A combined approach to assess the impact of Ecological Focus Areas on regional structural development

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Abstract

This paper aims to investigate how the implementation of Ecological Focus Areas (EFA) measures of the Common Agricultural Policy (CAP) will affect regional agricultural development, the economic performance of farms and land use changes in two case study areas in Sweden and Germany. The research approach combines agent-based modelling (ABM) with stakeholder interactions to evaluate how different policy scenarios involving a portfolio of selected measures will affect farm sizes, profits and incomes as well as farms' choices of EFA measures. Results show that structural impacts of EFA measures are minor in both regions compared with general impacts of external and internal convergence of Pillar 1 payments. Most preferred alternatives (fallow land in Sweden and catch crops in Germany) are rather cost and income preserving than decisive for the conservation of biodiversity. However general concern regarding the future of biodiversity and potential benefits for a sustainable agriculture was revealed during stakeholder workshops. This should further encourage initiatives towards future exchanges in order to better spatially target ecosystem services and reward efforts and outcomes accordingly.

Keywords: Common Agricultural Policy (CAP), EFA measures, biodiversity, ecosystem services, stakeholder interactions, agent-based modelling (ABM)

1 Introduction

One of the main objectives of Common Agricultural Policy (CAP) reform 2014-2020 was to strengthen its capacity to deliver environmental public goods in order to address the environmental challenges facing the European Union (EU). This reform is partly a response to declining biodiversity in Europe due to changing land uses and agricultural management practices in cultivated landscapes (EEA, 2010). Based on this evidence and considering that "the active management of natural resources by farming is one important tool to maintain the rural landscape, [to] combat biodiversity loss and contributes to [mitigating and adapting] to climate change" (European Commission 2010), 30% of direct payments to farmers ("Pillar 1") are now conditioned on compliance with greening measures (EU, 2013). This novelty is intending to complement actions supported via Pillar 2 schemes (especially the implementation of voluntary agri-environmental measures, or AEM) to foster the competitiveness of agriculture, to promote the sustainable management of natural resources, to encourage climate actions as well as to ensure a balanced development of rural areas. To be eligible for full Pillar 1 direct payments farmers are now obligated to adopt "greening" measures such as crop diversification, maintaining permanent grassland and pastures, or creating Ecological Focus Areas (EFA). Crop diversification aims to discourage monocultures and improve soil and ecosystem resilience (Mahy et al. 2015) while maintaining permanent grassland/pastures and EFA aim to deliver habitat protection, biodiversity improvement and soil carbon retention (Matthews 2012).

There are well-grounded doubts as to whether the proposed EFA measures will actually contribute to conservation of biodiversity and ecosystem services. In particular the following aspects are likely to water down any potential benefits for biodiversity: reduction of the EFA obligation from an initial 7% to 5% during negotiations, various exemptions based on farm sizes and types, and the possibility to classify for instance nitrogen fixing crops, catch crops and short-rotation coppice as EFA (Pe'er et al. 2014). Moreover the possibility of weighting EFA measures as a way to 'normalise' the biodiversity effects of different measures is also subject to criticism (Hart 2015, Matthews 2015).

Farm structures have been changing rapidly in the EU and their development is, for the most part, driven by economic forces. The resultant intensification of agriculture, abandonment of marginally productive but High Nature Value Farmland and changing scale of agricultural operations, are all contributing to the degradation of biodiversity and associated ecosystem services, which in turn is generating land use conflicts in rural areas (Henle et al. 2008). In order to understand and assess the present and future impacts of environmental measures such as EFA, our approach combines local knowledge with simulation methods in order to 1) take local specificities, practitioners' expectations and intentions into account and 2) deliver economic estimations of possible trajectories of agricultural development under different policy scenarios.

This research aims to evaluate how policies enhancing ecosystem services (public goods) will affect regional agricultural development and the economic performance of farms. To do this we combine agent-based modelling (ABM) with stakeholder interactions to evaluate how the so-called "greening measures", and especially the introduction of EFA, will affect farm growth and farmers' incomes.

The next section describes the two regions chosen for the study (one located in Sweden, the other one in Germany), the main steps of the research approach used, the main outcomes of the stakeholder workshops in each country as well as the agent-based model AgriPoliS which was adapted to each study region and extended in order to consider the implementation of greening measures. Section 3 presents some results of the modelling with respect to the scenarios defined with local stakeholders in the first workshop. Finally section 4 closes the study with a discussion around the results and further recommendations for future biodiversity enhancing policies.

2 Material and method

2.1 Short description of the case study regions

Two case-study regions were chosen for analysis, the "Mittelsächsische Platte" in the central part of Saxony (eastern Germany) and a subregion of the whole Götalands södra slättbygder (GSS) which occupies the southern plains of the south and west coasts of Scania (southern Sweden), both referred to as "Saxony" and "Scania" in the rest of this paper, respectively. In eastern Germany animal production is being progressively abandoned in favour of crop farming. As large farm structures are predominant due to historical reasons, farms are generally very competitive. However, the concentration of similar agricultural activity in the same area not only leads to changes in land use but implies an intensification of production as well as degradation of rural landscapes. The consequence is the continuing decline in biodiversity observed in cultivated landscapes today. The plains of Scania are a highly productive arable cropping region. Specialized crop production occurs on large, inter-connected fields where historical removal of field borders and other impediments has resulted in a relatively homogeneous landscape. The intensity and scale of production has also increased over time, putting additional pressure on the environment, through increases in fertilizer and chemical use, simplified crop rotations and lack of organic amendments to soils. In both regions these developments have led to nitrogen leaching, soil degradation, and declines in biodiversity and ecosystem services. Table 1 gives an overview on the two selected regions.

Table 1: Size and structure of the case study regions

	Scania	Saxony
Total UAA (ha)	201,577	168,259
- of which arable land (ha)	194,082	148,253
- of which grassland (ha)	7,495	17,649
Number of farms	2,690	858
Average farm size (ha)	75	196
Proportion of grassland of total UAA (%)	3.7%	10.5%

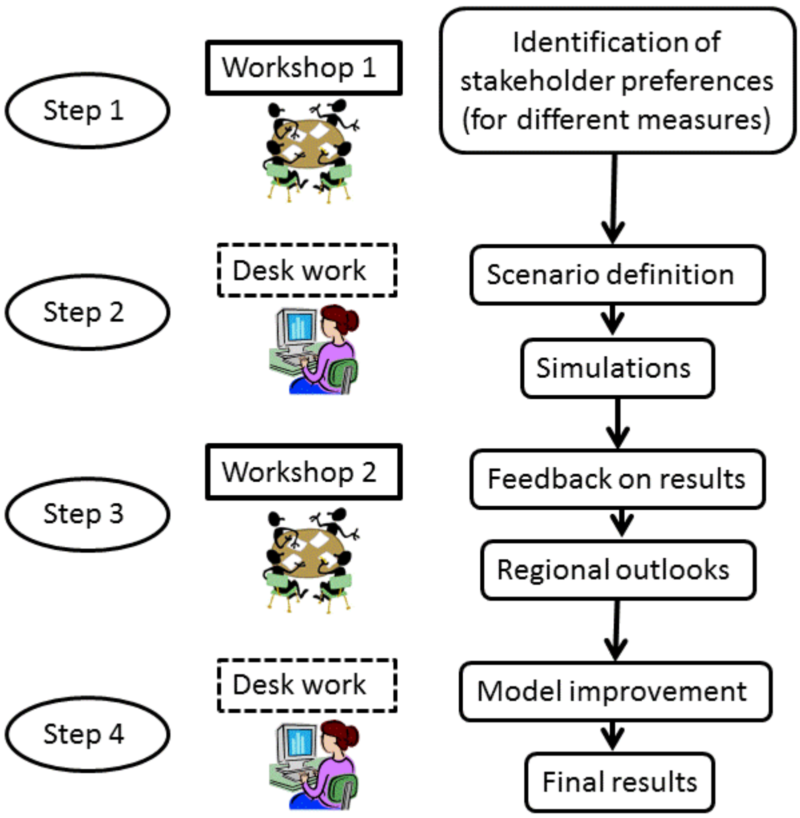
Source: LfULG 2013 (on request); SJV (2009). UAA: Utilized Agricultural Area.

More information about the regions as well as detailed figures on regional farm structures can be found in Sahrbacher et al. (2016b).

2.2 Overview of the research approach

Figure 1 below illustrates the four steps implemented to investigate the impacts of a selection of relevant EFA measures in Scania and Saxony.

Figure 1: Overview of the research approach used for impact assessment of EFA measures on biodiversity and agriculture



Source: own figure.

The following subsections describe in detail the sequence and content of the workshops as well as the modelling procedure.

2.3 Stakeholder workshops and scenario definition

A first series of workshops involving stakeholders from the agricultural sector, public institutions and environmental organisations were organised in Nossen (region Saxony, Germany) on 5 November 2014 as well as in Höör (region Scania, Sweden) on 13 November 2014 (Step 1, Figure 1). The objective of the workshops was to find out which measures are preferred by stakeholders to reach ecological as well as economic goals. The starting point for discussions was the proposed greening measures as well as agri-environmental measures to be implemented in the next programming period 2014-20. The measures were assessed by the participants regarding the perceived opportunities and barriers that each presented for reaching ecological and agricultural goals. At the same time solutions to tackle potential problems were discussed (for more details see Sahrbacher et al. 2016a). First, participants were asked to identify themselves as belonging to one of the following groups: Farmers, Administrators or Environmentalists. Then, in order to 1) select preferred greening measures to be modelled in AgriPoliS and 2) to assess the relevance of each of the measures in respect to their effectiveness for both biodiversity conservation and agricultural production, participants were given a questionnaire to be filled in anonymously. Each participant had the opportunity to formulate how much (in percent of the total EFA) and why they preferred specific EFA measures[1]. Apart from this, participants in Saxony were asked whether they would have implemented one of the greening measures in any case (i.e. without a greening payment) or not. Farmers were also asked about their own assessment of how much landscape elements already shape their arable land; non-farmers were asked to assess how much arable land farmers would allocate to such elements. In Scania participants were asked to assess the percentage of small biotopes on their arable land.

In the Swedish case, 18 out of 21 answers could be used to define six different scenarios based on the implementation of five different measures in different proportions for contributing to the EFA requirement, which were: fallow, field margins, short rotation coppice, leguminous crops and undersown crops. The cost-efficiency aspects of the measures as well as factors such as location, economics of the measures and production orientation were cited as highly relevant for participants of the "Farmers" group to motivate which measures could be implemented on EFA's and to what extent. Together with fallow, uncultivated field margins were most positively rated in all groups regarding their benefits for biodiversity. While the importance to link them to watercourses was mentioned in the "Environmentalist" group, the "Administrators" group highlighted their roles as natural corridors and their importance for recreational activities. Participants in the "Farmers" group assessed them as being area-effective, however they agreed with participants of the "Environmentalist" group to criticise their limited size, where fallow would certainly be more appropriate for contributing to biodiversity on a larger scale.

In the German case, 20 out of 28 answers could be used to outline four scenarios in total involving the following EFA measures in different proportions: fallow, flower strips, catch crops and leguminous crops. Like in Scania, economic considerations in the "Farmers" group were decisive by the choice of measures as well as farm concept and location. Therefore catch crops and leguminous crops, even though considered as irrelevant to maintain or increase on-field biodiversity, were preferred because of their positive agronomic properties (positive impact on soil fertility, reduction of nitrate leaching and erosion). Still according to participants of the "Farmers" group, land left fallow would contradict agriculture's primary goal (produce food and fibre) as well as expectations of private and institutional land owners aiming to reach high returns on agricultural land. Problems specific to crop farming

[1] Farmers were asked about the implementation of EFA on their farm; non-farmers were asked about their own perception of which measures in which proportion on EFA could be relevant to support biodiversity.

(increasing pest pressures -insects, weeds, and increased re-cultivation costs) constituted an additional source of concern for farmers when considering measures like flower strips. In the contrary, participants of the “Environmentalist” group highlighted the benefits of those measures to slow down the loss of birds, insects and pollinators on large-scale agricultural fields.

Based on these outcomes, several scenarios were developed for both regions (Step 2, Figure 1). Together with additional scenarios involving the non-introduction of EFA (but keeping the other two greening requirements) or a larger proportion of EFA to be implemented on arable land, a total of five scenarios per case study region are presented in Table 2.

Table 2: Description of the scenarios implemented in AgriPoliS

Implementation of EFA measures	Name of scenario	Description
No EFA	**REF**	Baseline scenario (CAP reform 2014-2020, without EFA obligations)
Flexible	**ALL5**	5% EFA
	ALL15	15% EFA
Mandatory	**ENV**	**Scania**: 20% fallow, 40% field margins, 40% catch crops
		Saxony: 40% fallow, 40% flower strips, 10% catch crops, 10% leguminous crops
	PROD	**Scania**: 10% field margins, 35% leguminous crops, 55% catch crops
		Saxony: 80% catch crops, 20% leguminous crops

Source: own figure.

The REF scenario only includes the implementation of the 2014-2020 CAP reform but excluding the EFA requirement (for more details on the baseline scenario see Sahrbacher et al. 2016b). All other scenarios (ALL5, ALL15, ENV and PROD) include the obligation for farms to implement EFA but to different extents and following specific requirements as indicated in Table 2. In the two scenarios ALL5 and ALL15, farmers are free to choose which EFA measures they would like to implement on 5% or 15% of their arable land, respectively, and this from 2015 onwards. It is not the case anymore in the scenarios classified as “mandatory”: farms are forced in the programme to implement the specific EFA measures indicated in Table 2 on 5% of their arable land during the whole simulation from 2015 onwards. In Saxony the “PROD” scenario is characterised by a focus on production and cost minimisation with the growing of leguminous crops and catch crops. In contrast 80% of EFA would be used for environmental purposes in the scenario “ENV” with the establishment of flower strips or fallow, which have a much more positive impact on biodiversity than leguminous crops and catch crops. In Scania, legumes are currently mostly used as fodder. However increased production could stimulate human consumption of legumes as well as provide residues for biogas production, both representing potential economic profits (“PROD” scenario). However, their cultivation could increase nitrogen leaching and the production of nitrous oxide, in contrast to fallow and field margins which could stop nutrient leaching and run-off, increase humus content and sequester carbon in the soils, thus contributing to more sustainable agriculture and the conservation of biodiversity (“ENV” scenario). Subsequently the identified scenarios were simulated (Step 2, Figure 1) with AgriPoliS to assess the potential impacts of the different implementations of EFA's on future farm incomes and structural development in Scania and Saxony.

2.4 Adaptation and extension of the agent-based model AgriPoliS

AgriPoliS is a spatially-explicit and dynamic agent-based model (Happe 2004, Happe et al. 2006, Kellermann et al. 2008). AgriPoliS enables the simultaneous consideration of some explanatory factors of structural change like competition for land, profitability of farming, human capital and farm-support programmes (Piet et al. 2012). It integrates key components of regional agricultural structures: heterogeneous farm enterprises of different types, space, markets for products and production factors. This bottom-up approach rests on the assumption that an agricultural region is a complex adaptive system in which individual agents, the farms, are the key decision-making units, indirectly interacting on land rental markets. From year to year, farms are able to grow or shrink, hire or fire workers, invest or disinvest, and continue farming or leave the sector. Accordingly, AgriPoliS simulates endogenous structural change.

AgriPoliS assumes each farm to maximise its household income in any one planning period. One planning period corresponds to one financial year. That is, a farm agent aims for maximising the total household income earned by farm family members either on or off the farm. The action space given to farm family members is defined by on-farm factor endowments (land, labour, fixed assets, liquidity), the situation on markets for production factors and products, the vintage of existing fixed assets, technical production conditions, overall economic framework conditions (work opportunities outside the farm, interest rate levels, access to credit), and the political framework conditions. Empirical data have been used for calibrating the model to the two case study regions (including costs and revenues linked to selected EFA measures): details on those data are provided in Sahrbacher et al. (2016b).

In order to maximise household income, farm factor endowments, production activities, investment possibilities, and other restrictions need to be brought together and optimised simultaneously. A suitable setting for this is a mixed-integer optimisation problem (MIP), the solution to which gives the optimal combination of action possibilities subject to the given framework conditions. For further formal details on the optimisation problem as well as on behavioural foundations of farms in AgriPoliS please see Kellermann et al. (2008). The model provides results at the individual, group or regional levels; this enables the researcher to observe the development of specific farms, groups of farms or whole agricultural regions, i.e. doing economics in a test tube.

AgriPoliS is usually adapted to case study regions based on a selection of typical farms that are scaled up to match a selection of characteristics of a specific region for a given year (Sahrbacher and Happe 2008). Though the basic rules and routine sequences of the model remain unchanged, each new modelled region implies the consideration of specific regional parameters as indicated in Table 3. Farms expand their size by renting land released on the land rental market by closing farms or which rental contract is terminated. Farms calculate their bid based on the shadow price calculated for an additional, specific plot/field taking into account distance costs, soil type (arable land or grassland in Saxony, high or low quality arable land and semi-natural grazing land in Scania) and potential economies of scale. Free land is allocated among farmers via a sequential first-price auction. Leases run for a fixed period of time. The duration of rental contract is randomly assigned within a minimum and maximum duration depending on the region considered (see Table 3). Rental contracts are binding during the entire contractual period. For more details on the renting procedure see Kellermann et al. (2008).

Table 3: Overview of general parameters used in AgriPoliS for Saxony and Scania

	Mittelsächsische Platte ("Saxony")	Götalands södra slättbygder ("Scania")
Calibration year	2013	2008
Generation change	25 years	25 years
Labour (p.a)		
Hired labour (€/AWU)	20,700	17,820
Off-farm labour (€/AWU)	17,000	15,840
Labour (€/h)		
Hired labour (€/h)	12.65	21.33
Off-farm (€/h)	8.50	16.00
Labour cost trend (p.a)	+0.5%	0%
Interest rates (%)		
Long-term	5.5	3.5
Short-term	8	4.5
Farm's savings	4	3
Plot size	3 ha	3 ha
Equity finance share	30%	25%
Useful life (years)		
Buildings	20 years (pigs and sows) 25 years (cattle)	25 years (cattle, suckler cows, ewe, pigs and sows) 22 years (dairy cows)
Machinery	12 years	12 to 20 years
Withdrawals (€/year)	16,000	22,222
Length of rental contracts	12 to 24 years	9 to 18 years

Source: own figure. AWU: Annual Working Unit; h: hour; €: Euros.

Costs for hired labour and salaries from off-farm employment are assumed to increase at rates mentioned in Table 3 ("Labour cost trend (p.a)") and farms are assumed to be price-takers, i.e. output prices are kept constant during the simulation. AgriPoliS is a regional model and unlike sector models, it does not aim at predicting price changes in case of changes in output levels. Four interest rates used in the model. Long-term interest rates concern capital borrowed to finance long-term investments like farm buildings (cowsheds etc.) and machinery in the long-term. Short-term interest rates concern liquidity to be reimbursed at the end of the simulation period. Farms' savings (equity capital) earn interests at the bank which can be reinvested in farms' operations in the following periods. Farms quit agriculture at the end of a period in case of bankruptcy (illiquidity) or if farm-owned production factors (land, labour, capital) earn higher income outside farming. Owned land is then valued thanks the average regional rent; family labour is valued at the level of off-farm income and regarding opportunity costs for working capital, a long-term saving rate is used for fixed-term deposits and is 1% higher than the farm's savings rate. If expected household income does not exceed those opportunity costs, farms decide to close down. Farms' owned/rented land is then leased/released on the rental market, enabling neighbouring farms to expand in size.

The introduction of EFA in the model occurred in an extension of the MIP as indicated in Table 4. As indicated there, and with respect to the EU regulation regarding CAP 2014-2020 (EU 2013), farms with less than 15 ha do not have to implement EFA. Similarly farms with more than 75% of permanent grassland or green fodder producing farms are exempted from EFA. Farms growing green fodder on more than 75% of their arable land, provided arable land does not exceed 30 ha are exempted from implementing EFA as well.

Table 4: Implementation of EFA in the MIP, based on the example of the German case for the year 2015

	Produciton activity I	Production activity II	Production activity III	Field beans	Alfalfa	Fallow land	Flower strips	Catch crops	Undersown crops	Basic payment	Greening payment	Greening yes>15ha	Greening no<15ha	Greening yes<75% GL	Greening no>75% GL		
Objective function	GM	GM	GM	GM	GM	GM	GM	GM	GM	1	1	0	0	0	0		RHS
Arable land	1	1		1	1	1	1									<=	Farm's arable land
Grassland			1													<=	Farm's grassland
Basic payment	-87	-87	-87	-87	-87	-87	-87			1						<=	0
Greening component	-187	-187	-187	-187	-187	-187	-187				1					<=	0
EFA min.	0.05	0.05		-0.65	-0.65	-0.95	-0.95	-0.3	-0.3				-∞		-∞	<=	0
Greening_yes>15ha	1	1		1	1	1	1					-∞				<=	15
Greening_no<15ha												1	1			<=	1
Greening_yes<75% GL	0.75	0.75	-0.25	0.75	-0.25	0.75	0.75							-∞		<=	0
Greening_no>75% GL														1	1	<=	1
Greening_yes>30ha	1	1		1		1	1							-∞	-30	<=	0
Previous crop from CC	-1			-1	-0.33			1								<=	0
Subsequent crop from CC		-1		-1				1	1							<=	0
Undersown crops		-1							1								
Subsequent crop of leguminous plants	-1			1	0.33			-1									

GM: gross margin; RHS: right-hand side; GL: grassland; CC = catch crops
Source: own figure based on Günther (2015).

2.5 Feedback on first simulation results in Workshop 2

A second workshop was organised in Nossen (Saxony) on 24 February 2016 and Höör (Scania) on 15 March 2016 (Step 3, Figure 1). The aim was to present simulation results to stakeholders based on the scenarios jointly defined with stakeholders during the first workshops. More detail about these events will soon be provided elsewhere.

Stakeholders' feedback and remarks helped improving the models for both regions in two regards:

- Stakeholders provided a plausibility check of simulation results in the middle and long-term (for instance impacts of EFA on livestock figures) which helped the researchers to reconsider and recalibrate some model data;
- Opinions on proportions of measures on EFA after implementation of greening measures (supported by official figures available in the German case) helped calibrate the model for EFA in the ALL5 scenario (real world CAP) to near up reality best for the year 2015.

The next section presents results of improved model regions (Step 4, Figure 1) and policy scenarios presented above (Table 2).

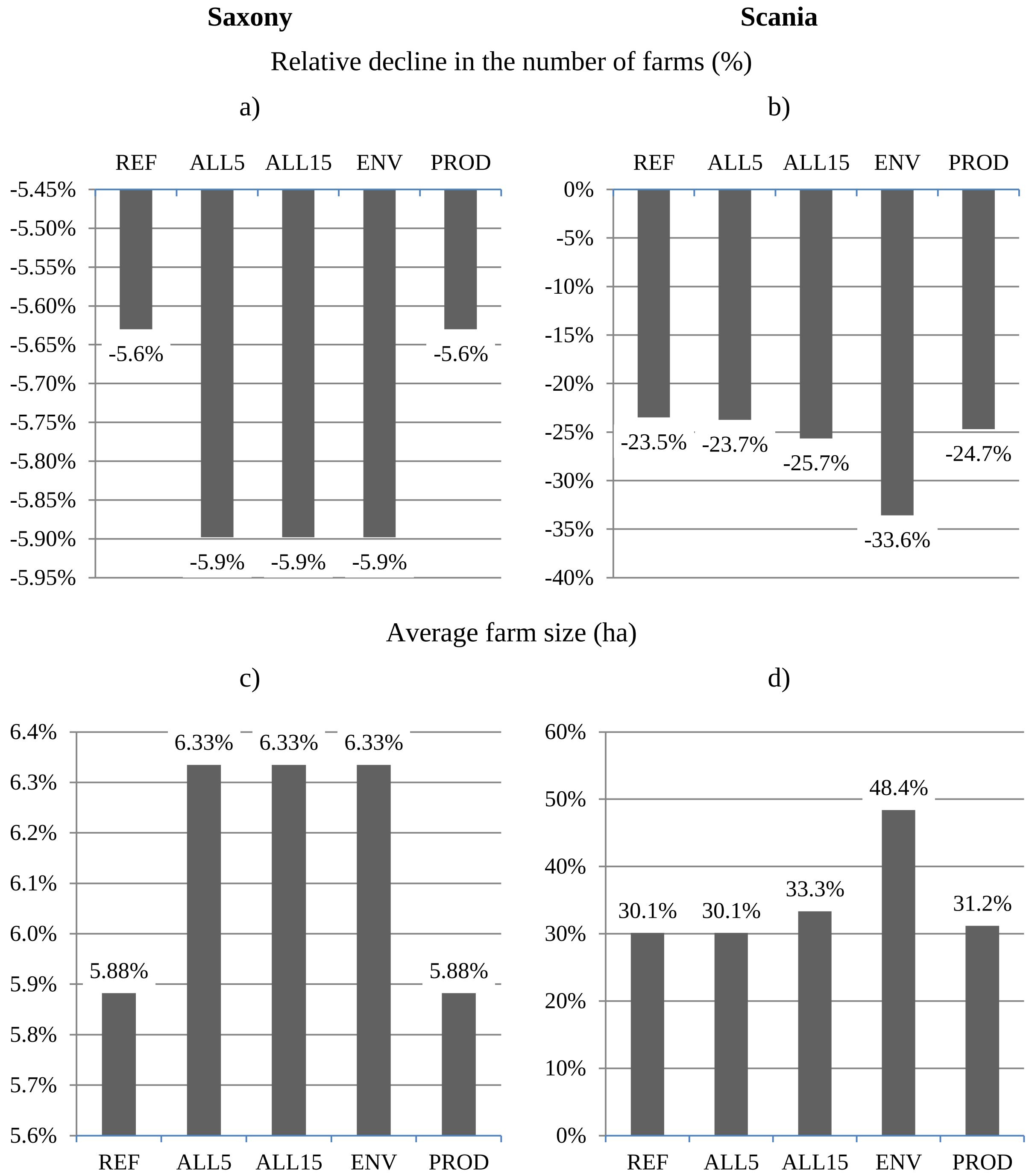
3 Results

As indicated in Table 3, AgriPoliS has been adapted to the case study regions for the years 2008 and 2013 for Scania and Saxony, respectively. Most results presented below focus on consequences of policy scenarios between the years 2014 (i.e. one year before the implementation of the CAP 2014-2020 reform) and 2020. Since 2015, Sweden has made the choice to equalize farm subsidies within the country by 2019 and fully exploit the possibility offered to EU members states to implement special animal premiums (13% of the country's payment). Therefore from the year 2015, farmers in Scania have to cope with a decrease in Pillar 1 payments from 330 €/ha in 2014 towards 193 €/ha from 2019 onwards (greening component included) whereas livestock production benefits a top-up payment of 91 Euros per animal older than one year. Convergence of payments occurs in Saxony as well and the decrease in Pillar 1 payments will amount up to 38 €/ha between 2014 and 2019 to reach 260 €/ha in 2019 onwards (of which 85 €/ha greening component). For further details on policy frameworks considered in both regions please see Sahrbacher at al. (2016b).

3.1 Impacts of farm structures and incomes: little impacts due to EFA

Figure 2 illustrates impacts of implemented scenarios on indicators of structural change (number of farms and average farm size) in the year 2020. There are minor changes in farm structures with regards to different EFA restrictions. In Saxony the slight decline in the number of farms between 2013 and 2020 does not differ much when considering various EFA implementations (Figure 2a). Similar conclusions can be drawn when looking at average farm sizes as well (Figure 2c). In the contrary results in Scania reveal important impacts on farm structures regarding number of farms (Figure 2b) and average farm size (Figure 2d) which is due to a large extent to important changes in Pillar 1 payments levels (see explanation above). However, faster structural change occurs when stricter EFA requirements (mandatory choice of EFA measures on 5% of arable land) are applied in the ENV scenario. In the PROD scenario the trend in the decline in number of farms follows the trend observed in the REF scenario but due to the stricter mandatory conditions land abandonment is observed (further details on land uses are provided in section 3.2).

Figure 2: Relative decline in number of farms (in %) and average farms size (in ha) in 2020 compared to 2014

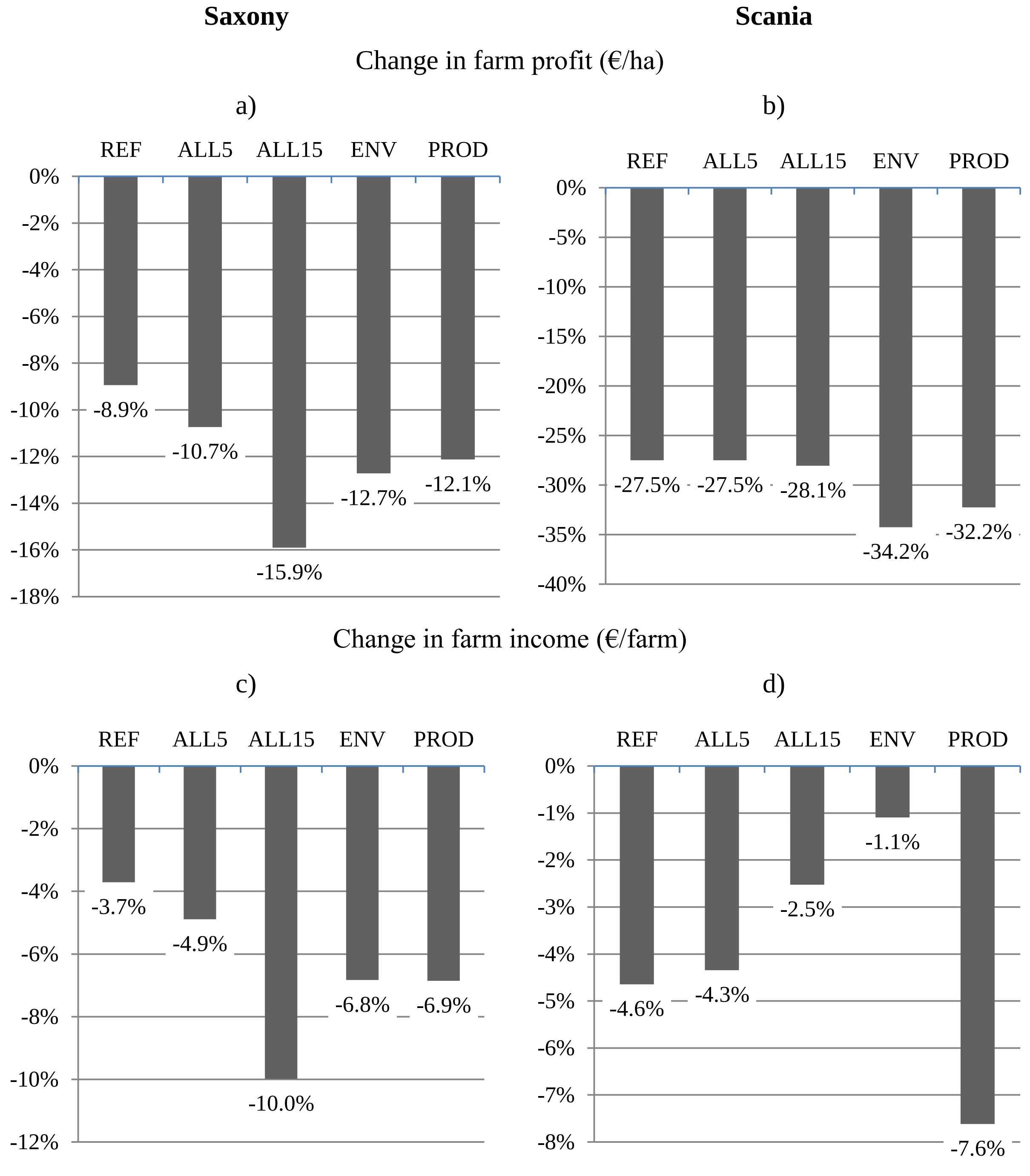


Source: own figure.

Figure 3 reveals similar figures for profits and incomes in the German case (Figure 3a and 3c).Whereas farm profits decrease up to 9% in the REF scenario in 2020 (new CAP 2014-2020, no EFA requirements) compared to 2013, farm incomes decrease as well but to a lesser extent (3.7% compared to 2013). The introduction of EFA has a significant but minor impact on profits which decrease 1.8% further with the obligation for farms to provide 5% of EFA on arable land using the most suitable combination of measures (ALL5). Again, impacts on farm incomes are less pronounced (1.2%). The obligation to implement EFA on 15% of arable land

(ALL15) has impacts profits and incomes with a further decrease of 5.2% and 5.1% respectively.

Figure 3: Development of farm profits and farm incomes (in %) in Saxony and Scania in 2020 as proportions of profits and incomes observed in 2014



Source: own figure.

Surprisingly, the policy scenario chosen by farmers themselves at the workshop in Saxony (PROD scenario: 80% catch crops and 20% leguminous crops on 5% EFA) leads to higher decreases in profits and incomes compared to the flexible selection of EFA measures made at the individual level. With a decrease in profits of 12.7%, the mandatory implementation of measures better designed for favouring biodiversity (ENV scenario: 40% fallow, 40% flower strips, 10% catch crops, 10% leguminous crops) only cause an additional decrease of 3.8%

compared to the reference scenario without EFA. Decrease in farm incomes in the "mandatory" scenarios (PROD and ENV) are 3.1% and 3.2% higher than in the REF scenario, respectively.

In Scania farmers experience a decline in farm profits as well, mostly due to the equalization of national support. However, there are changes in income and profit with the introduction of EFA measures (Figure 3b and 3d) compared to the REF scenario. As the rigidness of the EFA conditions increase, farm income losses are reduced except in PROD scenario. This is related to structural change; increases in average farm size (Figure 2d) allow farmers to offset income losses by taking advantage of economies of scale. In the PROD scenario, even though average farm size is similar to REF, profit per hectare further decreases compared to REF, because of the strict EFA regulations (extra costs) leading to decreasing farm incomes. However, even though farms in ENV scenario take advantage of the significant increase in farms size and experience the smallest reduction in income, losses in profit per hectare are the highest. Such effect is mainly related to the mandatory implementation of EFA. In both scenarios ENV and PROD farmers experience additional increases in production costs, but 35% EFA of leguminous crops in PROD (profitable on high productive arable land) leads farmers in ENV to face the highest declines in profits over all scenarios.

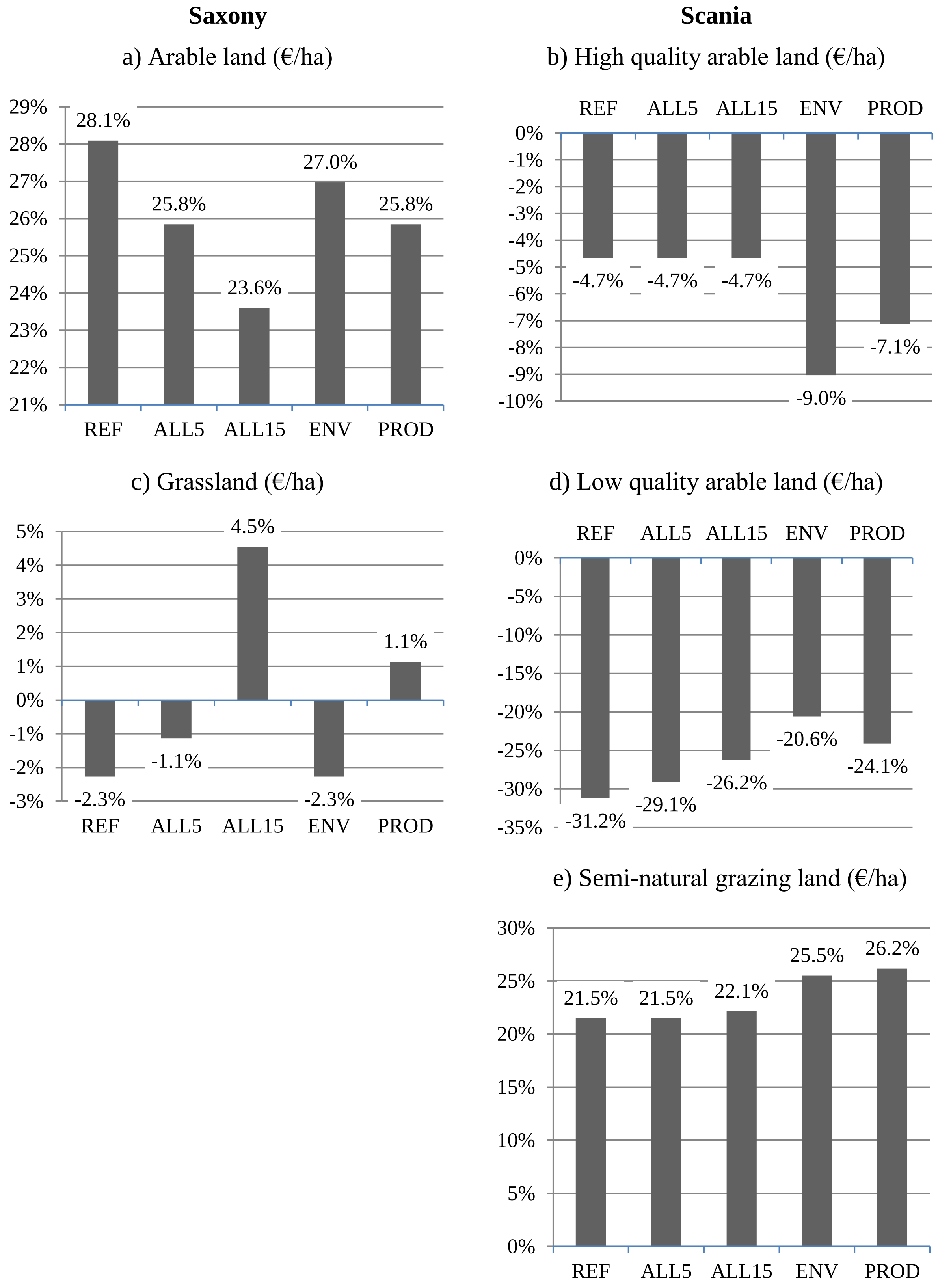
When flexible choices of EFA apply losses in profits per hectare are similar to REF. This is mainly due to farms' dynamic adjustment of production activities over time by allocating low productive or marginal land to meet the EFA requirements. Therefore farms can still continue to use the most productive land in production, thus offsetting induced costs from EFA restrictions. In addition, the generous scaling factors for field margins (1 ha of uncultivated field margin counts towards 9 ha of EFA) together with crops that have already grown by farmers (e.g., leguminous crops), waters down the EFA requirements and do not generate negative impacts on farmers' incomes compared with no EFA obligations (REF scenario).

Figure 4 illustrates the development of land rental prices in both regions in 2020. In both regions, the lowest impacts on rental prices for all soil qualities are observed in the ALL5 scenario compared with the REF scenario (no EFA) in 2020. In Saxony land rental prices are indirectly influenced by developments in livestock production for which leguminous crops, recognized as EFA measure, can be used as fodder. Such measure might create artificial incentives to invest in production activities which would otherwise have not been chosen as an option, creating pressure on rental prices for grassland (due to grazing livestock) as well as on rental prices for arable land (due to leguminous crops). Especially EFA as implemented in scenario ALL15 might artificially encourage dairy and beef cattle productions[2]. Results of the PROD scenario show similar figures, to a lesser extent though.

In Scania pressure on arable land rental prices on low quality land is increasing with the level of rigidness of EFA restrictions compared with the REF scenario. Actually farms use their low quality arable land to comply with the EFA obligations (Figure 4d, ENV and PROD). However, an indirect effect is that intensive productions are even more concentrated in certain areas, which may offset the environmental benefits originating from EFA. Consequently in an environment where farms can freely choose the combination of EFA measures, it can be expected that land rental prices for high productive arable land will not change much since mainly low quality land is used to comply with EFA.

[2] Without consideration of value chains in the region –not to mention milk prices, which might not favour such investments as confirmed by stakeholders in Saxony during Workshop 2.

Figure 4: Relative change in land rental prices with respect to land use and quality in 2020 in all policy scenarios compared to 2014



Source: own figure.

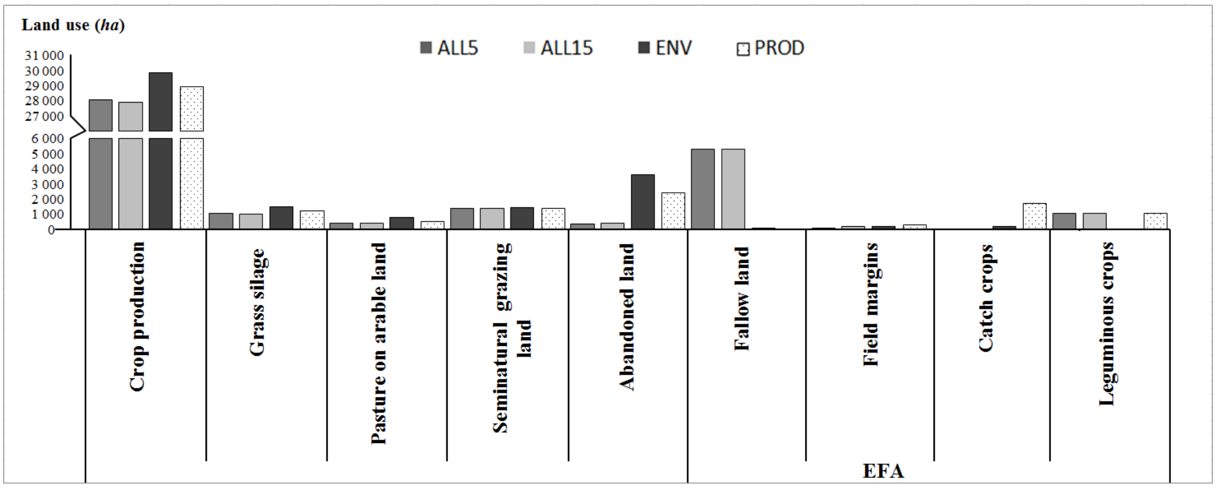
However, when stricter EFA conditions apply (mandatory EFA measures in scenarios PROD and ENV) high productive land becomes less attractive for farmers which results in lower rental prices compared with scenarios where the implementation of EFA measures is flexible (ALL5 and ALL15). In this case farms release their high productive land because they are unable to meet the requirements considering that rental prices for low quality arable land are already high: this results in a decrease in rental prices. It is especially the case for small farms (<50 ha) which have difficulties to cope with strict regulation for EFA together with the decrease in Pillar 1 payments until 2020. Regarding rental prices for semi natural grazing land in Scania, the prices are expected to rise rapidly. However, since there is no much semi-natural grazing land available in the region (3.7% of total area), a small change in the demand lead to very high increases in rental prices. Demand in semi natural grazing land is indirectly driven by the livestock coupled payment which is reflected in an increase in beef cattle and dairy cow production.

3.2 Land use changes and implementation of EFA measures

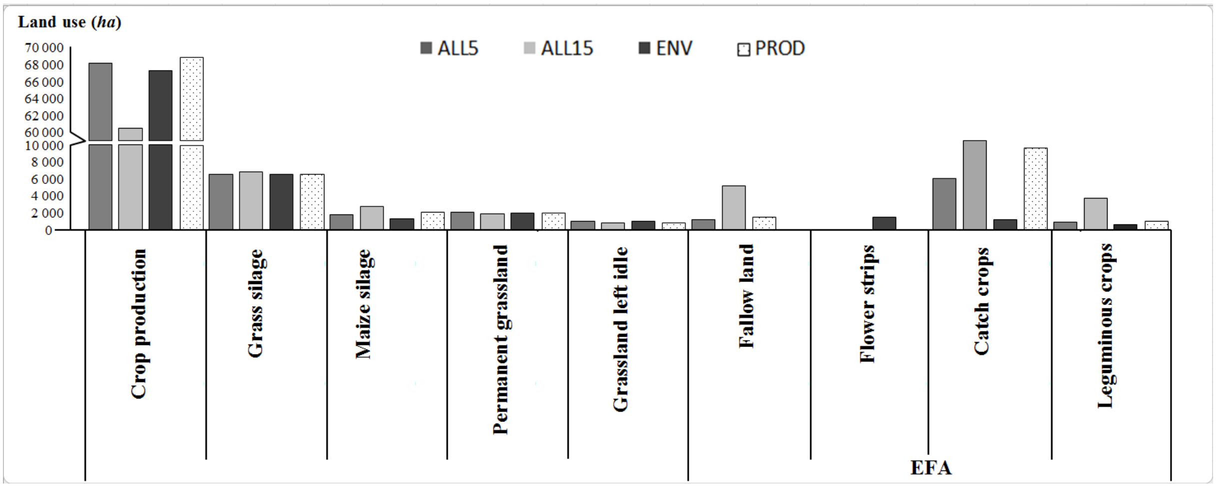
Figure 5 provides an overview on land use changes between EFA scenarios in 2020, and Figure 6 illustrates choices operated by farms regarding the combination of EFA measures on either 5% (scenario ALL5) or 15% (scenario ALL15) of farms' arable land.

Figure 5: Land uses (in ha) in Scania and Saxony in 2020

Scania



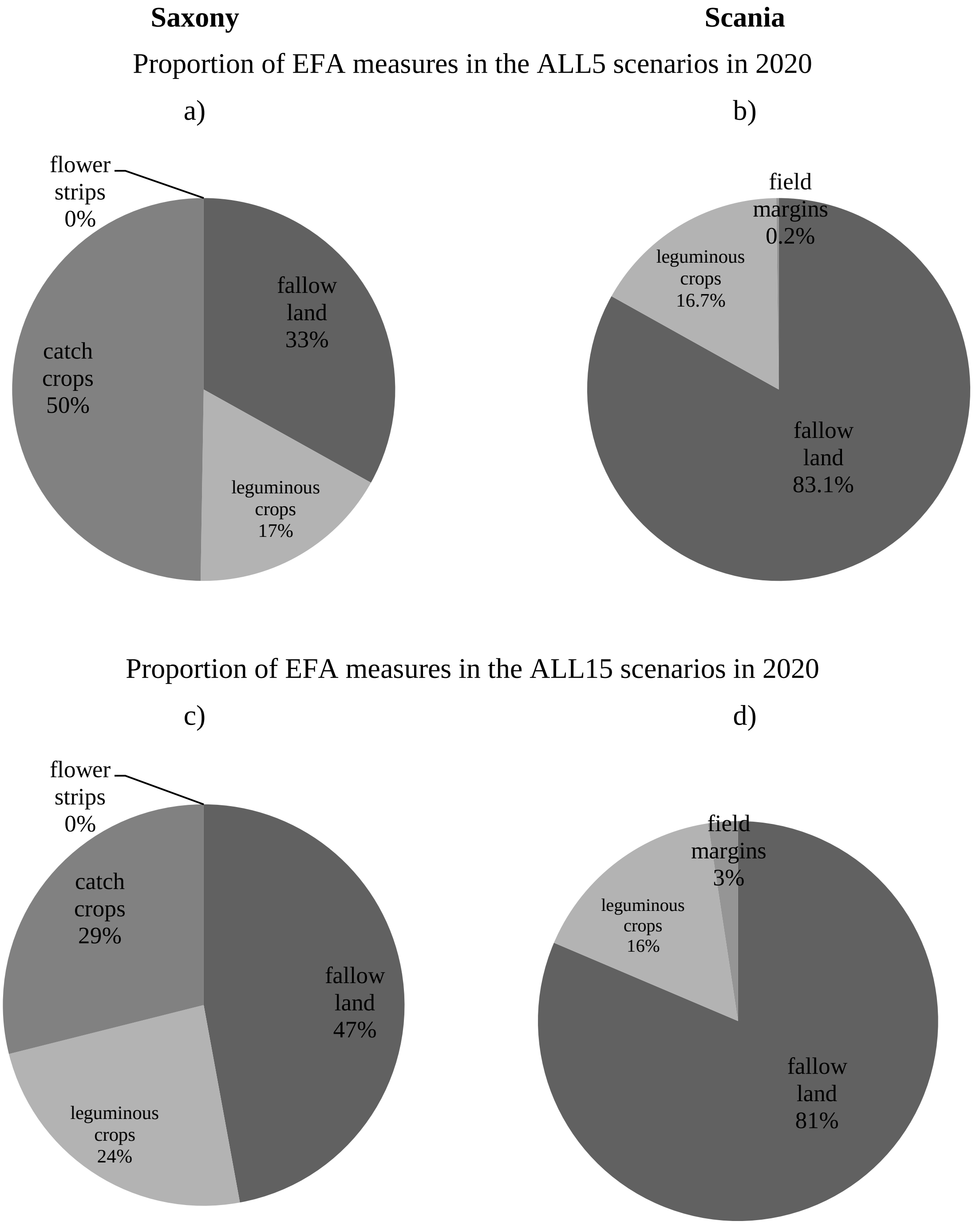
Saxony



Source: own figure.

In Scania the significant increase in fallow land is due to the decline in support from 2015 because of the national equalization of payments (see introduction to section 3). The area of fallow in the region is superior to the required area in EFA (about 2,000 ha in case all EFA was used as fallow). Therefore the flexible implementation of EFA measures will not necessarily imply much change in land use compared with the REF scenario (Figure 5, ALL5 and ALL15) and per se allow the income level to remain stable as in the REF scenario (Figure 3d). In scenarios ENV (20% fallow, 40% catch crops and 40% field margins) and PROD (80% catch crops, 20% leguminous crops), fallow land which would have been preferred in the flexible scenarios (see Figure 6 as well) is shifted to a lesser extent for intensive and extensive grass production (silage and pastures – though on a small area) as well as for crop production.

Figure 6: Proportion of EFA measures implemented on the compulsory area of 5% (scenarios ALL5) and 15% (scenarios ALL15) of farm arable land in 2020



Source: own figure.

Moreover, the increased use of grassland in those scenarios is also an indirect effect originating from the coupled livestock support which leads farms to use parts of their arable land as pastures and silage. However, around 3,800 ha (ca. 10% of the total UAA) is abandoned because of the mandatory implementation of EFA measures. Interestingly field margins gain in importance with the expanded EFA as implemented in scenario ALL15, at the expense of fallow land. It is to note that neither catch crops nor short rotation coppice were chosen, mainly because of their relative lower profitability and low weighting factor (0.3). Even though catch crops constitute a mandatory EFA alternative in ENV and PROD, the area declines over time (see Appendix 1). Regarding the dynamic development of EFA, an interesting aspect is the immediate strong effect in 2015, especially for protein crops and field margins in ALL5 and ALL15 scenarios (flexible choice). But over time as the support is converged and reduced, farmers reconsider the farm practices and shift to fallow land and provide even more EFA area than necessary. Hence, this would be to a certain level an indirect effect of the national equalization of support. Even though EFA restrictions are imposed, the reduction in support by around 130€ provides incentives to farmers to allocate most low productive arable land as fallow to offset the losses in profits and income.

In Saxony there is no land abandonment to observe in any of the scenarios. In case of flexible implementation of EFA measures, fallow land becomes an interesting alternative for farms in scenario ALL15 to limit income losses due to the decreasing area potentially interesting for crop production (see Figure 5). Leguminous crops see their importance on EFA increase in this case as well, but to a lesser extent compared to fallow (Figure 6c). Results show as well that flower strips are never preferred or even chosen as an alternative in farms' portfolio of EFA measures in both ALL5 and ALL15 scenarios (see Appendix 1).

4 Discussion and conclusion

This paper evaluated how different implementation of EFA and preferences of local stakeholders would affect regional agricultural development, the economic performance of farms and land use changes in two European regions. For this purpose simulations with the agent-based AgriPoliS together with stakeholder interactions have been used to evaluate how the so-called "greening measures", and especially the introduction of EFA, will affect farm growth and farmers' incomes.

At first, results revealed the general importance of Pillar 1 payments in both regions. Whereas the equalization of Pillar 1 payments causes land abandonment of less productive areas in the Swedish region, the decrease in Pillar 1 payments in the German region does not necessarily prevents rental prices from increasing further with or without the implementation of EFA measures. However structural impacts of those measures revealed to be minor in both regions. Far more important were indirect consequences of "productive" EFA measures: leguminous crops for instance had an impact on the increase in livestock productions in Saxony. Even though not realistic in this regional context, such indirect impacts reveal some policy failure when greening measures supposed to enhance biodiversity end up encouraging the production of local proteins for fodder or provide additional support for applying meaningful agricultural practices (for instance catch crops in the German case).

Moreover, fallow land as most preferred EFA measure is rather selected by farms to limit incomes losses caused by the mandatory implementation of EFA on arable land, or in case of an implementation on a larger area. It is to note that measures like flower strips, field margins or short rotation coppices would not be considered profitable enough by farms in the model and would therefore hardly be implemented, if at all. In case of a strict obligation to implement few EFA measures (of which the two latter EFA measures mentioned before), results show that this could lead to land abandonment at least in the present Swedish case study, otherwise resulting in reduced EFA in absolute terms. It is therefore to question whether this outcome would meet policy expectations. In the long-run this could constitute a potential asset for future generations indeed: convergence of abandoned land to forest or grass, benefiting bird diversity, nesting habitat, pollination services, reduction of green gas emissions, etc. However this would be at the expense of biodiversity in other areas where agricultural production could become more intensive, as our results indicate as well. Farmers might use marginal land to meet the EFA requirements indeed, and keep on using their most productive land even more intensively, which makes it unlikely that current EFA obligations generate environmental benefits commensurate with greening payments.

Together with present results on land use changes, further research shows poor environmental outcomes regarding EFA impacts on biodiversity, on biological control potential as well as on pollination services (Hristov et al. 2016). The main reason for this is that farmers are not incentivized to optimize their land-use decisions and in field management practices by considering the environmental benefits or the impact on ecosystem services, but rather to minimize the cost of achieving the EFA obligation wherever it takes places. There seems to be both a need for the farming sector to recognize the long term benefits upon ecosystem services (supporting and regulating) at farm level -for which EFA might be a good start- as well as a necessity for all regional actors to agree on a spatial targeting of environmental measures without which a large proportion of payments would not meet initial expectations.

During the workshops organised in Sweden and Germany local stakeholders revealed a strong interest in learning and discussing extensively about EFA measures at disposal in their region as well as about the situation and stakeholders' opinions in the other case study region. There were high concerns about the actual impacts of regionally relevant EFA measures on biodiversity and the environment. From farmers' point of view, economic risk linked to EFA measures (in case for instance one EFA crop would fail to establish) as well as contractual commitments with land owners were cited as reasons not to engage in measures more obviously in favour of biodiversity. However increased flexibility called for during the workshops (number, combination of possibilities and time scale of measures) regarding measures contributing to biodiversity conservation was soon confronted to potential difficulties for local offices to efficiently support, monitor and control more complex measures than the current ones. In both case study regions the importance of local constraints and opportunities lead stakeholders to suggest that 1) measures should target places where they would have the greatest effect; 2) reward farmers accordingly when their efforts (and management costs) would justify it. To this extent variable, flexible and transparent public support would be acceptable in order to reward commitments according to outcomes.

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Appendix 1. Area of EFA in 2015 and 2020 between scenarios in both regions

Scania	**Area (ha)**		**Proportion (%)**	
ALL5	**2015**	**2020**	**2015**	**2020**
Fallow land	1,356	5,276	42.4	83.1
Leguminous crops	1,779	1,058	55.6	16.7
Catch crops	0	0	0	0
Undersown in barley	0	0	0	0
Field margins	63	14	2	0.2
Total	**3,198**	**6,348**		
ALL15	**2015**	**2020**	**2015**	**2020**
Fallow land	1,341	5,294	39.0	81.4
Leguminous crops	1,722	1,055	50.1	16.2
Catch crops	0	0	0	0
Undersown in barley	0	0	0	0
Field margins	377	156	11.1	2.4
Total	**3,440**	**6,505**		
ENV	**2015**	**2020**	**2015**	**2020**
Fallow land	491	85	20.0	20,0
Leguminous crops	0	0	0	0
Catch crops	123	0	5.0	0
Undersown in barley	860	169	35.0	40.0
Field margins	982	169	40.0	40.0
Total	**2,456**	**423**		
PROD	**2015**	**2020**	**2015**	**2020**
Fallow land	0	0	0	0
Leguminous crops	1,697	1,080	35.0	35.0
Catch crops	974	1,009	20.1	32.7
Undersown in barley	1 693	689	34.9	22.3
Field margins	485	309	10.0	10.0
Total	**4,849**	**3,087**		

Source: own calculations.

Saxony	**Area (ha)**		**Proportion (%)**	
ALL5	**2015**	**2020**	**2015**	**2020**
Fallow land	857	1,205	23.5%	33.1%
Flower strips	757	893	14.6%	17.2%
Catch crops	7,511	6,038	61.9%	49.7%
Leguminous crops	0	0	0.0%	0.0%
Total (ha)	**9,125**	**8,136**	***3,640***	***3,641***
ALL15	**2015**	**2020**	**2015**	**2020**
Fallow land	3,594	5,130	33.0%	47.1%
Flower strips	4,745	3,728	30.5%	24.0%
Catch crops	13,247	10,497	36.5%	28.9%
Leguminous crops	0	0	0.0%	0.0%
Total (ha)	**21,586**	**19,355**	***10,890***	***10,889***
ENV	**2015**	**2020**	**2015**	**2020**
Fallow land	1,451	1,452	39%	40%
Flower strips	587	571	11.2%	10.9%
Catch crops	1,210	1,210	10%	10%
Leguminous crops	1,451	1,452	39.5%	39.6%
Total (ha)	**4,699**	**4,685**	***3,676***	***3,667***
PROD	**2015**	**2020**	**2015**	**2020**
Fallow land	0	0	0	0
Flower strips	1,082	1,063	20.7%	20.4%
Catch crops	9,672	9,674	79.3%	79.6%
Leguminous crops	0	0	0.0%	0.0%
Total (ha)	**10,754**	**10,737**	***3,659***	***3,646***

Source: own calculations.

Note: total areas in italics are calculated considering weighting factors for the EFA measures selected