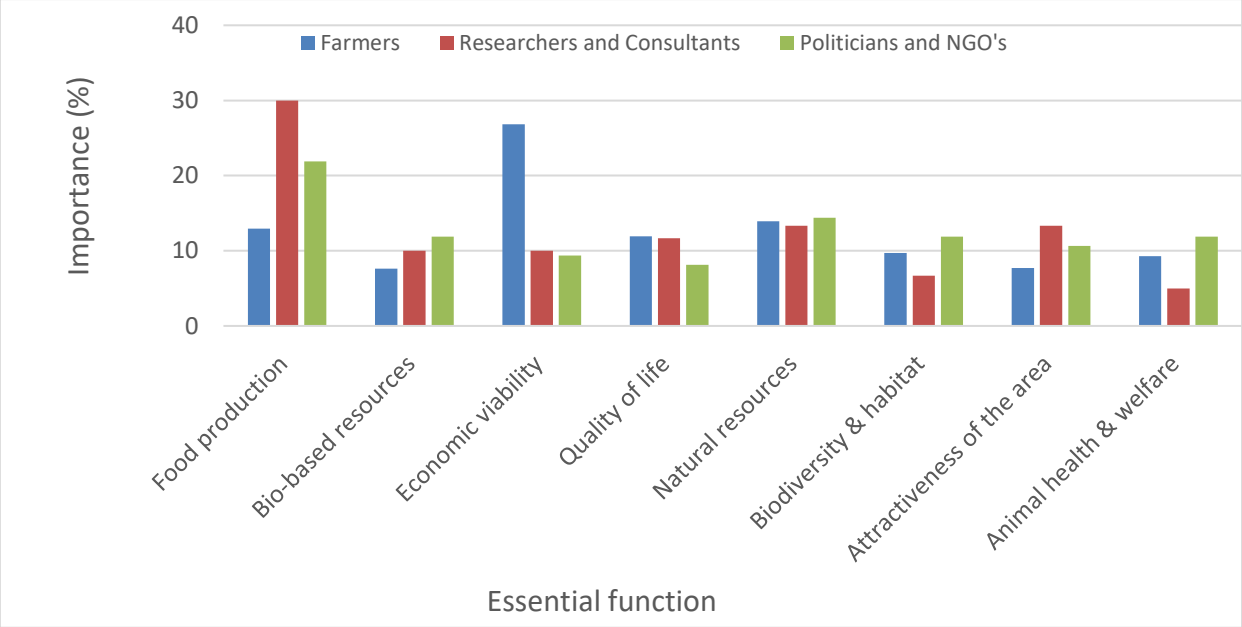

Figure 2. Bar graph with scoring per EF, aggregated by stakeholder group. 100 points needed to be divided over eight functions.

The plenary discussion revealed some disagreement of participants with the functions as defined in SURE-Farm. In general, it was stated that agriculture has to bring decent paid jobs. One participant wants to wider the defined function of "Improve quality of life" with the addition of "providing employment with decent salary and offering decent working conditions". Quote: "It is be observed more and more that labor in the European Union is hired from abroad and beyond that. This people are earning low wages, which cannot be the aspiration of fairness in agricultural sector". The stakeholder groups *politicians and NGO's* and *farmers* discussed about the definitions of "decent salaries" and which sources are appropriate to use to raise the salaries. The consensus of the plenary discussion is that the farming system is working, but rather not sustainable because the wages were not adjusted over the years to the increased value upstream of the value chain.

4 Indicators of functions

4.1 Indicator importance

Before the ranking of predefined indicators, the participants intervened to exchange and add some additional indicators. For the function "delivery of bio-based resources" the participants want to add the indicator "share of crop rotation". It describes the share of crops in the crop rotation, which are used for the production for bio-based outputs, e.g. the share of rapeseed in

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the crop rotation for biodiesel. For the function "economic viability" the indicator "ability to invest" was additionally chosen by the participants. Also, for the function "quality of life" the indicator "share of women" is replaced by the indicator "wages". Lastly, the indicator "attractive village life" was selected by the participants for the function "attractiveness of the area".

Per function maximum 100 points can be used to score the importance between the defined indicators. The indicator "gross margin" is the most important indicator in total (see transformed data Appendix B, Table A3) with on average 31 points for all participants and represents the function "economic viability". The second most important indicator is "milk production" (24) representing the function "food production". Also, relatively high importance receives the indicator "wages" (21) representing the function "quality of life", "cereal production" (19) and "other food crops" (17) representing the function "food production". With on average 18 points both indicators "soil quality" and "water quality" are also scored relatively high, which are representing the function natural resources" as well as "internet connection" (16), which is representing the function "rural area". Least important with on average 5 points is the indicator "cultural, social offerings" (belongs to function "quality of life), followed by ""production of biogas" (belongs to function "bio-based resources), "agrotourismus" (belongs to function "attractiveness of rural areas) and legal framework of animal welfare (belongs to function "animal health and welfare"), while all scored 7 points. Highest standard deviation by far has the indicator "gross margin per hectare" (22), the indicators "legal framework for fertilizer" (11), "ability to invest" (13), "wages" (11) and "milk production" (Table A3). The high standard deviation reflects contrasting views between the stakeholders. This was expected since the indicators are representing the economical perspective of the farm and the payment of the employees. Also, high standard deviation is seen for indicators characterizing natural resources, which often are discussed controversially.

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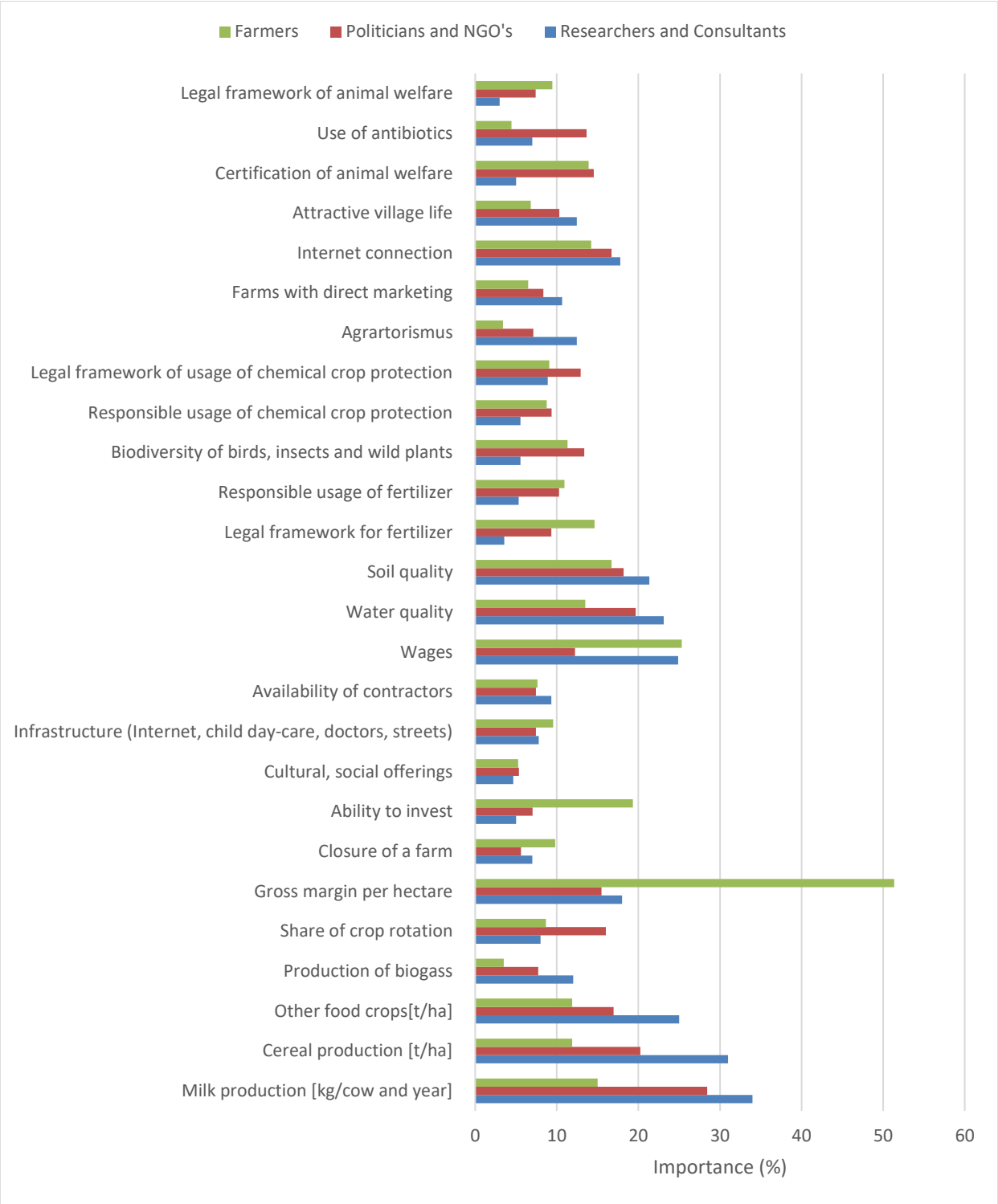

Figure 3. Bar graph with scoring of importance per indicator, aggregated by stakeholder group. Per EF, 100 points were divided over the indicators. *Values are transformed to include the importance and number of indicators of the function that the indicators represent.*

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It is observed that for the *farmers* mostly the indicators for the function "economic viability" ("gross margin", "closure of farms", "ability to invest") and the indicator "wages" (function: "quality of life") are important. "Gross margin" is perceived circa three times more important by the *farmers* than by the other groups. The high overall standard deviation for "wages" is caused by differences between the groups, which reflects the difference in perception. *Farmers* and *researcher and consultants* have a similar perception while *politicians and NGO's* score it with half the importance (see transformed data, Table A3). However also, two of the four indicators of natural resources, which are "legal framework for fertilizer" and "responsible usage of fertilizer", are important for *famers*. For the indicator "responsible use of fertilizer" a high standard deviation is noticed for *farmers,* which is due to differences in the interpretation of the indicator. For the *researchers and consultants* mostly indicators of "food production" and "attractive rural areas" are important. The indicator "milk production" is scored more than twice as important by *researches and consultants* than by *farmers*. Also, for the group *researchers and consultants* two of the four indicator of the function "natural resources", are important, which are "water quality" and "soil quality". In addition, "availability of contractors" (function: "quality of life") is in focus of *research and consultant*. Indicators of animal welfare ("certification of animal welfare", "use of antibiotics", "legal framework of animal welfare") are in the main focus of interest of *politics and NGO's*. Next to that two indicators of the function "biodiversity", which are "biodiversity of insects, birds and wild plants" and "legal framework of chemical crop protection", and the indicator "share of crop rotation" (function: "bio-based resources") are in the main focus of the stakeholder group *politics and NGO's*.

4.2 Indicator performance

The performance of the indicators is scored between one and five points, while 5 points is the score for very good performance and one for very poor performance. Indicators with good performance are "milk production" (4.2), "water quality" (4.1) and "soil quality" (3.8) and were scored as important indicators too (Figure 4). "Production of biogas" is the best performing indicator (4.4) but scored low in importance. "Gross margin" (3.1) and "cereal production" (3.4) are indicators with a medium performance but scored as important once. Indicators with a low performance, which are scored as important indicators simultaneously, are "internet connection" (1.6) and "wages" (2.0). Other indicators with a low performance and low importance at the same time are "infrastructure for streets, hospitals, schools etc." (2.0), "agri-tourism" (2.0), "cultural, social offering" (2.4), "availability of contractors" (2.4) and "farms with direct marketing" (1.7). High standard deviation is observed for the three indicators of the

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function “animal health and welfare” which are “legal framework of animal welfare”, “use of antibiotics” and “legal framework of animal welfare” (Appendix B, Table A4). This indicates contrasting views of the stakeholder groups, which could have been expected since animal welfare is a topic which is controversially discussed in society. The scores for the indicators “legal framework of fertilizer” and “biodiversity” also show a high standard deviation (Appendix B, Table A4).

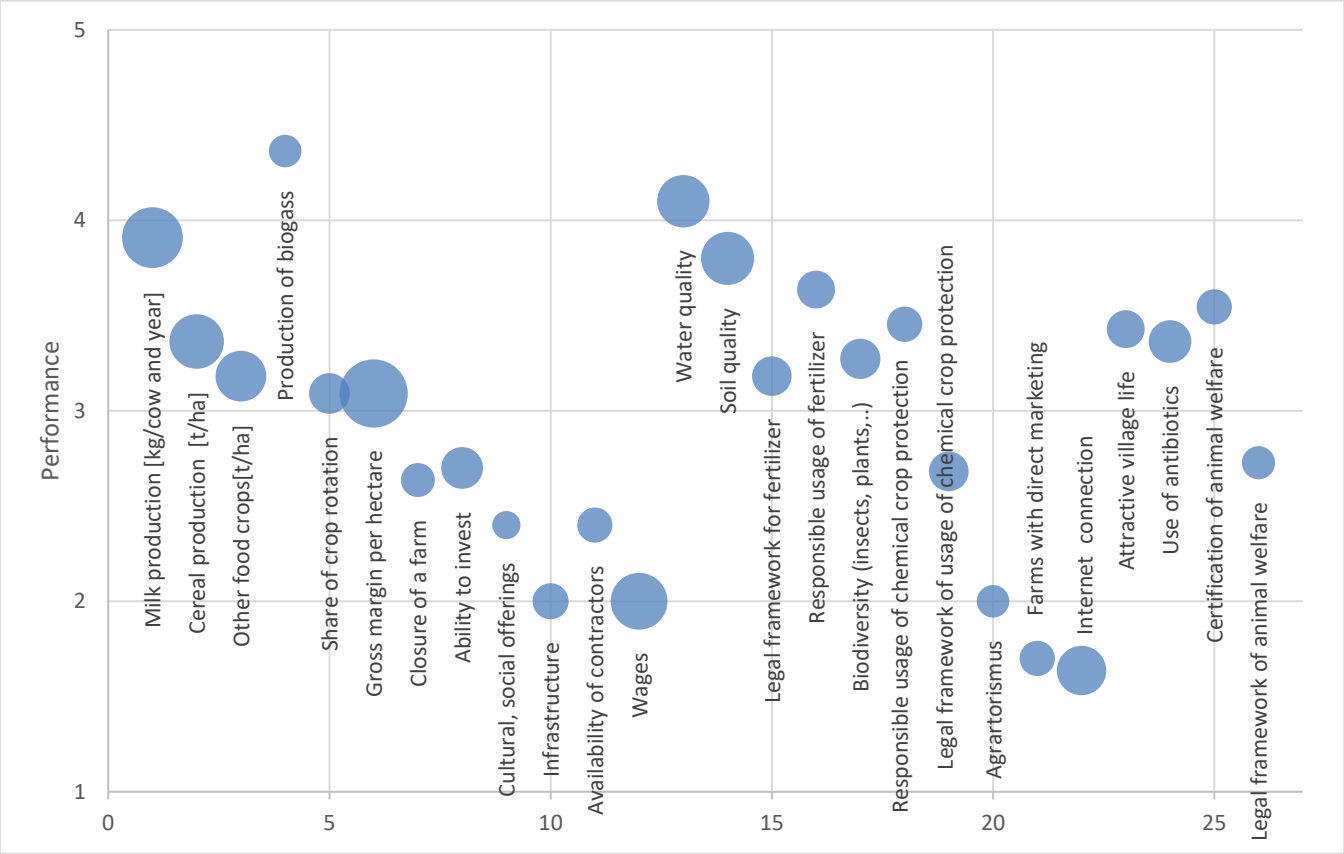

Figure 4. Bubble graph presenting averaged scores on performance of **indicators** (from 1 to 5), while also indicating their importance (size of the bubbles), relative to each other.

The stakeholders disagree in the performance of different indicators. The performance of “milk production” is scored lower by the *farmers* compared to the other two stakeholder groups (see Figure 5). “Gross margin” is scored in the performance highest by the *politics and NGO’s*. The indicator “closure of farms” is scored rather good performing by the stakeholder *research and consultant* compared the *farmers*. The indicator “infrastructure” is scored higher by the *politics and NGO’s* compared to the *farmers*. The same scoring pattern is seen for the indicator of “availability of contractors”. Many of the indicators of the public good, like e.g. “legal framework

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of fertilizer", "responsible use of fertilizer", "biodiversity", "responsible use of chemical crop protection" legal framework of chemical crop protection", "use of antibiotics", "certification of animal welfare and "legal framework of animal welfare" are scored lower in their performance by the *policies and NGO's* compared to the stakeholder groups *farmers, consultant and research*. The indicator "farms with direct marketing" and "attractive village life" are scored highest in their performance by politics and NGO's compared to the stakeholder groups *farmers, consultant and research*.

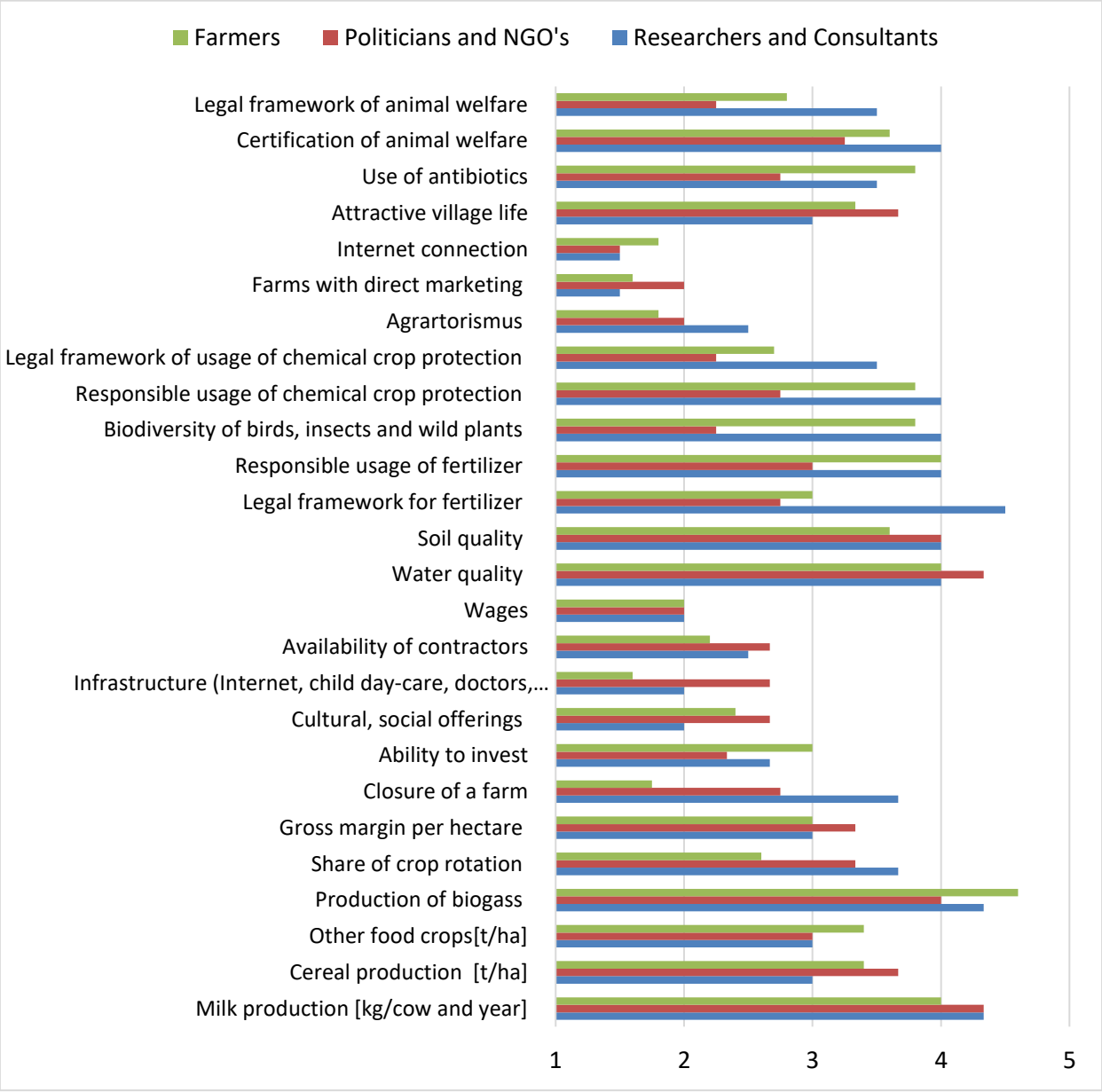

Figure 5. Bar graph with scoring of performance per indicator (from 1 to 5), aggregated by stakeholder group.

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To summarize the farming system performance, a reflection on the farming systems functions (importance and performance), with the relevant indicators and their classification into private and public goods, can be conducted. This is presented in Figure 6. In total the public goods are scored more important compared to the public goods (Appendix Tab. A2). However, the function "natural resources" (indicator: soil and water qulity) which after "food production" (indicator: milk production) and "economic viability" (indicator: gross margin) is the third most important function. From this tree functions "natural resources" scores best in performance and "economic viability" lowest. Over all the function "quality of life" (indicator: wages) is scoring lowest in performance while having a average importance of the functions, which is indicating a bottleneck for the Altmark region. Both private and public goods scored equally in their performance on average (Appendix Tab. A5).

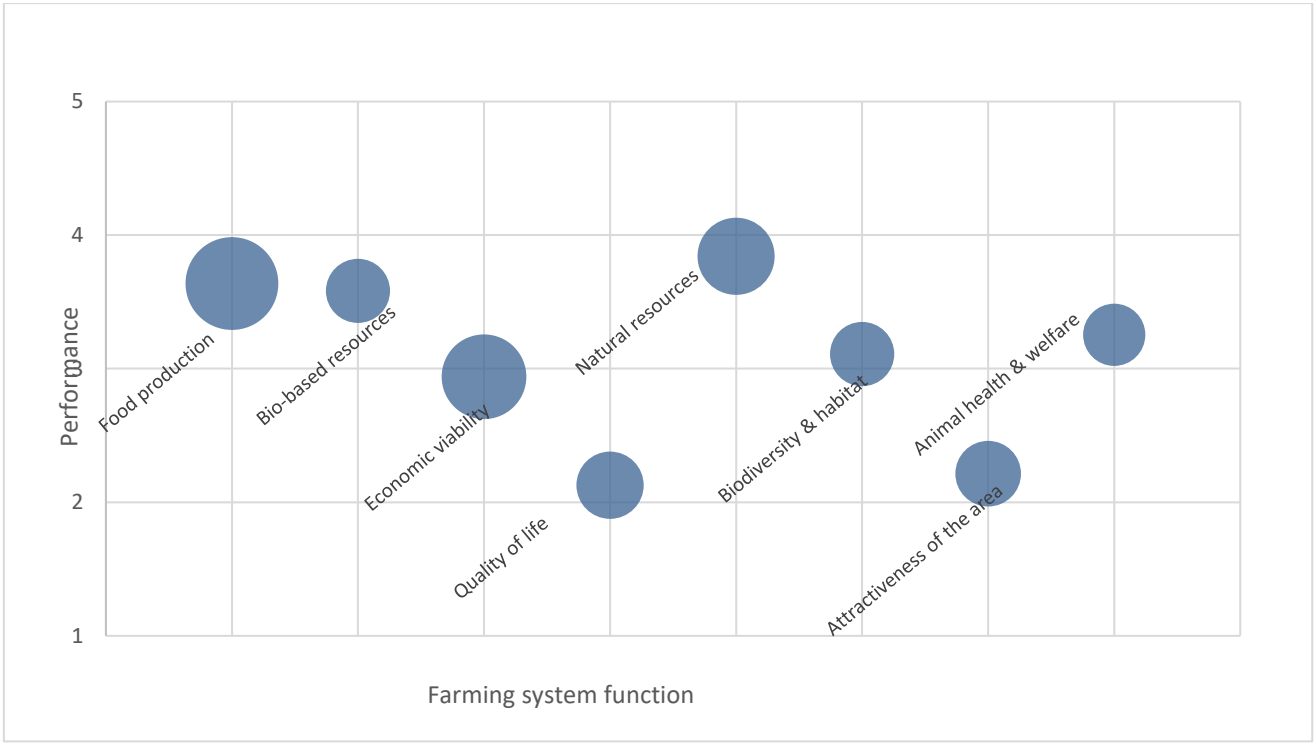

Figure 6. Bubble graph presenting averaged scores on performance of **functions** (from 1 to 5), while also indicating their importance (size of the bubbles), relative to each other.

4.3 Indicator selection

Gross margin is a main indicator because the importance is scored high. During the workshop it was mentioned as the main indicator for assessing the performance of the farming system. However, the importance is perceived controversial among the stakeholder groups. Quote from a farmer: "In case of not receiving a sufficient gross margin, the farming business is not able to

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survive". The performance of the gross margin is also scored low and therefore, improvement is needed.

Legal framework of animal welfare is chosen because it was mentioned during a discussion in the beginning of the workshop. Also, during the plenary discussion participants were wondering why the animal welfare was scored rather high in the performance. Quote from a participant: "The question is, whether the legal framework has many different regulations, or if they are good ones". The participant implied that only because there are many regulations the good performance is not justified. Also, for different stakeholder groups the performance is observed differently and therefor a controversial point.

Wages as an indicator was chosen because it was heavily discussed during the first part of the workshop and the graph shows a high importance and low performance at the same time. Quote from a participant: "The current farming system is working, but it is not working sustainably because the wages are not decent and not adjusted in the last 30 years". This means that that wages are not sufficiently high, but the farmers see it in the responsibility of the whole farming system to adjust the wages.

5 Resilience of indicators

5.1 Indicator 1 – Gross margin

According to the participants, the gross margin dependents on the following main factors: weather influences, politics and the condition of the financial system. The performance of the gross margin was gradually increasing, but already had a plateau in the year 2002 till 2005 (Figure 7). In the year 2002 there were flooding events and in the year 2003 was a drought, which were impacting both the crop yield and the grassland productivity. In the year 2005 the agricultural reforms took place which was the cause for a slow increase of the of the gross margin's performance due to a liberation process on the market. During the agricultural reform, commodities were adjusted to the world market. This means that already in 2005, the prices for cereals where liberated to compete on the world market, while sugar beet started to compete on the world market in 2017. According to the participants, the global financial crisis impacted gross margins negatively in 2009 (Figure 7). The financial crisis was a big challenge because commodities were competing at the global price world market. According to the participants the highest performance of gross margin was reached in the year 2013 with a performance of 130%. Also, the year 2013 was a year of flooding and resulted in a year with lower crop yields in arable farming. After that year the performance was deceasing continuously again till the present year.

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The decrease after 2013 was among others due to the milk quota abolishment and especially in the year 2018 the negative impact of the drought on the yields of (fodder) crops. Next to this, political decisions are challenging a stable gross margin. The implemented legal framework for animal husbandry in the year 2014 made it necessary for farmers with livestock to invest in new stables. In some cases, this is challenging, because the farmer didn't even pay off the credit of the current stable yet.

A challenge in the future is the upcoming probation of Glyphosate in the next 3 or 5 years and also the usage of seed dressing will stop. This will be challenging because these types of crop protection are cost saving measures. Stop of Glyphosate and seed dressing usage, also makes tillage with plough necessary again and complicates the cultivation of rapeseed. At the same time, the production of maize and its profit, will decrease in the next years due to legal frameworks which will stop the promotion of biogas through subsidies.

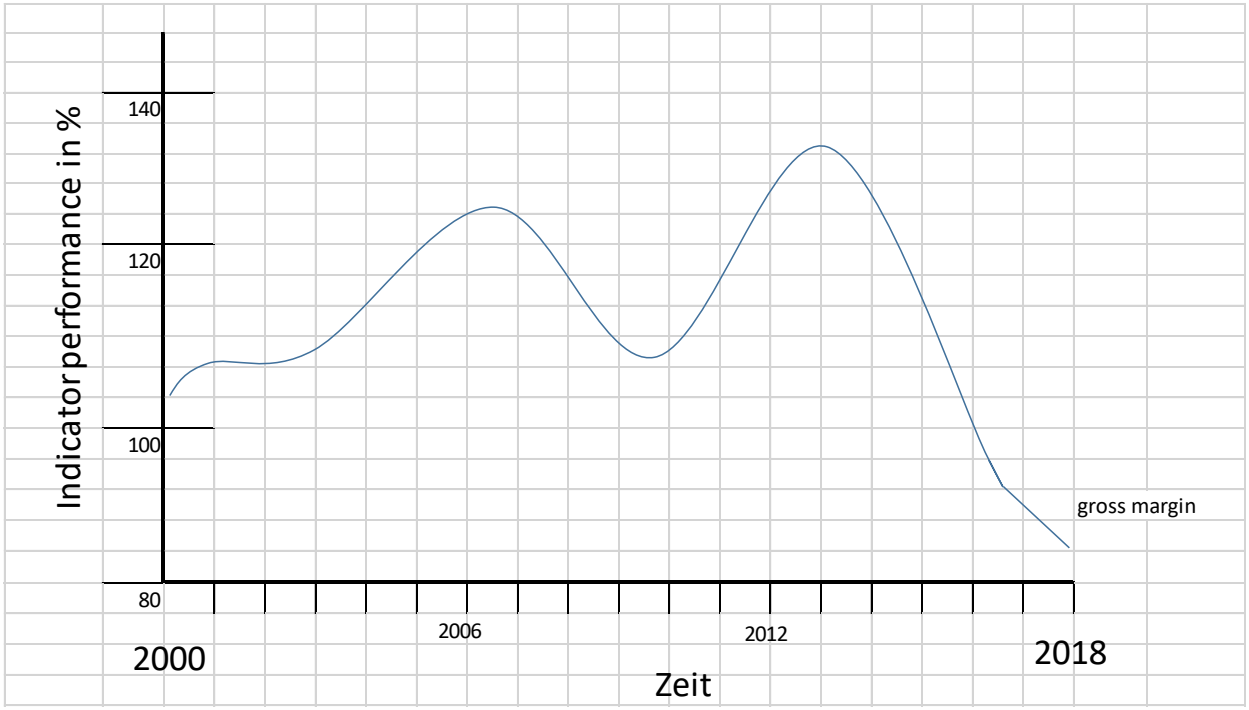

Figure 7: Performance of the Indicator "gross margin" from period from 2000 till 2018

Several strategies were used in the last 18 years to increase the performance of the gross margin. In the beginning of the 2000's, an intensification of the bio-based resources was observed, especially the extension of rapeseed production. A synergy between this strategy and the "German Renewable Energy Sources Act (REA)" in the beginning of the 2000's is given. The REA implies regulations which are economic incentives for farmers to extent bio-based resources. The

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economic incentive is due to financial support of the government for bio-resources production for electricity generation. This led to an increase of the rapeseed production area, which had a financial benefit, especially for the Altmark region. One strategy was the cultivation form “tillage without ploughing”. This was a cost saving measure because financial reserves for tractor and machinery usage was saved. Instead, Glyphosate was used which was cheaper compared to the soil tillage. There is also a synergy between the usage of Glyphosate and the extension of rapeseed production, since the production of rapeseed was facilitated by the usage of Glyphosate. By usage of Glyphosate a cost saving cultivation could be realized, which was beneficial for the gross margin. During the last years of low yields, also the strategy of reducing investment was chosen e.g. to choose not to invest in a new tractor. The increase in milk production and pig farming was a passive way of improvement.

The trend of the drawn performance of the gross margin is well reflected by the participants according to the data of the agricultural reports of Saxony-Anhalt. Still it was not possible for the participants to draw all details of the performance on paper. The perceived stagnation of the gross margin due to flooding was correct as reported by agricultural reports. To illustrate the impact the agricultural report 2002 estimated as a loss of 51,352,000 Euro. Half of it was caused through damage of grassland productivity, which is used for cattle fodder in milk production (MRLU, 2003). However, contrary to the drawn plateau of the gross margin in the year 2003/2004, the performance decreased in reality, due the decreasing producer price for milk and cattle compared to the previous years. At the same time costs for fodder were increasing in those years which negatively impacted the gross margin(MRLU, 2003). In the year 2005 for the first-time subsidies were decoupled from production and payed to the farms, which was a cause for an increasing gross margin in all types of farms (Sachsen-anhalt, 2006). This was an important event for the agricultural sector and correctly illustrated in the drawn performance of the gross margin by the participants. In the year 2008 an increasing demand for the agricultural production was observed on the international market with stagnating production levels. This led to an increase of the prices and therefor increasing income. The better performance of the gross margin in the year 2008 compared to the previous ones is not perceived by the participants. Still the overall tendency of the gross margin is well reflected by the participants, also regarding the end of the observed time span of 18years (MULE, 2016).

5.2 Indicator 2 - Animal welfare

The performance was separately assessed for the pig, cattle and the poultry sector (Figure 8). The performance of all three sectors is presented in three curves and set 100% in the year 2000. Pig farming: In the year 2008, the agricultural investment funding programme (AFP) was

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implemented and brought an increase of the performance to 110% (Figure 8). Over the time span from 2007 till 2013 the legal framework for pig keeping in boxes was changed. This gave also a positive impact for the performance of 10 percent. The participants drawn the increase in performance to occur already before the regulations were implemented.

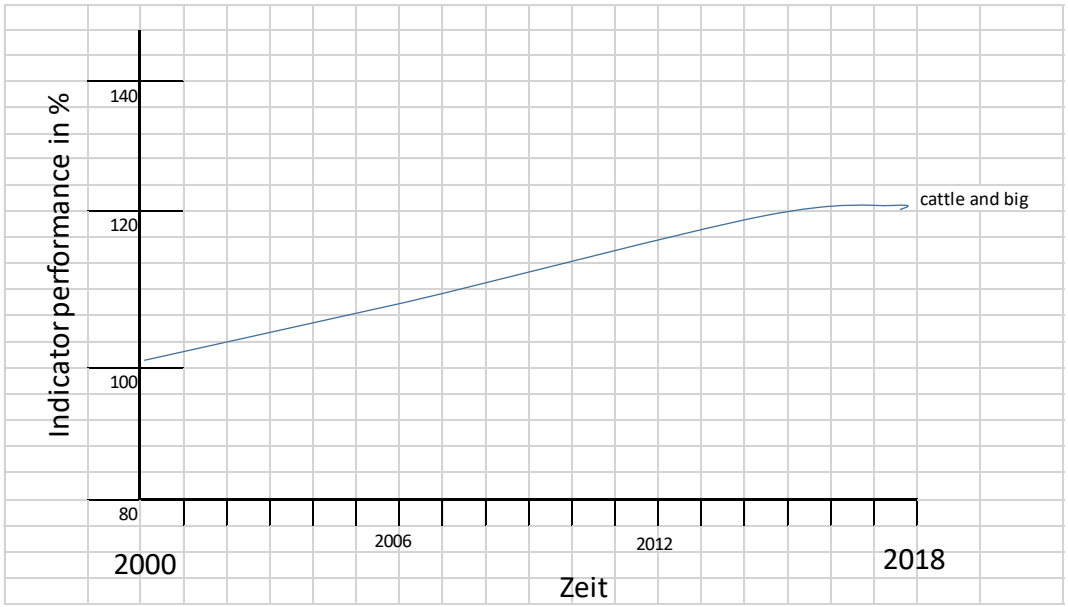

Figure 8: Performance of the Indicator "animal welfare in case of cattle and pig farming" from period from 2000 till 2018

Cattle farming: In the year 2008 the AFP was implemented and was cause for the gradually increase of the performance (Figure 8). The AFP resulted in increase of the performance to a level of 110%. In the year 2014 Animal Protection Keeping of Production Animals Order (German designation: TierSchNutztV) was implemented which impacted the performance also positively and increased the level to a score of 120%. After these changes the performance did not improve but also not decrease and stayed constant.

Poultry farming: In the year 2004 the labelling requirements were introduced, which had a quite large positive impact on the performance with an increase to a 120% performance (Figure 9). In the year 2010, production of hens in cages was prohibited. This leads to a slow and constant increase of the performance, which reached around 135% in 2018.

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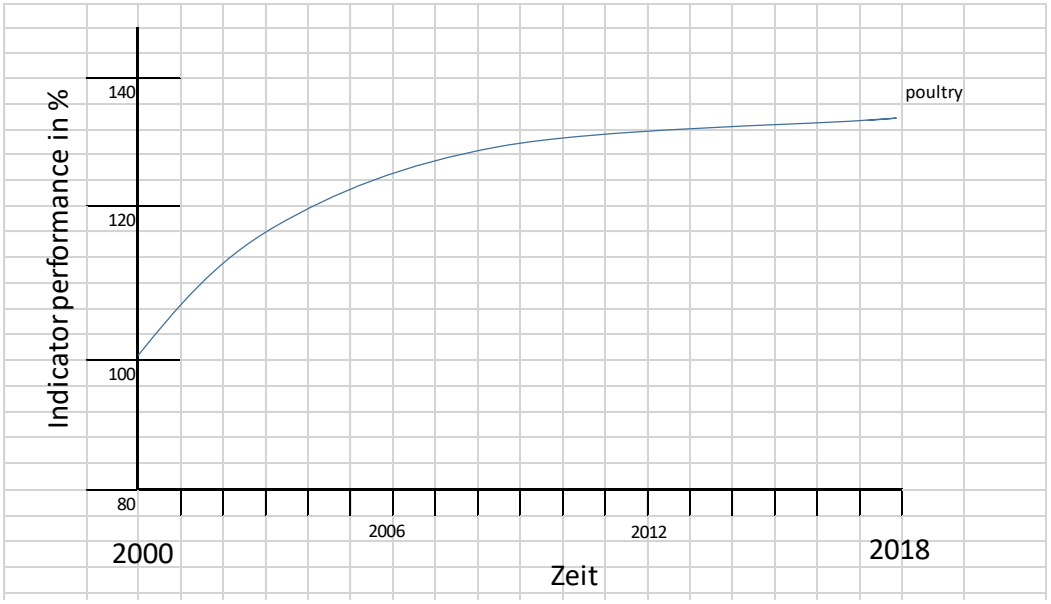

Figure 9: Performance of the Indicator "animal welfare in case of poultry" from period from 2000 till 2018

A challenge for the animal production sector is social resistance against large scale livestock production and the perceived missing transparency of production conditions in marketing. For the customer it is a challenge to choose products because e.g. before 2004 there were no regulations to label the eggs according the housing conditions for the chicken. A big challenge for animal welfare is the fulfilment of the legal frameworks by the farmers. The animal keeping facilities, which are according to the regulations, are cost intensive. Also, for the farmer it can be challenging to understand the requirement of the regulations and how to apply for the financial support for the implementation.

A strategy to improve the performance of pig and cattle farming was the "Agricultural Investment Funding Programme (AFP)" implemented in the year 2008. This program has the purpose to financially support the investment in economic viable agriculture which is environmental- and animal friendly. Between the years 2007 and 2013, the legal regulations of boxes for the pig keeping was changed. This strategy ensured a shorter period in boxes and more space for the pigs. For cattle farming," The Order on the Protection of Animals and the Keeping of Production Animals (German designation: TierSchNutztV)" was implemented in the year 2014. This especially strengthened the regulations to improve the animal welfare of calf keeping. For the poultry sector two strategies were used: "labelling requirements for eggs" introduced in the year 2004 and the "ban caged poultry" in the year 2010. After the

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implantation of labelling requirements, the consumers had the opportunity to decide on the keeping conditions for the hens.

Since animal welfare is a qualitative indicator it is difficult to measure the accuracy of the participants perception with reality. Only assumptions can be used to measure the indicators performance. As published in Articles the animal welfare of pigs is observed critical and therefor new forms of animal keeping are suggested to improve the animal welfare (Bündnis 90/Die Grünen, 2017). Another article states that resources are invested to improve the animal welfare of pig keeping in the future. This is due to the critic that the mother is restrained in the cage after 4 weeks of giving birth that she cannot turn (Dörthe Hein, 2015). But the score of animal welfare performance certainly depends on stakeholder groups. As observed in the previous results that politicians and NGO's score the performance of legal framework of animal welfare worse than farmers and researchers and consultants.

5.3 Indicator 3 - Wages

Considering the nominal wages an increase would be observed over the last 18 years. But it was agreed, to considered them in relation to the inflation, meaning that the real wages were presented. The trend of the real wages was decreasing over the illustrated timespan. The wages do not show a parallel trend with the gross margin performance. This can be explained for instance by the fact that wages are fixed through contracts, which leads to a delayed adjustment of wages to the business performance. The performance started in the year 2000 at a score of 100%. Over the time span of the last 18 years, the real wages were decreasing constantly to a level of performance of 80% at the end of 2018. Only the implementation of the minimum wage gave a short and small increase of the performance in the year 2015. Also, the attempt to make the working conditions more favorable and flexible had a minor impact to slow down the decrease of performance in the last years.

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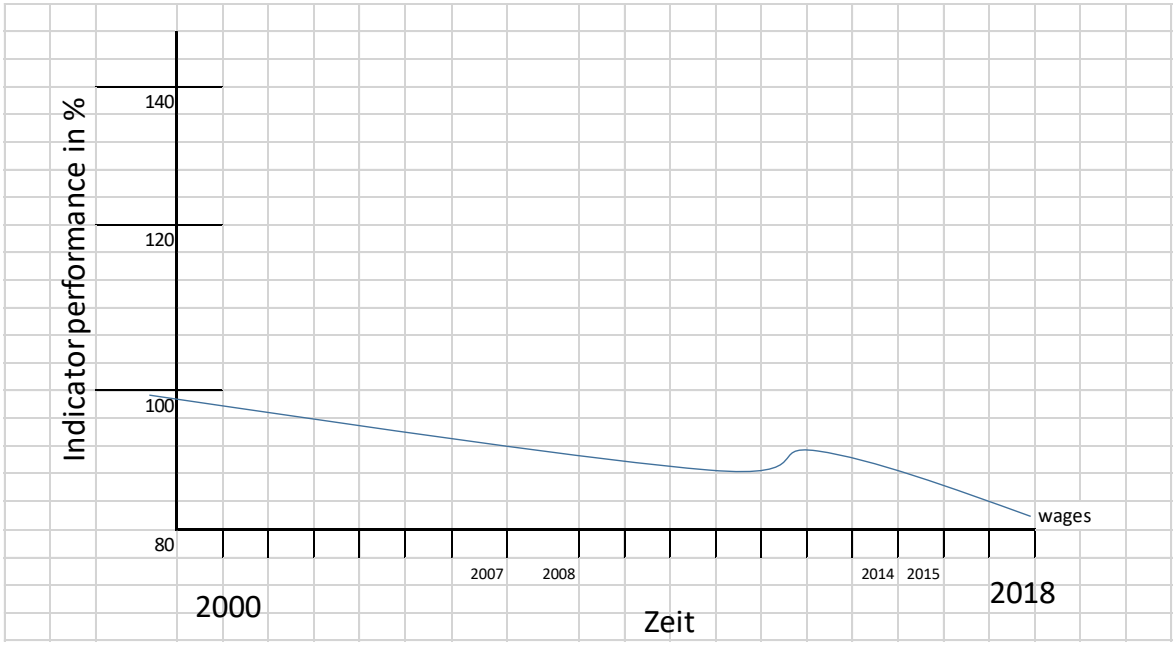

Figure 10: Performance of the Indicator "animal welfare in pig keeping" from period from 2000 till 2018

Participants were stating that over the last years no adaption of the wages in the agricultural sector to the inflation level was taking place. One participant mentioned a national law, which should guarantee an adjustment of wages in the agricultural sector to inflation since agriculture production is at the beginning of the value chain. Therefore, mostly the legal framework for the politics, which leads to the decline of food prices, is seen as the challenge for the payment of decent wages. Other participants argued that the biggest challenge is in the level of the total revenue of farming businesses which hinders the payment of wages.

A strategy to increase wages was the introduction of minimum wages in the year 2015. This is a governmental law, which defines the lowest remuneration that employers can legally pay their workers. Also, a strategy to improve the indicator's performance was to enhance working conditions. The participants seen the indicator "wages" more broadly than only the pure amount of received income. In this case the participants took more social aspects into account, to characterize the indicator. Employers were taking more care that employees are able to take flexible holidays for instance. Also, the technological progress was used to increase the comfort at the working space, e.g. the utilization of a milking carousel with soft ground, to increase the comfort for the workers handling the machine.

Strategies to increase the income in total were also mentioned as a measure to increase the wages. In the opinion of some participants the reason for low wages is the in not profitable

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performic of the farms in general (the average gross margin). Those strategies are e.g. production of niche products and increase productivity.

Since the participants were considering the real wage, while in agricultural reports are publishing nominal wages, a direct comparison of the accuracy of the data is difficult. Still the comparison of the perceived performance of the participants with real data published in the agricultural reports of Saxony-Anhalt, is confirming the tendency of decreasing wages. A steep decrease of the wages was noted in the agricultural report in the year 2007 when the financial crises took place. Since all businesses loss profit and could pay less for wages the participants didn't especially reflect this in the graph. This was not explicitly drawn by the participants. In the year 2011 an increase of wages was given in the data of the agricultural report of Saxony-Anhalt (Agrarbericht Sachsen-Anhalt, 2010/11). This could be explained by the relaxation of the financial situation after the financial crises. Also, this was not captured in the drawing exercise by the participants. As indicated by the participants the wages noticeable increased in the year 2015 after the implementation of the minimum wage. After this event the actual wages were on the same level than in the year 2000 (Agrarbericht Sachsen-Anhalt, 2018). Taking inflation into account it is assumed that real wages decreased over the last 20 years which is according the participants perception.

6 Resilience attributes

6.1 Case-study specific strategies

The level of implementation was scored from one to five, while one stands for a not implemented and fife for very well implemented. In general, strategies were considered to be moderately to well implemented.

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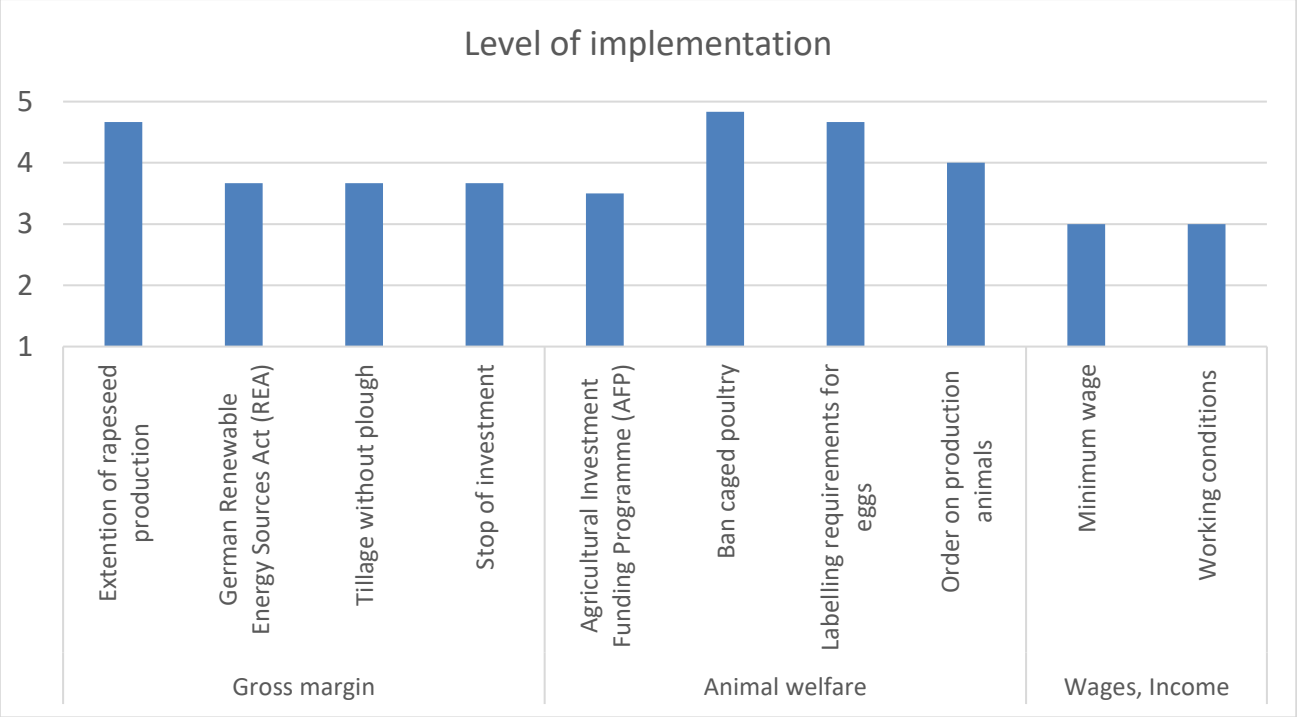

Figure 11. Bar graph showing level of implementation of strategies. 1 = not applied, 2 = slightly applied, 3 = moderately applied, 4 = adequately applied, 5 = perfectly applied.

For the indicator “gross margin” the strategy “extension of the rapeseed production” was scored highest in implementation, with a score of 4.5 (see Figure8). The other three strategies for the same indicator were scored with a value of 3.7. For the indicator “animal welfare” the strategy “ban caged poultry” was scored highest in implementation (score 4.8), followed by the strategy “labelling requirements for eggs” (score 4.7). The “order on the protection and keeping of production animals” was scored with a value of 4 and the “Agricultural investment funding programme” is scored lowest as strategy for this indicator with a value of 3.5. The strategy for the indicator “wages”, which are “minimum wages” and “working conditions”, score both the same a value of 3.

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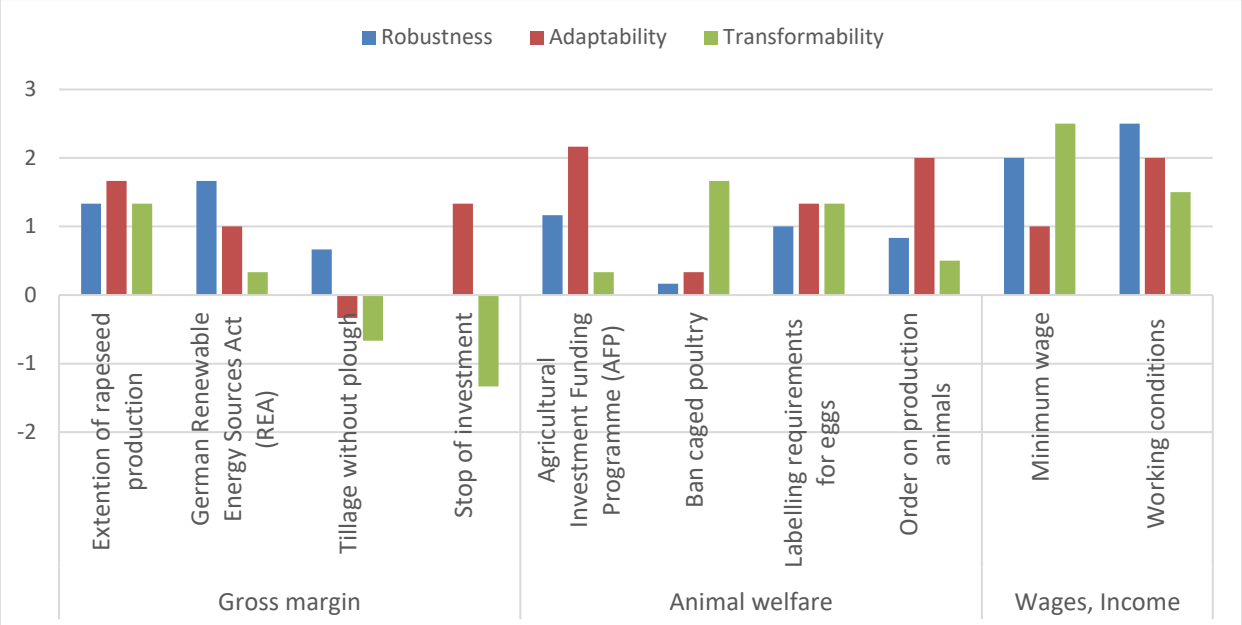

Figure 12. Bar graph showing average scoring of effect of strategy on robustness, adaptability and transformability of the farming system. A 0 implies no relationship, a 1 or -1 a weak positive or negative relationship, a 2 or -2 an intermediate positive or negative relationship, and a 3 or -3 is a strong positive or negative relationship.

The strategy "stop of investment" contributes to the adaptability of a system but counteracts the transformability of the system. At the same time, it does not contribute to robustness because the current performance of a system cannot be maintained in the first place. "Tillage without ploughing" makes the system robust because it is a cost saving method and hence the income can be increased which contributes to stabilization of the current system. However, there is a trade-off between both the capacity of adaption and transformation because the system relies on external inputs, which prevents transformation "The German Renewable Energy Sources Act (REA)" contributes most to the robustness of the system since the income of current system becomes more stable through subsidies. "Extension of rape production" is perceived to contributes most to adaptability of the system. By extension the area to cultivate bio-based resources the farm is adapting. The strategy with the highest level of implantation "extension of rapeseed production" contributes most to the resilience capacity of adaptability. The other strategies have the same level of implementation and contribute to adaptability and robustness. Therefore, a tended towards an adaptable and robust but not transformable system is observed. A synergy between the strategy "extension of rapeseed production" and "REA" is given. The REA give an incentive to farmer to extend the area to cultivate those bio-based resources crops. Another synergy is between the strategies "tillage without plough" and

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"extension of rapeseed production". The agricultural practice of tillage without plough was incentivized by the usage of Glyphosate, which was also facilitating the production of bio-based resources.

In relation to animal welfare, the "agricultural Investment Funding Programme (AFP)" is mostly contributing to the adaptability of the system, because it gives economic incentives through political regulations to use existing capital to adapt the production in a sustainable way. "Order on the protection and keeping of production animals (German designation: TierSchNutztV)" contributes to the adaptability. The system is forced by new regulations to adapt to higher animal welfare standards but is not transforming. There is a synergy between strategy "Agricultural Investment Funding Programme (AFP)" and the "Order on the protection and keeping of production animals (German designation: TierSchNutztV)", both contribute to a strengthening animal welfare through governmental incentives. The strategies "AFP" and "TierSchNutztV" are implanted least and contributing to adaptability of the system. "Ban caged poultry" is a strategy contributing to the transformability since the system has to change in order to follow the regulation of the strategy. This is also the strategy with the highest level of implantation, showing a potential for the system to transform. "Labelling requirements for eggs" follow the same mechanism than "ban of caged poultry" and contribute mostly to adaptability and transformability. Therefore, a tended towards an adaptable and transformable system is observed.

In relation to wages, the increase of the "working conditions" is a strategy contributing mostly to the robustness of the system since it is strengthening the performance of the unchanged system. On the other side "minimum wage" is contributing to transformability and less to robustness of the system. System had to transform in order to fulfil the strict governmental regulations. In the long term the system can become more through the improved working conditions. Both strategies have the same level of implantation but contribute to robustness and transformability.

6.2 General resilience attributes

The current application level of the resilience attributes in the farming system was scored from one to fife. One means no application and fife means the attribute I applied very much in the farming system. On average, all attributes were evaluated to be applied in a (very) small to moderate extent. The highest application rate of all attributes has the attribute "socially self-organized" with a score of 3.5, followed by the attribute "coupled with local and natural capital

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(production)", with a value of 3.1. The successional attributes are "response diversity" (score 2.9) and "spatial and temporal heterogeneity of farm types" (score 2.8). The attribute applied the least in the farming system are "reasonable profitable" (score 1.6), "functional diversity" (score 1.9) and "diverse policies" (score 1.9).

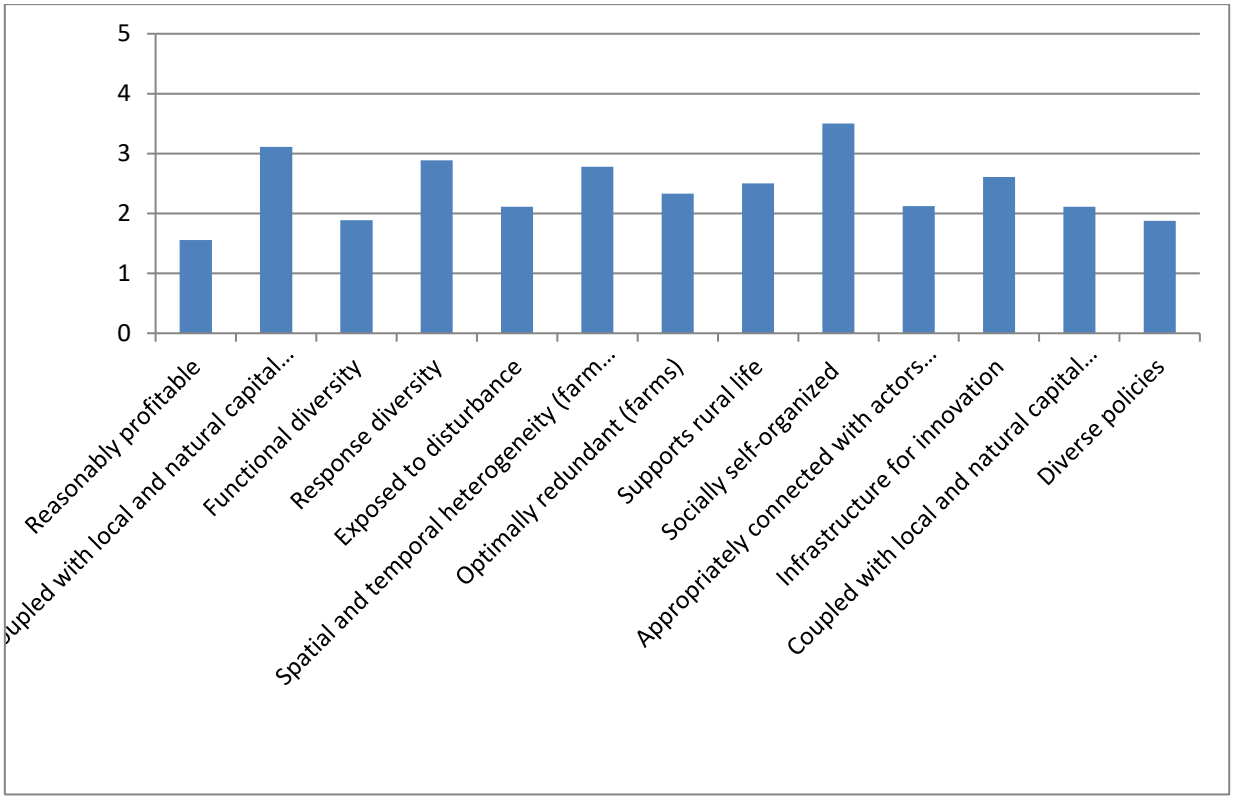

Figure 13. Bar graph showing current performance level of resilience attributes. Performance is scored as 1 = not at all, 2 = small extent, 3 = moderate extent, 4 = big extent, 5 = very big extent.

In the guidelines there are mentioned five general resilience principles which are: diversity, openness, tightness of feedbacks, system reserves, and modularity (The Resilience Alliance, 2010). The high performing attributes "socially self-organized" in the Altmark region is defining the system with the principle of modularity, since a bypass of socially self-organization is used to increase the performance. The system is using additional, alternative ways of connections for the purpose of marketing, purchasing to increase the modularity of the systems components. This increases the resilience. The second highest attribute "coupled with local and natural capital" is a characteristic to strengthening the principle of system reserves. The resources have to be maintained in the region due to poor soil fertility and unfavourable weather patterns. Because of the limited productivity of the land, the Altmark is using the limited resources and

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therefore has extensive agriculture. Because of those conditions the farms developed "response diversity" to adjust to and gain diversity in the management. The two attributes "spatial and temporal heterogeneity" and "response diversity" are related to the principle of diversity which is enhancing resilience performance. A diverse production system increases the resilience because of distribution of the income in case of failure of one component. In the Altmark the farms are mostly quite diverse in their production because of the low soil quality, unfavourable climate conditions and rural structures.

Within SURE-Farm, 4 Processes are studied, which are: agricultural practices, governance, risk management and farm demographics (Meuwissen et al. 2019). The most important attribute for the Altmark, which is "socially-self organized" contributes to the process governance. By building their own networks and institutions, the stakeholders in the case-study initiate new opportunities to govern the system e.g. through new selling options by skipping one or multiple actors. The attribute "coupled with local and natural capita (production)", contributes to the process of agricultural production. Like mentioned above the agricultural system has to be adapted to limited resources and therefore implement specific agricultural production practices to produce in the longer term. The attribute "response diversity" as well as the attribute "spatial and temporal heterogeneity (farm type)" contributes to the process of risk management. Risks which are mostly managed with this attribute in the Altmark are short term environmental and economic risks (e.g. weather extremes and fluctuating market prices).

Scored by the participants all of the attributes contribute most to robustness and the least to transformability (Figure 11).

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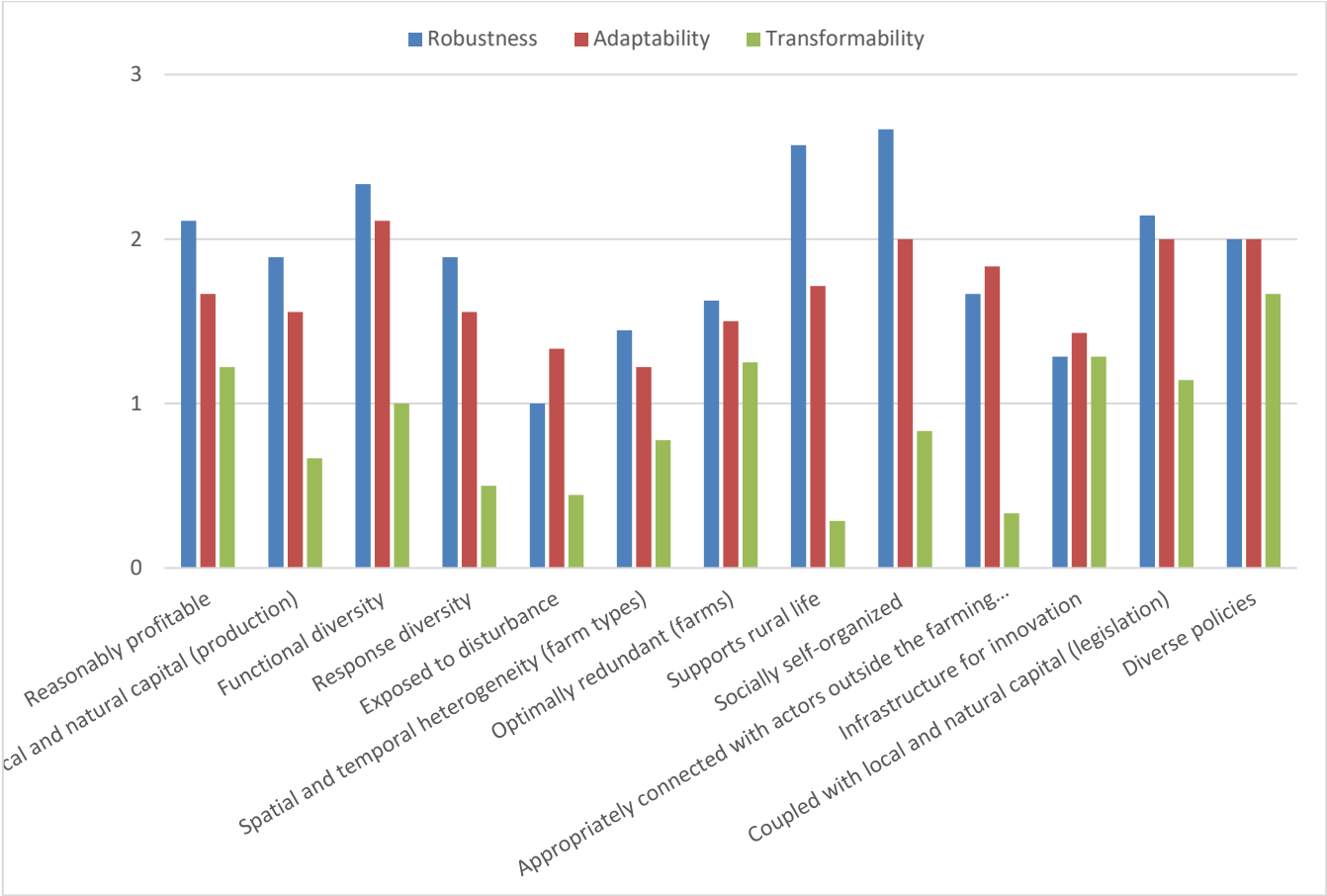

Figure 14. Bar graph showing average scoring of perceived effect of attribute on robustness, adaptability and transformability. A 0 implies no relationship, a 1 a weak relationship, a 2 a relationship of intermediate strength, and a 3 is a strong relationship.

For the attributes there are no trade-offs seen, in the sense that one positive relation courses a negative relation of another capacity. The participants score the attribute “expose to disturbance” as contributing to adaption, since a system with many challenges is forced to adapt more frequently. The attribute “infrastructure of innovation” is equally contributing to robustness and transformation. In case innovation is accessible the transformation of a farming system is possible. A synergy is given because innovation can also lead to an investment into a more robust system. The same can be seen for the attribute “diverse policies”, which is scored by the participants to have influence on all capacities depending on the direction of the policy.

The farming system is according to the attributes robust and abatable and less transformable. All the higher scoring attributes contribute most to the robustness of the system and least to the transformability. However, given the moderate level of application of the attributes, a high level of robustness performance is not ensured.

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5 Discussion

5.1 Functions of the farming system

The main findings are that private goods are more important than public goods but perform equally good in the German CS. The most important function is the "provision of food", which is performing well (score 3.6 in scale 1 to 5), followed by the function "economic viability", which is performing worse (score 2.9 in scale 1 to 5). Economic viability is perceived most important by *farmers*, while the food production is scored most important by research and consultancies, which is the expected perspective of the stakeholders. The importance of "economic viability" can be explained by findings of previous studies. Those found, that the Altmark has a weak capital base, high share of rented land, and low proportion of high-quality arable land (Appel and Balmann, 2018) and therefor represents an important challenge, which is perceived by the actors. Overall "natural resources" is the third most important function (representing public goods) and scores the best performance (3.8 in a score from 1 to 5), which is due to the extensive way regional agricultural system is typically managed (Appel et al., 2016; Appel and Balmann, 2018). *Farmers* perceive the performance of public goods lower compared to the stakeholder group *research and consultancy*. It was expected that *farmers* perceive the performance better than the other stakeholders, since for them factors for production are more relevant. However, as seen in other literature the *farmers* represent the position of conserving the resources, especially in case they are limited (Lange et al., 2015). This is even strengthened by the fact that the year 2018 was a drought year with negative impact on resources and yields. It is proven that policy makers and NGOs perceive the performance lowest, since they represent the critical view and establish laws for regulations. "Wages" is the fourth most important indicator (function "quality of life") and is performing low (2.0 in scale 1 to 5), which is reflected in the data of the published agricultural reports in the past years (agricultural report Sachsen-Anhalt 2003 till 2018). Wages is representing, next to infrastructure, the main challenge, due to the low performance (Ostermeyer and Balmann, 2011). Animal welfare is perceived as important function not because of the scored performance, but because of the high share of animal production, compared to the rest of the state. In addition, there are certain hotspots of livestock production with large stocks (Appel and Balmann, 2018), which imply contradicting perspective and controversial discussion between stakeholders.

The SURE-Farm project is using the adaptive cycle concept to assess the processes of farming systems and their current state to evaluate the potential room for improvement and evaluate

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the need for re-orientation (see methodology). The agricultural system in the Altmark region in the current state, is characterized mostly through the "exploitation and conservation" phase in the adaptive cycle. Attributes which affirm this are "coupled with local and natural material (production)", "special and temporal heterogeneity" and "response diversity", since they describe the system. Strategies in the past to increase profitability (e.g. through extension of biogas production) and quality standards (e.g. through diverse policies), are characterizing the exploitation stage in the adaptive cycle (Holling 2002). Natural capital, in form of the used resources, is conserved, because of the extensive farming management. However, according to the participants of the workshop, the farming system is not resilient in profitability. This is reflected by the indicator "gross margin", which scored medium good while the indicator "wages" scores low and therefore identifies one of the main challenges for the farming system where reorientation might be needed. The following subsections reflect on the need for reorientation and the room for increasing the resilience of the system.

5.2 Robustness, adaptability and transformability of the farming system

The resilience capacities can be defined by evaluating the level implementation of identified strategies and resilience attributes and their contribution to the resilient capacities.

5.2.1 Strategies

The strategies, identified by the participants, can be categorized into different groups. One is categorized by strategies, which contribute to adding value to the production. In the Altmark the added value is the biogas production. This is reflected in the overall highest performance of the indicator "production of biogas". The strategy to extent the rapeseed production was applied for that purpose and increased the adaptability of the system in the short term. The German Renewable Energy Sources Act (REA) was the law to stimulate the biogas production. Through previous research it is known that the REA did not increase the profitability of biogas farms on average. This is due to a transfer of a significant fraction of the added value to the landowner, because of increased rental prices on agricultural land (Appel et al. 2016). The REA could not contribute to adaptation or transformation of the gross margin but rather contributed to robustness of the system. Those strategies that contribute to added value in the production can be characterized by the attribute "response diversity" of the farms, whereby the strategy of the REA is related to policies. Since the importance of the function "bio-based resources" scored rather low, the system might shift to source profit from other functions, like food production.

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Strategies for cost saving purposes, which are used to affect the performance of the gross margin, are important for the Altmark. Strategies “Tillage without plough” and “stop of investment” are associated with that category. Such strategies are contributing to robustness and adaptability but show a trade-off with transformability. Those strategies for cost saving purposes, could be defined by a new attribute "balanced system reserves". In resilience literature the attribute is defined as “the degree to which a system is skewed toward one strength at the expense of others” (Kerner and Thomas, 2014). This implies a system has balanced reserved when inputs, controls, processes, or outputs change but does not percive a weakening of the system. The system reserves can be balanced according Abel et al. (2006) between “natural, human, social, physical and financial capital”. Through the strategy “tillage without plough” more capital was invested to use glyphosate (physical capital) for the cultivation to save financial capital, which was at risk due to lower agricultural prices (less income). This increased modularity of the system because one farming practice could be exchanged with another and contributes to robustness of the system. “Stop of investment” was a shift of financial capital (e.g. investment into a new tractor) to maintain the human capital pools. This makes the system adaptable in the short term but shows a trade-off with transformation: a transformation of the system is hindered because investment enable fundamental change (Abel et al., 2006).

Other strategies are associated with regulatory incentives of the government to increase the sustainability of production (strategies related to animal welfare). Those are the “AFP” and the “order on the protection and keeping of production animals” which are political regulations on standards of animal keeping and contribute to the long-term adaptability of the system. Those strategies can be categorized by the attribute “coupled with local and natural capital (legislation)” because they are incentives to use the existing capital to improve the production system. However, other strategies can be categorized into the group of strict government regulations which are improving the production quality. Strategies of this group are “ban of caged poultry” and “labelling requirements for eggs”. Both strategies contribute to adaptability and transformability of the system. Also, the strategy “minimum wage” can be categorized by this group since it is a strict government regulation. Those strategies can be categorized by the attribute “diverse policies”. Diverse policies score highest in the contribution to the capacity transformation compared to the other attributes. But since this attribute is scored rather low in application, it can mean that other policies are needed for a transformation. Also, policies that apply fixed rules to increase income tend to cause a system to lose resilience in the long term (Holling 1986, 1995).

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5.2.2 Attributes

None of the attributes scored a high level of application but rather low to moderately (1.9 to 3.5 on a scale 1 to 5). Also, the participants assessed that the attributes contribute overall most to the robustness of the system. The attribute with highest presence in the farming system is "socially-self organized". This implies opportunities for increased resilience in the Altmark region through networks between farming system actors. According to Cabell and Oelofse (2012) this attribute is associated with the reorientation phase in the adaptive cycle. It can be argued that the Altmark farming system has to pass through this reorientation phase to reach more self-organization to increase the resilience. Despite that, there are also attributes that were assessed to be highly present in the Altmark which were associated with adaptability: "spatial heterogeneity" and "coupled with local and natural resources". The attribute "production coupled with natural resources" scored second highest in level of presence. Combining the level of application and contribution to the capacities a higher value for adaptability is observed, compared to the other capacities. This is reflected in the more extensive form of production of the Altmark, which relies on the maintenance of the limited resources. According to Hoekstra et al. (2018), those system reserves are used to cope with change and surprise as a buffer capacity. Spatial heterogeneity is an important attribute contributing to resilience (Resilience Alliance, 2010). High assessed levels of presence are due to the heterogeneity in size, production and and specialisation of farms. But because of limited economical reserves for human capital, the system has limited opportunities for transformation. Attributes which characterize transformation are scored low with regard to being present in the system, for instance "infrastructure for innovation", "functional diversity" and "appropriately connected with actors outside the farming system". The attribute "infrastructure for innovation" was assessed to be moderately present, compared to the others. To improve working conditions, automation and new technologies were implemented in the past in the farming system of the Altmark region. This increased productivity mostly in the dairy sector, which contributes to robustness of the system. To transform the system, investment in infrastructure is needed to gain better access to more innovations, which enables transformation. Lastly the attribute "reasonably profitable" is scored lowest of all attributes and illustrates the need for change.

5.2.3 Assessing the accordance with different rationales

To assess the capacities of the Altmark system, the accordance of system characteristics with rationales defined by Hoekstra et al. (2018) can be assessed. Hoekstra et al. (2018) are defining two narratives in their work, which are characterizing the management of social-ecological systems under uncertainty. The first rational is the control rational, which is characterized mostly by the focus on robustness and efficiency. Secondly, the resilient rational is characterized by a focus on adaptability and transformability.

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The potential of a resilient system, through adaptive and transformative capacities is mainly based on diversity of the farming system in the Altmark region. Complementary strategies used in the past to adapt to several governmental changes (end of second world war and reunion of Germany) was creating heterogeneity in size, production and farm type (Levin, 1999). Also, the strategies "AFP" and the "order on the protection and keeping of production animals" to increase animal welfare, were applied to use the existing resources in an adaptive way. The extensive management (does not refer to organic production) of resources in the Altmark region is a characteristic of the resilient rational (Hoekstra et al., 2018), which is confirmed by the higher score of the attribute "coupled with natural resources". At the same time, other attributes and strategies determine the narrative of a robust and less flexible system, which Hoekstra et al. (2018) defines as the control rationale. The increase of biogas production through extension of e.g. rapeseed and maize production was intended to increase the profitability and according to Scott (1998) it represents a rationale of a controlled system. The strategies of cost saving measures are the economic use of limited resources and also defining the control rationale (Blanchard and Fabrycky 2014). The lack of system reserves creates a more robust system since the range of maneuver is limited.

The system is mainly robust, and adaptability, however transformability is mainly limited due to the low economic performance.

7.3 Options to improve the resilience of the farming system

Based on the workshop results, conversations with research experts and related literature options to improve the resilience of the farming system in the Altmark region can be suggested.

One of the challenges of the farming system is to find educated workforce (farm demographic surveys). To increase resilience, it could be beneficial to give incentives to raise attractiveness of education in the agriculture sector. The regional media of the Altmark published an article that the green party is in favor to open a technical school to teach also about organic production practices (Bündnis 90/Die Grüne, 2018). This is due to fact that organic production increased during the last years, without educational support. This is challenging because the rural area is limited in infrastructure to offer the platform for educational purposes. Because of this, the local government evolved a development concept, to tackle the biggest challenges like poor infrastructure (Schmidt, 2003). At the same time the incentive to raise attractiveness of education is limited because the payment of low wages. Low wages are discouraging people to choose an education or job in agriculture.

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To increase the profit of the farming system, participants mentioned the option of using niche products. A certain marketing strategy needs to be developed to sell the output. For farmers in the Altmark it is difficult to compete on the market. Direct sales could increase the profitability, because part of the profit does not have to be handed over to a middle man. The internet is a platform to organize this marketing strategy, but the infrastructure is also limited and has to be expanded. Also, here the local government is building on development concepts to increase digitalization in the rural area attempt to increase internet connections (Scheinert, 2015). This is connected to the attribute "socially-self organized", which can provide opportunities to use the created networks for better distribution and sales of agricultural produce. The attribute "socially self-organized" was scored highest by the participants in the workshop. The concept of community supported agriculture (CSA) is one option used in the Altmark region to increase modularity of the system and increase the income (Ritter-Findeisen, 2017).

The demographic change is one of the main challenges for the Altmark region, because of outmigration and loss of potential working force and successors. It is noticeable that in the past many governmental regulations were driving the direction of the farming system. The political framework which is driving the support of rural areas and demographic change will influence the direction of the farming system resilience. For an adaptable system in the long-term, flexible, adaptive legislations are needed, which are coupled with local and natural conditions.

7.4 Methodological challenges

Challenges occurred during the explication of the scoring system in the workshop. Especially during the exercise to score the importance and performance of the indicators, the participants were questioning the methodology and were first not willing to engage. Many questions and assumptions from their side were necessary to increase the cooperativeness to score the indicators. It is questionable if the participants confound the scoring for importance and performance of the indicators. The importance of e.g. the indicators "farms with direct marketing" was scored very low, which is reflected in the trend of the performance score. However, this is contradicting with the group discussion where the importance was highlighted despite the poor performance. Observation of the workshop shows that the participants perceived the performance of the indicators more important to assess than the importance. Therefore, it is crucial to explain the purpose of the exercise comprehensibly to ensure the engagement of the participants. A short definition of the system functions and indicators with examples could have been useful to accelerate the exercise.

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The exercise to score the resilience capacities for the strategies and attributes were complex and not enough time was available to explain the concept in the necessary depth. The capacity of robustness can be optioned through a change in a short term (month to years) (Anderies *et al.*, 2013). However, a transformation process can be realized in a longer period, comprising several decades to centuries. Depending on the time scale the participants are using to determine contribution to resilience, they might focus only on certain capacities. Also, examples of the three resilience capacities could have helped in this situation with a remark to take different time perspective into account. An improvement can be, to shorten this exercise and include an additional open discussion round, to ask stakeholders for personal examples of strategies and attributes and how they think there are influencing the resilience.

During the open discussion at the end, it was a challenge to receive the unadulterated opinion of the participants. This was challenging because certain participants were taking the lead in the conversation which can bias the conclusion of the discussion. Stakeholder groups with less representatives can lose the weight of statement in case the group is represented by passive participants, which is more likely in small groups. Also, some of the participants already knew each other from other discussion rounds. This can also lead to biased inputs because participants embody the opinion of the predefined roles of the last discussion round. A way of improvement would be that the moderator asks other participants for their opinion more directly to balance the expressed views.

7.5 Conclusions

By summarizing the findings of the country report, it can be stated that wages and poor infrastructure are the main challenges for the resilience of the Altmark region. The strategy “minimum wages” was used as a strict governmental regulation to increase performance of the wages and. However. this strategy increased the performance only slightly, and low wages remained the main challenge after all. The low economic viability of the system is the cause of this challenge, which was identified by the participants. Used strategies in the past to increase the performance of gross margin, were balancing different system reserves. Those strategies contribute to robustness and adaptation but hamper transformation of the system. Transformation might be needed because the resilience attribute of “reasonable profitable” was scored low. The highest scored resilience attribute is “socially-self organized” and contains a chance for the resilience in the Altmark region, through networks between the farming system actors. Lastly, many diverse policies were applied to raise the indicator “animal welfare” which

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contributed to adaptability and even transformation. However, the attribute “diverse policies” was scored low in application in the system and might identify the need for other regulations.

The agricultural system, in its current state, is characterized mostly by the “exploitation and conservation” phase of the adaptive cycle (Holling 2002). Strategies in the past to increase profitability (e.g. through extension of biogas production) and quality standards (e.g. through diverse policies), are characterizing the exploitation stage in the adaptive cycle. Natural capital is conserved, because of the extensive management. The diversity of the production system combined with the extensive management are characterizing the system as adaptive, in the resilient rational according to Hoekstra et al. (2018). However, the human capital is limited because the farming system is not sustainable in terms of profitability and consequently cannot pay decent wages to agricultural workers. Therefore, the farming system is mainly adaptable and also robust in particular processes but experiences a lock-in due to low wages and infrastructure issues. Consequently, transformability of the farming system is considered to be low.

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References

Abel, N., Cumming, D. H. M. and Anderies, J. (2006) 'Collapse and reorganization in social-ecological systems', Ecology and Society, 11(1).

Anderies, J. M. et al. (2013) 'Aligning key concepts for global change policy: Robustness, resilience, and sustainability', Ecology and Society, 18(2). doi: 10.5751/ES-05178-180208.

Appel, F. and Balmann, A. (2018) 'Human behaviour versus optimising agents and the resilience of farms – Insights from agent-based participatory experiments with FarmAgriPoliS', Ecological Complexity. Elsevier. doi: 10.1016/J.ECOCOM.2018.08.005.

Appel, F., Ostermeyer-Wiethaup, A. and Balmann, A. (2016) 'Effects of the German Renewable Energy Act on structural change in agriculture – The case of biogas', Utilities Policy. Elsevier Ltd, 41, pp. 172–182. doi: 10.1016/j.jup.2016.02.013.

Blanchard, B. S. and Fabrycky, W. J. (2014) Systems Engineering and Analysis 5th edn (Harlow: Pearson)

Bündnis 90/Die Grünen. Franke: „Sachsen-Anhalt braucht eine Fachschule für Ökolandbau!" Die Altmark, Grüne Weise für alle. March 2018 [Accessed 28.04.2019] Available from http://gruene-altmark.de/franke-sachsen-anhalt-braucht-eine-fachschule-fuer-oekolandbau/

Bündnis 90/Die Grünen. Mehr Tierwohl: Sauen müssen sich bewegen können. Die Altmark, Grüne Weise für alle. March 2017 [Accessed 28.04.2019] Available from http://gruene-altmark.de/mehr-tierwohl-sauen-muessen-sich-bewegen-koennen/

Dörthe Hein. June 2018. In Iden steht der Saustall der Zukunft. Volksstimme.de. June 2015 [Accessed 28.04.2019] Available from https://www.volksstimme.de/nachrichten/deutschland_und_welt/deutschland/1487475_In-Iden-steht-der-Saustall-der-Zukunft.html

Gunderson, L.H. C.S. Holling and S. S. Light. 1995. Barriers and Bridges to the Renewal of Ecosystems and Institutions. Columbia University Press, New York.

Hoekstra, A. Y., Bredenhoff-Bijlsma, R. and Krol, M. S. (2018) 'The control versus resilience rationale for managing systems under uncertainty', Environmental Research Letters. IOP Publishing, 13(10), p. 103002. doi: 10.1088/1748-9326/aadf95.

Holling, C. S. 1986. Resilience of ecosystems; local surprise and global change. pp. 292-317 in Sustainable Development of the Biosphere, W. C. Clark and R. E. Munn, editors. Cambridge University Press, Cambridge.

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

Holling, C. S., Gunderson, L. H. (2002). Resilience and adaptive cycles. In Panarchy: Understanding Transformations in Human and Natural Systems (pp. 25–62).

Kerner, D. A., Thomas, J. S. (2014) Resilience Attributes of Social-Ecological Systems: Framing Metrics for Management. Resources 3, 672-702; doi:10.3390/resources3040672

Lange, A., Siebert, R. and Barkmann, T. (2015) 'Sustainability in land management: An analysis of stakeholder perceptions in Rural Northern Germany', Sustainability (Switzerland), 7(1), pp. 683–704. doi: 10.3390/su7010683.

Levin, S. A. (1999) Fragile Dominion. Cambridge, MA: Perseus

MRLU [Ministerium für Raumordnung Landwirtschaft und Umwelt des Landes Sachsen-Anhalt] (2003) 'Bericht zur Lage der Land-, Ernährungs- und Forstwirtschaft des Landes Sachsen-Anhalt 2003'.

MULE (2016) 'Bericht zur Lage der Landwirtschaft des Landes Sachsen-Anhalt', pp. 1–100.

Ostermeyer, A. and Balmann, A. (2011) 'Perception of dairy farming from different views – results of a stakeholder discussion in the region Altmark , Germany', Change.

Resilience Alliance. (2010). Assessing resilience in social-ecological systems: Workbook for practitioners. Version 2.0. Online: http://www.resalliance.org/3871.php.

Ritter-Findeisen, I. August 2017. So geht Landwirtschaft heute!. Volksstimme.de. [Accessed 28.04.2019] Available from https://www.volksstimme.de/lokal/stendal/zukunft-altmark-so-geht-landwirtschaft-heute

Sachsen-anhalt, L. (2006) 'Forstwirtschaft und Tierschutzbericht des Landes Sachsen-Anhalt'.

Scheinert, K. (2015). Land(auf)Schwung: Die Förderregion Stenda. Bundesministerium für Ernährung und Landwirtschaft [Accessed 28.04.2019] Available from https://www.bmel.de/DE/Laendliche-Raeume/BULE/land-auf-schwung/Foerderregionen/_texte/Portrait-Stendal.html

Schmidt, U. 2003. Regionales Entwicklungskonzept Altmark. Regionalen Planungsgemeinschaft Altmark

Scott JC1998 Seeing Like a State: How Certain Schemes to Improve. The Human Condition Have Failed (New Haven, Connecticut: Yale University Press)

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Appendix A. Workshop memo

The workshop was conducted in a conference room of a conference center in Zethlingen in the Altmark region. The facilities of the room were of good quality and sufficient for the purpose of the workshop. The used tables were arranged in a “U from” with the open end towards the screen of the presentation. The temperature was high enough since the caretaker pre heated the room already before the workshop. The light was a bit too low during some parts of the workshop. It was a cloudy day and not sunlight was entering the room. At the same time the ambient light was switched off to see the proception of the power point presentation better. It would have helped to switch it one when participants were filling out the survey papers to increase the concentration.

There was offered tea, coffee and small snacks during the whole workshop. This helped to increase the motivation of the participants. Also, the food for lunch was of good quality and the participants were satisfied after. It was noticeable that the concentration dropped before lunch time so maybe it would have been good to have the lunch break some minutes earlier. The lunch break helped to obtain a better atmosphere because the participants could get to know each other and had the option to talk about other topics besides the workshop.

The attitude of the participants was good on average. The highest attitude could be noticed in the beginning. After the doubts of the participants towards the scoring system of the indicators it dropped noticeable. Due to the good guidance of the moderator the workshop could proceed without major disruptions. Also, during the scoring of the three capacities of the attributes the concentration of the participants decreased. In this situation the one to one guidance offered by the researcher team helped the participants to increase their focuse.

The workshop started at 9:45 a clock with coffee, tea or other refreshments. The official start was at 10:00 a clock with the presentation. In between the participants were allowed to get a coffee, tea or other refreshments and fruits, but there was no official break. At 12: 15 a clock a lunch break took place for one hour. Also, in the afternoon participants were allowed to get coffee, tea or refreshments and fruits during the workshop, but there was no official break. The whole workshop ended at 16:00 a clock.

Table A1. Stakeholder overview

Function	Organization	Stakeholder group
Private Consultant	Berteuung und Beratung	Research and Consultant

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Farmer	Agrargesellschaft GmbH	Farmer
Market-manager	Sparkasse	Research and Consultant
NGO	Friends of the earth (BUND)	Politics and NGO
Farmer	Farmer	Farmer
Farmer	Organic farmer	Farmer
Researcher and teacher	Anhalt University of Applied Science	Research and Consultant
Farmer, Student	Student and farmer	Farmer
Member of the parliament of Sachen-Anlaht	Politics green party	Politics and NGO
Member of the parliament of Sachen-Anlaht	Politics SPD	Politics and NGO
Manager	Bauernverband	Politics and NGO
Farmer	Agrargemeinschaft	Farmer

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Appendix B. Details on ranking and rating the functions and indicators

Table A2. Mean and standard deviation of scores per essential function (EF) per stakeholder group and for all participants. 100 points needed to be divided to 8 EF.

	Farmer		Research and Consultant		Politics and NGO's		All	
Function	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Food production	12.9	5.6	30.0	20.0	21.9	12.5	20.2	13.3
Bio-based resources	7.6	4.9	10.0	0.0	11.9	2.4	9.6	3.8
Economic viability	26.8	23.1	10.0	0.0	9.4	3.1	16.8	16.6
Quality of life	11.9	4.4	11.7	7.6	8.1	3.8	10.6	5.0
Natural resources	13.9	5.4	13.3	7.6	14.4	4.3	13.9	5.1
Biodiversity & habitat	9.7	4.6	6.7	2.9	11.9	2.4	9.7	3.9
Attractiveness of the area	7.7	6.3	13.3	14.4	10.6	1.3	10.1	7.6
Animal health & welfare	9.3	2.6	5.0	5.0	11.9	2.4	9.1	4.0

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Table A3. Importance of indicators per stakeholder group; original values and transformed values to include importance of the function and number of indicators per function. Transformed values allow for direct comparison between all indicators across all functions.

	Transformed values											
	Farmer		Politics and NGO's		Research and Consultant		Total		Farmer		Politics and NG	
Indicator	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev	Mean	St. D
Milk production [kg/cow and y	34.0	4.6	28.4	7.6	34.0	9.6	24.2	10.6	38.6	13.4	43.3	
Cereal production [t/ha]	31.0	2.3	20.2	5.5	31.0	4.6	19.4	8.7	30.6	6.7	30.8	
Other food crops[t/ha]	25.0	2.3	16.9	4.5	25.0	6.2	16.9	6.6	30.6	6.7	25.8	
Production of biogass	12.0	2.3	7.7	1.2	12.0	2.0	7.0	3.9	28.8	13.1	32.5	
Share of crop rotation	8.0	5.0	16.0	1.2	8.0	2.0	11.0	4.9	71.3	37.7	67.5	
Gross margin per hectare	18.0	17.8	15.5	9.6	18.0	5.2	31.1	21.6	63.8	23.9	55.0	
Closure of a farm	7.0	10.3	5.6	6.1	7.0	9.6	7.7	8.3	12.2	14.7	20.0	
Ability to invest	5.0	16.7	7.0	4.9	5.0	4.6	11.6	12.6	24.0	21.6	25.0	
Cultural, social offerings	4.7	3.5	5.4	2.6	4.7	0.0	5.1	2.5	11.0	8.2	16.5	
Infrastructure (Internet, child c	7.8	6.8	7.5	1.6	7.8	2.7	8.4	4.4	20.0	15.0	22.9	
Availability of contractors	9.3	3.9	7.5	1.6	9.3	8.1	8.0	4.3	16.0	7.5	22.9	
Wages	24.9	11.7	12.2	3.1	24.9	10.8	20.8	10.7	53.0	23.9	37.6	
Water quality	23.1	4.6	19.7	3.7	23.1	3.1	18.0	5.5	24.2	9.5	34.2	
Soil quality	21.3	4.4	18.2	3.6	21.3	0.0	18.4	3.8	30.0	8.5	31.6	
Legal framework for fertilizer	3.6	11.4	9.3	13.1	3.6	3.1	10.1	10.8	26.2	21.0	16.3	
Responsible usage of fertilizer	5.3	4.6	10.3	8.9	5.3	5.3	9.3	6.3	19.6	9.1	17.9	
Biodiversity of birds, insects ar	5.6	4.8	13.4	5.3	5.6	1.4	10.6	5.1	38.8	18.5	37.5	
Responsible usage of chemical	5.6	1.2	9.4	4.5	5.6	5.1	8.2	3.6	30.0	6.3	26.3	
Legal framework of usage of ch	8.9	5.4	12.9	3.9	8.9	6.3	10.3	5.1	31.1	11.8	36.3	
Agrartorismus	12.4	3.5	7.1	4.4	12.4	1.5	6.9	4.9	11.0	16.4	16.8	
Farms with direct marketing	10.7	6.2	8.3	3.2	10.7	4.6	8.2	4.9	21.0	18.9	19.6	
Internet connection	17.8	8.3	16.7	5.4	17.8	7.7	15.9	6.8	46.0	30.7	39.3	
Attractive village life	12.4	3.9	10.3	6.0	12.4	1.5	9.4	4.6	22.0	8.7	24.3	
Certification of animal welfare	5.0	1.5	14.5	3.1	5.0	4.6	11.9	5.0	16.0	5.0	38.3	
Use of antibiotics	7.0	7.9	13.7	7.0	7.0	1.7	8.2	7.3	50.0	30.0	40.8	
Legal framework of animal wel	3.0	6.7	7.4	5.3	3.0	3.0	7.2	5.7	34.0	26.3	20.8	

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Table A4. Mean and standard deviation of scoring on performance of indicators per stakeholder group and for all participants. Indicators were scored from 1-5 where 1 = very low, 2 = low, 3 = medium, 4 = good, and 5 = perfect.

	Corrected values							
	Farmer		Politics and NGO's		Research and Consultant		Total	
Indicator	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev
Milk production [kg/cow and year]	3.400	1.517	4.333	0.58	4.333	0.577	3.909	1.136
Cereal production [t/ha]	3.400	0.894	3.667	0.58	3.667	1.000	3.364	0.809
Other food crops[t/ha]	3.400	1.140	3.000	0.00	3.000	1.000	3.182	0.874
Production of biogas	4.600	0.548	4.000	0.00	4.000	1.155	4.364	0.674
Share of crop rotation	2.600	1.517	3.333	1.15	3.333	0.577	3.091	1.221
Gross margin per hectare	3.000	0.707	3.333	0.58	3.333	0.000	3.091	0.539
Closure of a farm	1.750	0.500	2.750	0.96	2.750	1.155	2.636	1.120
Ability to invest	3.000	1.414	2.333	0.58	2.333	0.577	2.700	0.949
Cultural, social offerings	2.400	0.548	2.667	0.58	2.667	0.000	2.400	0.516
Infrastructure (Internet, child day-care, doctors, streets)	1.600	0.548	2.667	0.58	2.667	0.000	2.000	0.667
Availability of contractors	2.200	0.837	2.667	0.58	2.667	0.707	2.400	0.699
Wages	2.000	1.732	2.000	0.00	2.000	0.000	2.000	1.155
Water quality	4.000	0.707	4.333	0.58	4.333	0.000	4.100	0.568
Soil quality	3.600	0.548	4.000	1.00	4.000	0.000	3.800	0.632
Legal framework for fertilizer	3.000	1.225	2.750	1.50	2.750	0.707	3.182	1.328
Responsible usage of fertilizer	4.000	0.000	3.000	1.41	3.000	0.000	3.636	0.924
Biodiversity of birds, insects and wild plants	3.800	0.447	2.250	1.50	2.250	0.000	3.273	1.191
Responsible usage of chemical crop protection	3.800	0.837	2.750	1.50	2.750	0.000	3.455	1.128
Legal framework of usage of chemical crop protection	2.700	0.975	2.250	1.50	2.250	0.707	2.682	1.146
Agrartorismus	1.800	0.837	2.000	1.00	2.000	0.707	2.000	0.816
Farms with direct marketing	1.600	0.548	2.000	1.00	2.000	0.707	1.700	0.675
Internet connection	1.800	1.304	1.500	0.58	1.500	0.707	1.636	0.924
Attractive village life	3.333	0.577	3.667	1	3.667	Value not available	3.429	0.535
Use of antibiotics	3.800	1.643	2.750	1.26	2.750	0.707	3.364	1.362
Certification of animal welfare	3.600	1.517	3.250	1.71	3.250	0.000	3.545	1.368
Legal framework of animal welfare	2.800	1.643	2.250	1.50	2.250	0.707	2.727	1.421

Legend: colour the scores of the means, with 1-2 = red, 2-3 = orange, 3-4 = light green, and 4-5 = dark green.

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Table A5. Mean and standard deviation of scoring on performance of functions per stakeholder group and for all participants. Derived from scoring of importance and performance of indicators.

	Corrected values							
	Farmer		Politics and NGO's		Research and Consultant		Total	
Function	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev
Food production	3.3	0.9	2.7	1.8	3.4	0.6	3.1	1.2
Bio-based resources	3.1	0.8	3.3	0.6	3.6	0.4	3.3	0.6
Economic viability	2.6	0.9	2.4	1.4	3.0	0.3	2.6	0.9
Quality of life	2.0	1.0	2.4	0.3	2.1	0.1	2.2	0.7
Natural resources	3.6	0.2	2.9	1.8	4.0	0.1	3.4	1.1
Biodiversity & habitat	3.4	0.4	2.4	1.5	3.8	0.3	3.1	1.0
Attractiveness of the area	1.8	0.8	1.7	1.1	1.6	1.0	1.7	0.8
Animal health & welfare	3.3	1.4	2.7	1.4	3.6	0.4	3.1	1.2

Legend: colour the scores of the means, with 1-2 = red, 2-3 = orange, 3-4 = light green, and 4-5 = dark green.

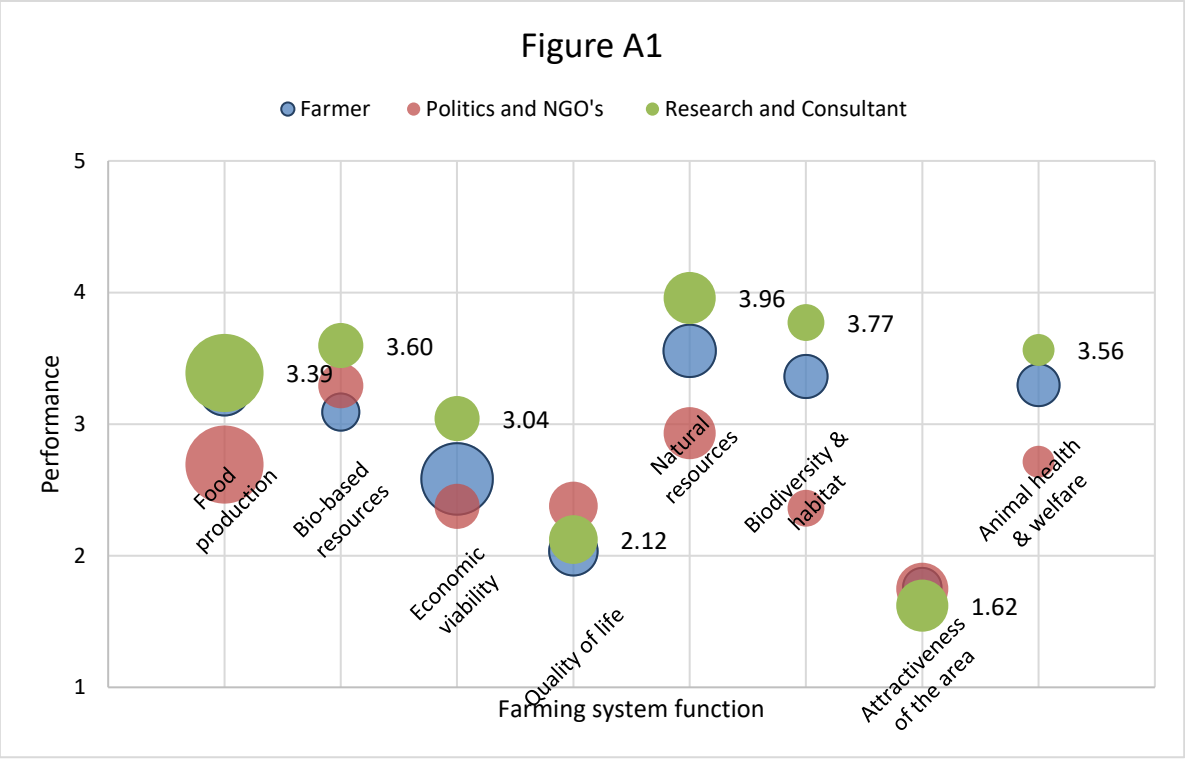

Figure A1. Bubble graph presenting averaged scores on performance of **essential functions** (from 1 to 5), aggregated by stakeholder group, while also indicating their importance (size of the bubbles), relative to each other.

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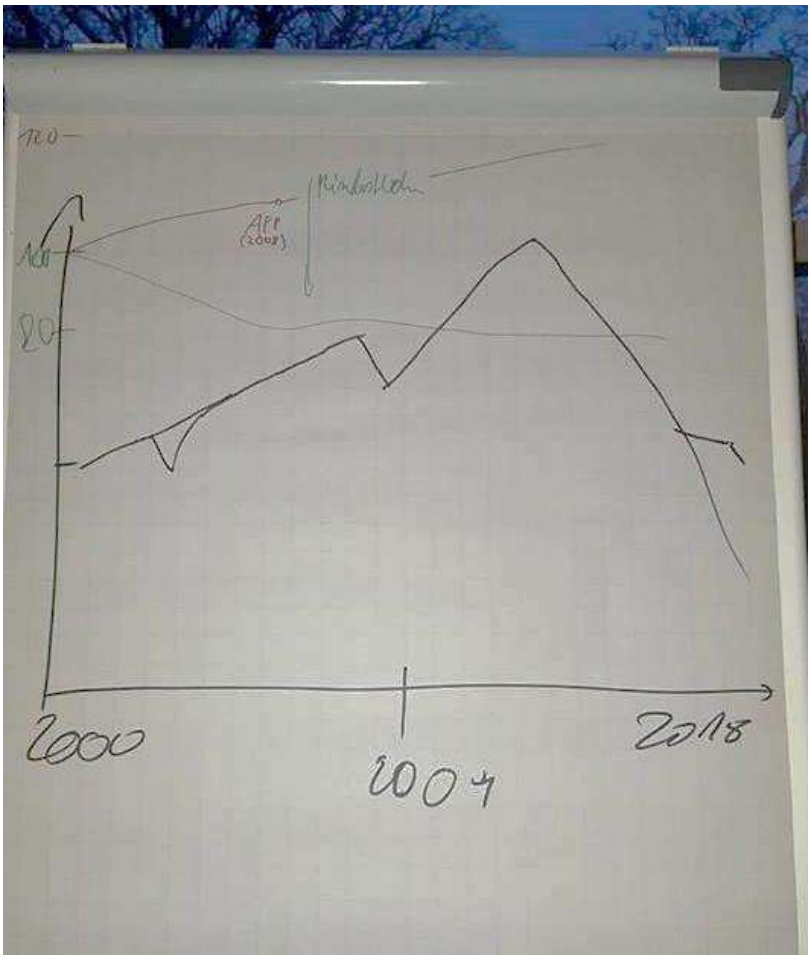
Appendix C. Dynamics of main indicators

Photo of the three drawn indicator (gross margin, wages, animal welfare) performance over the last 18 years



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Appendix D. details on scoring strategies and resilience attributes

Table A6. Mean (and standard deviation) of implementation scores of strategies and their potential contribution to robustness, adaptability and transformability

				Potential contribution to resilience capacities					
		Implementation score		Robustness		Adaptability		Transformability	
Selected indicator	Strategy	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev
Gross margin	Extension of rape production	4.7	0.6	1.3	1.5	1.7	1.5	1.3	1.5
Gross margin	German Renewable Energy Sources Act (EEG)	3.7	1.5	1.7	2.3	1.0	1.7	0.3	2.5
Gross margin	Tillage without plough	3.7	0.6	0.7	1.2	-0.3	2.1	-0.7	2.3
Gross margin	Stop of investment	3.7	1.5	0.0	2.6	1.3	2.9	-1.3	2.1
Gross margin	Grand Total	3.9	1.1	0.9	1.8	0.9	2.0	-0.1	2.1
Animal welfare	Agricultural Investment Funding Programme (AFP)	3.5	1.0	1.2	1.2	2.2	1.2	0.3	0.8
Animal welfare	Ban caged poultry	4.8	0.4	0.2	1.9	0.3	1.4	1.7	1.8
Animal welfare	Labelling requirements of eggs	4.7	0.8	1.0	1.3	1.3	1.2	1.3	1.5
Animal welfare	Order on the protection and keeping of production animals	4.0	0.0	2.3	1.0	1.5	1.0	2.0	0.8
Animal welfare	Grand Total	3.0	0.9	0.8	1.4	1.5	1.4	1.0	1.6
Wages, income	Minimum wage	3.0	-	2.0	1.4	1.0	1.4	2.5	0.7
Wages, income	Working conditions	3.0	-	2.5	0.7	2.0	0.0	1.5	0.7
Wages, income	Grand Total	3.0	0.0	2.3	1.0	1.5	1.0	2.0	0.8
Gran Total		4.1	1.0	1.0	1.5	1.3	1.5	0.8	1.8

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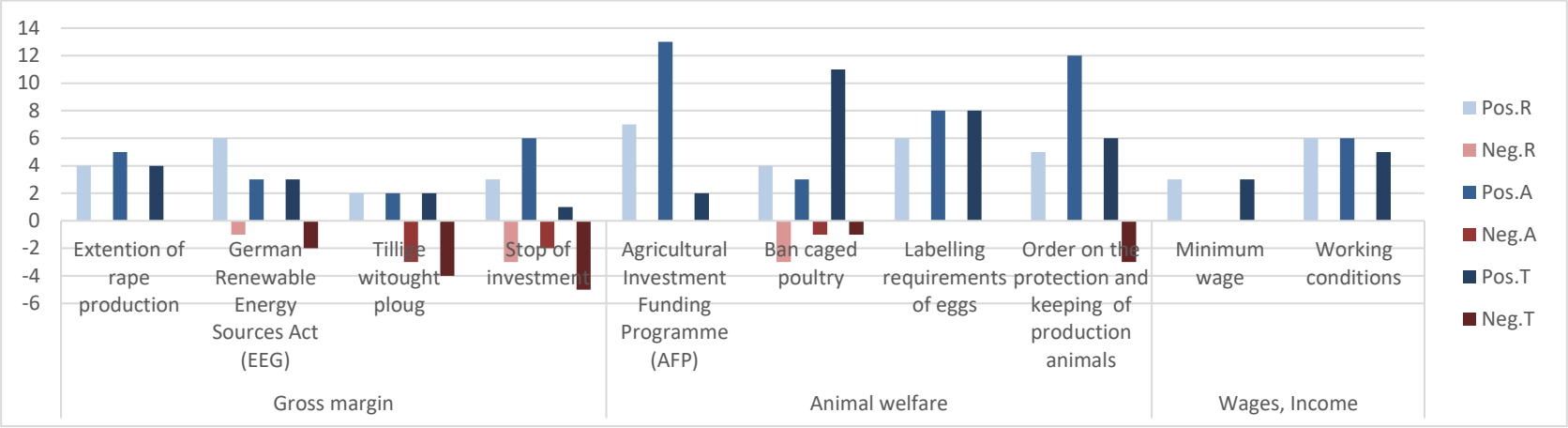

Figure A2. Bar graph presenting total positive and negative points allocated to a strategy's contribution to robustness, adaptability and transformability.

Table A7. Mean and standard deviation of performance scores of resilience attributes. Per stakeholder group and for all participants.

	Extent into which attribute applies in FS							
	Farmer		Politics and NGO's		Research and Consultant		Total	
Resilience attribute	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev
Reasonably profitable	1.3	0.5	3.0	1.4	1.0	0.0	1.6	1.0
Coupled with local and natural capital (production)	2.8	0.5	3.5	0.7	3.3	1.5	3.1	0.9
Functional diversity	2.0	0.0	2.0	1.4	1.7	0.6	1.9	0.6
Response diversity	3.3	0.5	2.0	1.4	3.0	1.0	2.9	0.9
Exposed to disturbance	2.3	0.5	3.0	0.0	1.3	0.6	2.1	0.8
Spatial and temporal heterogeneity (farm types)	3.0	0.8	3.0	1.4	2.3	0.6	2.8	0.8
Optimally redundant (farms)	1.5	1.0	5.0	0.0	1.7	1.2	2.3	1.7

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Supports rural life	2.3	1.0	4.0	1.4	1.5	0.7	2.5	1.3
Socially self-organized	3.3	1.3	4.0	0.0	3.5	2.1	3.5	1.2
Appropriately connected with actors outside the farming system	2.0	1.4	3.0	1.4	1.5	0.7	2.1	1.2
Infrastructure for innovation	2.6	0.5	4.5	0.7	1.3	0.6	2.6	1.3
Coupled with local and natural capital (legislation)	2.0	0.0	2.5	0.7	2.0	1.0	2.1	0.6
Diverse policies	1.3	1.5	3.5	2.1	1.3	0.6	1.9	1.6

Table A8. Mean and standard deviation of resilience attribute's contribution to robustness, adaptability and transformability. Per stakeholder group and for all participants.

	Extent into which resilience attribute potentially can contribute to resilience capacities in FS											
	Farmer						Politics and NGO's					
	Robustness		Adaptability		Transformability		Robustness		Adaptability		Transformability	
Resilience attribute	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Reasonably profitable	2.8	0.5	2.8	0.5	2.5	0.6	2.5	0.7	1.0	1.4	0.0	0.0
Coupled with local and natural capital (production)	2.0	1.4	1.5	0.6	1.0	2.2	2.0	1.4	1.5	0.7	0.0	1.4
Functional diversity	2.0	1.4	2.5	0.6	1.5	1.0	3.0	0.0	2.0	0.0	-1.0	0.0
Response diversity	1.5	1.3	1.3	2.2	1.0	1.7	3.0	0.0	2.0	1.4	0.0	0.0
Exposed to disturbance	2.0	1.4	2.5	0.6	1.5	1.7	0.5	3.5	0.0	2.8	-0.5	0.7
Spatial and temporal heterogeneity (farm types)	1.8	1.5	1.5	1.7	1.5	1.3	1.0	2.8	0.5	0.7	0.0	0.0
Optimally redundant (farms)	1.3	1.5	1.3	1.5	2.0	1.7	3.0	0.0	2.5	0.7	1.5	2.1
Supports rural life	2.7	0.6	1.7	1.5	0.3	0.6	2.5	0.7	2.0	1.4	0.5	0.7
Socially self-organized	3.0	0.0	2.0	1.0	1.7	1.5	2.0	-	2.0	-	0.0	#DIV/0!

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Appropriately connected with actors outside the farming system	1.0	0.0	1.3	0.6	0.7	0.6	3.0	-	3.0	-	0.0	#DIV/0!
Infrastructure for innovation	1.0	1.0	1.3	1.2	1.3	0.6	3.0	-	3.0	-	3.0	#DIV/0!
Coupled with local and natural capital (legislation)	2.7	0.6	2.3	1.2	1.3	1.5	1.0	-	1.0	-	0.0	#DIV/0!
Diverse policies	2.5	0.7	3.0	0.0	3.0	0.0	3.0	-	3.0	-	3.0	#DIV/0!

	Extent into which resilience attribute potentially can contribute to resilience capacities in FS											
	Research and Consultant						Research and Consultant					
	Robustness		Adaptability		Transformability		Robustness		Adaptability		Transformability	
Resilience attribute	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Reasonably profitable	1.0	2.6	0.7	2.5	0.3	2.5	2.1	1.6	1.7	1.7	1.2	1.8
Coupled with local and natural capital (production)	1.7	1.5	1.7	1.5	0.7	1.2	1.9	1.3	1.6	0.9	0.7	1.6
Functional diversity	2.3	1.2	1.7	2.3	1.7	2.3	2.3	1.1	2.1	1.3	1.0	1.7
Response diversity	1.7	1.2	1.7	1.2	0.3	0.6	1.9	1.2	1.6	1.6	0.5	1.1
Exposed to disturbance	0.0	2.6	0.7	2.5	-0.3	1.5	1.0	2.2	1.3	2.0	0.4	1.7
Spatial and temporal heterogeneity (farm types)	1.3	2.1	1.3	1.5	0.3	0.6	1.4	1.7	1.2	1.4	0.8	1.1
Optimally redundant (farms)	1.0	2.6	1.0	2.6	0.3	2.5	1.6	1.8	1.5	1.8	1.3	2.0
Supports rural life	2.5	0.7	1.5	2.1	0.0	0.0	2.6	0.5	1.7	1.4	0.3	0.5
Socially self-organized	2.5	0.7	2.0	1.4	0.0	0.0	2.7	0.5	2.0	0.9	0.8	1.3
Appropriately connected with actors outside the farming system	2.0	1.4	2.0	1.4	0.0	0.0	1.7	1.0	1.8	1.0	0.3	0.5
Infrastructure for innovation	1.0	2.6	1.0	2.6	0.7	2.1	1.3	1.8	1.4	1.8	1.3	1.5
Coupled with local and natural capital (legislation)	2.0	1.7	2.0	1.7	1.3	1.5	2.1	1.2	2.0	1.3	1.1	1.3
Diverse policies	1.3	2.9	1.0	3.5	0.3	2.5	2.0	2.0	2.0	2.4	1.7	2.2

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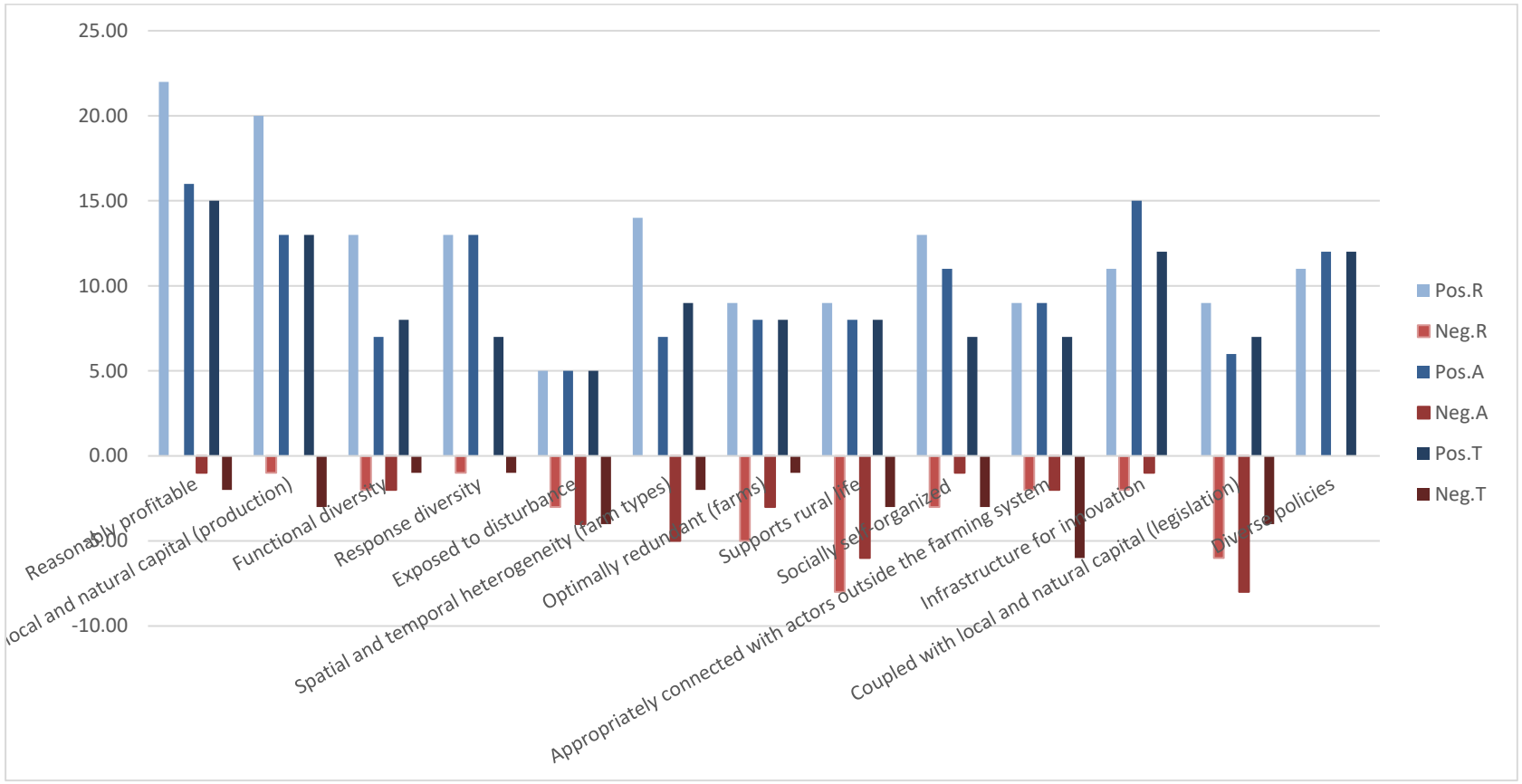

Figure A3. Bar graph presenting total positive and negative points allocated to a resilience attributes' contribution to robustness, adaptability and transformability.

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Appendix E. Workshop challenges and improvements

Challenges occurred during the explication of the scoring system in the workshop. Especially during the exercise to score the importance and performance of the indicators the participants were questioning the methodology and were first not willing to engage. Many questions and assumptions from their side were necessary to increase the cooperativeness to score the indicators. It is questionable if the participants confound the scoring for importance and performance of the indicators. The importance of e.g. the indicators "farms with direct marketing" was scored very low, which is reflected in the trend of the performance score. However, this is contradicting with the group discussion where the importance was highlighted despite the poor performance. Observation of the workshop shows that the participants perceived the performance of the indicators more important to assess than the importance. Therefor it is crucial to explain the purpose of the exercise comprehensibly to unsure the focused engagement of the participants. A short definition of the system functions and indicators with example could have been useful to accelerate the exercise.

The exercise to score the resilience capacities for the strategies and attributes were complex and not enough time was available to explain the concept in the necessary depth. The capacity of robustness can be optioned through a change in a short term (month to years) (Anderies *et al.*, 2013). However, a transformation process can be realized in a longer period, comprising several decades to centuries. Depending on the time scale the participants are using to determine contribution to resilience, they might focus only on certain capacities. Also, examples of the three resilience capacities could have helped in this situation with a remark to take different time perspective into account. An improvement can be, to shorten this exercise and include an additional open discussion round, to ask stakeholders for personal examples of strategies and attributes and how they think there are influencing the resilience.

During the open discussion at the end it was a challenge to receive the unadulterated opinion of the participants. This was challenging because certain participants were taking the lead in the conversation which can bias the conclusion of the discussion. Stakeholder groups with less representatives can lose the weight of statement in case the group is represented by passive participants, which is more likely in small groups. Also, some of the participants already knew each other from other discussion rounds. This can also lead to biased answered because participants embody the opinion of the predefined roles of the last discussion round. A way of improvement is that the moderator asks other participants for their opinion more direct to balance the expressed views.

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