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# **Ecological impacts of Greening versus Agri-Environmental and Climate Measures (AECM): An ecological-economic evaluation for Lower Saxony, Germany**

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# Ecological impacts of Greening versus Agri-Environmental and Climate Measures (AECM): An ecological-economic evaluation for Lower Saxony, Germany

Sebastian Lakner<sup>1</sup>, Carsten Holst<sup>1</sup> & Guy Pe'er<sup>2,3</sup>

**Abstract:** *The introduction of Greening and the ecological focus area (EFA) due to the CAP-reform 2013 has introduced a new agri-environmental instrument into the CAPs first pillar, aside of the established agri-environmental and climate measures (AECM) within the second pillar. This introduction poses the questions, to what extent both instruments are collaborating to achieve positive environmental outcome. The paper presents an economic-ecological method to evaluate both EFA and AECM measures evaluation on arable land with respect to biodiversity. We investigate the effectiveness and efficiency and the spatial impact of EFA and AECM using the approximation method of the ecology score, which is based on an ecological ex-ante evaluation. The results show that EFA has taken a large area within Lower Saxony mainly with catch crops. The AECM has reduced it's are from 2012 to 2016, however, increased its respective funds, which suggests a trend for more 'dark green' AECM. The spatial analysis shows that EFA achieves effects mainly in arable regions of Eastern Lower Saxony. Both measures show rather low coherence, only on 15.4% of the land we find synergetic effects of both measures. The funds per ecology score suggests, that EFA has a lower efficiency (596 EUR/ES) in comparison to AECM (307 EUR/ES).*

**Keywords:** *Greening, Agri-Environmental Programs, Biodiversity, Agricultural Policy*

## 1 Introduction

The introduction of the Ecological Focus Areas (EFAs) within Greening in 2015 was proposed to contribute to biodiversity and to act additively to the existing agri-environmental and climate measures (AECM) as the main instrument to protect biodiversity so far. According to EU Regulation 1307/2013 (fig. 44), the objective of EFAs is “to safeguard and improve biodiversity on farms” (European Council 2013a). While several studies examined the effectiveness of EFAs in terms of biodiversity, remaining questions relate to how EFAs and AECM influence each other. This is true both for ecological and socio-economic dimensions of both instruments.

In Germany, about 1.428 bn. EUR are dedicated to Greening, which is substantially overweighing the AECM (BMEL 2017), which take only about 699.2 Mio. EUR (own calculations based on EC 2016). The existing literature suggests that Greening and EFA provide ‘windfall gains’ to farmers, i.e. payments without any costs involved (Schmidt et al. 2014, Lakner & Holst 2015), which makes Greening and EFA an offer which is too attractive to decline: In Germany, only around 140 farmers above the required thresholds were not applying the greening requirements (BMEL 2017).

On the other hand, agri-environmental programs are voluntary. The uptake of AECM is rather high in marginal production regions, whereas participation in high productive regions is generally low. This in mind, the introduction of Greening has induced the hope that with EFAs as a financially attractive measure could increase the ecological effects in high productive regions and thereby help improve the overall performance of the CAP particularly with respect to biodiversity. Since farmers can apply both schemes at the same time (Ministry for Agriculture Lower Saxony 2015), a key question is to what extent greening is affecting the participation rate in agri-environmental measures. If participation in AECM has reduced due to greening, the effect can be regarded as competition.

This paper models the potential ecological impact of EFA and AECM on biodiversity on the county level in order to analyze the spatial effects of both instruments; We investigate the relation of the newly introduced EFAs to the AECM, show the potential coherence (complementary, synergistic or reinforcing effects) of both instruments in the counties of Lower Saxony, Germany. Will investigate the following specific questions:

1. How did the introduction of EFA affect the uptake and funds of AECM?
2. How are effectiveness of EFA and AECM from a spatial perspective
3. How efficient is the implementation of EFA and AECM in Lower Saxony?
4. How is the coherence between EFA and AECM from a spatial perspective: In which regions can we see synergistic, complementary or reinforcing effects on biodiversity from the introduction of EFA?

To address these questions, we focus on EFA-options that are comparable with AECM on arable land, i.e. fallow land, catch crops and flowering and buffer strips.

## **2 Background**

### **2.1 EFA and AECM in Lower Saxony**

Our paper focuses on the federal state of Lower Saxony, which is one of the major agricultural production regions in Germany. It has the second largest land endowment of 2.6 ha agricultural land, farmed by 35,700 farms (Ministry for Agriculture Lower Saxony 2017a). Taking the gross value added, Lower Saxony had the second largest value (after Bavaria) with 3.671 bn. EUR between 2011 and 2016, which is also due to the animal production region western Lower Saxony. Its agricultural sector contributes roughly 17.6% to the agricultural gross value added in Germany. (Statistical Office of the Federal States 2019). Focusing just on the animal production, the contribution to gross value added is even higher with 27.3%. The agricultural report of the Federal Government in 2015 indicates farms in Lower Saxony to have the third largest average farm profit (BMEL 2015: p.98 or 103; 2013/14; including wages).

As in other parts of the EU and Germany, Agri-Environment-Climate-Measures, being part of the Rural Development Program (known also as Pillar II) of the CAP, are voluntary and their proposed payments are calculated according the potential opportunity costs of each measure (following Article 28 (6) EU Regulation EU Regulation 1305/2013 for the period 2014-2020 (EU Council 2013)). In Lower Saxony about 394,489 ha were registered in 2012, which is about 15% of the total arable land (Ministry for Agriculture Lower Saxony 2017b). The following table provides an overview on funds, participation and area dedicated to agri-environmental programs in Lower Saxony 2012 and 2016, noting that payments for AECM were affected by changes in regulations regarding co-funding.

**Table 1: Participants, Uptake and Budgets for Agri-environmental Measures in Lower Saxony**

	<b>AEM 2012<sup>3</sup></b>	<b>AECM 2016<sup>4</sup></b>	<b>Change AECM 2012-2016 (%)</b>	<b>EFA 2016<sup>6</sup></b>
Number of contracts	18,941	19,287	+ 1.8	30,891
Budget (in Mio. EUR) <sup>2</sup>	42.78	76.42	+ 78.6	114.71
AECM Area (ha) <sup>1</sup>	394,489	319,703	– 19.0	304,014
<i>Catch crops</i>	<i>132,541</i>	<i>63,986</i>	<i>– 51.7</i>	<i>261,333</i>
<i>Flowering &amp; buffer strips</i>	<i>9,931</i>	<i>20,893</i>	<i>+ 110.4</i>	<i>1,943</i>
<i>Fallow land</i>	<i>58</i>		<i>– 100.0</i>	<i>26,353</i>
<i>N-fixing crops (EFA)</i>			–	<i>8,784</i>
<i>Landscape elements (EFA)</i>			–	<i>5,295</i>
<i>Other measures on arable land</i>	<i>88,987</i>	<i>41,767</i>	<i>– 53.1</i>	<i>306</i>
<i>Grassland-measures</i>	<i>83,447</i>	<i>75,883</i>	<i>– 9.1</i>	
<i>Organic Farming</i>	<i>79,526</i>	<i>117,174</i>	<i>+ 47.3</i>	
Budget per area	108.4	239.0	+ 120.4%	377.29
Share 'dark-green measures' <sup>5</sup>	14.5%	39.2%	+ 170.5%	11.0%

**Source.** Own calculations based on figures from Ministry of Agriculture 2017b and Dahl 2016.

**1:** Without environmental-friendly application of slurry (A3 in 2012 and BV2 in 2016);

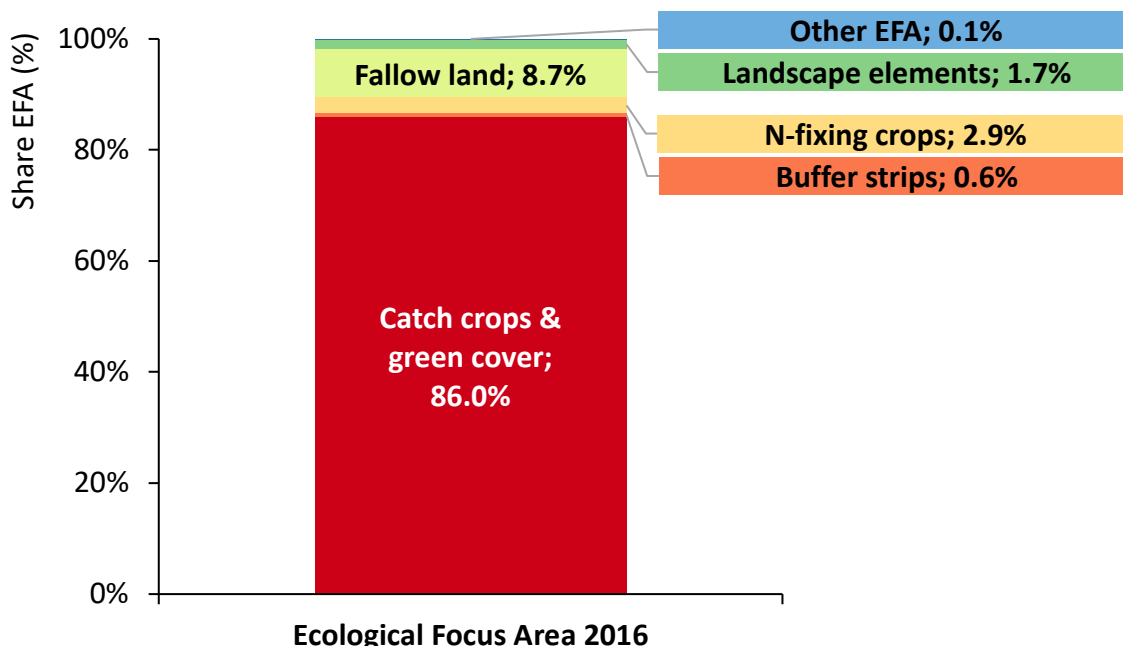
**2:** The budget for EFA was calculated, assuming that 50% of payments for Greening goes into crop diversification and maintenance of grassland. The EFA is therefore multiplied by 43.5 EUR/ha;

**3:** 'NAU/BAU 2007-2013'; **4:** 'PFEIL 2014-20'; **5:** 'Dark-green measures' are targeted, rather complex measures with high requirements and rather high payment rates. **6:** 'Dark-green measures' within greening are fallow land, buffer strips and landscape elements.

In 2015, the Ecological Focus area was introduced: In Lower Saxony, 304,014 ha were registered as Ecological Focus Area (EFA) (using unweighted area), taking a share of about 15.9% of all arable land in the federal state (Dahl 2016). In the implementation, farmers can choose from various options that can be combined in any way to fulfill this requirement, fitting for their individual farm. Weighting factors between 0.3 for catch crops and green cover and up to 2.0 for landscape

elements like hedges should reflect the potential ecological value of the options. Thus, for example, 1 m<sup>2</sup> of *catch crops* corresponds to an Ecological Focus Area of 0.3 m<sup>2</sup>, while 1 m<sup>2</sup> of a hedge or row of trees is calculated as 2 m<sup>2</sup> EFA due to the significantly greater benefit for biodiversity in agricultural landscapes. The following Figure 1 shows the shares within EFA in Lower Saxony based on farmers' decisions 2016, using the unweighted area:

The figures show a very stable decision pattern of farmers for most of the options. The largest part of this area of around 86% is taken by catch crops, another 8.7% by fallow land. The remaining area is registered as landscape elements (1.7%), buffer strips (0.6%) and N-fixing crops (2.8%). The effective, 'dark-green' options are buffer strips, fallow land and landscape elements, take 11% of the total EFA.



**Figure 1: Implementation of EFA options in Lower Saxony 2016.**

*Source: own calculations; Data from Dahl 2016;*

*Values represent real share of the area, before applying weighting factors.*

## 2.2 Effectiveness and efficiency of EFA and AECM

There is a broad literature on the different motivations and determinants of farmer participation in Agri-environmental programs. The literature shows in many cases positive effects of AECM, but overall a varied and mixed effect including cases of low effectiveness (Kleijn et al. 2006; Batáry et al. 2015). Batáry et al. 2015 indicated AECM have overall positive impact, especially when focusing on non-production areas. However, the impacts are lowered by an overall limited budget and extent (Pe'er et al. 2017b), poor design and implementation and low uptake by farmers. Part of

these limitations emerge from high administrative costs of up to 30% (Fährmann & Grajewski 2013), perceived too low or even missing economic incentives (Niens & Marggraf 2010; Lastra Bravo et al. 2015), farmers' attitude (Defrancesco et al. 2008, Batary et al. 2015). Additionally, opportunity costs lead to a lower uptake in high productive regions, although AECM in such areas could create a relatively high added value (Tscharntke et al. 2012). Participation in AECM is higher in marginal production region, where costs of participation is low. Noteworthy, Armsworth et al. (2012) show that an increase in administrative costs is accompanied by improved biodiversity levels that can be regarded as justified in terms of the benefits compared to costs. According to Plieninger et al. (2012) payment rates should much better match the local cost structure and in order to improve the uptake in high productive regions. It was proposed that cross-border cooperation and collective approaches can improve performance as well (Plieninger et al. 2012).

During the negotiations of the Ciolos-reform 2011-2013, Greening was watered down by introducing exemptions and listing weak EFA-options (Erjavec & Erjavec 2015, Pe'er et al. 2014, Alons 2017). Consequently, greening measures – especially those taken up by farmers – have low effectiveness (Hart 2015; Pe'er et al. 2017a; European Court of Auditors 2017), low efficiency due to windfall gains (Schmidt et al. 2014; Lakner & Holst 2015; Pe'er et al. 2017a,b) and still at the cost of increasing administrative complexity (ECA 2017; Zinngrebe et al. 2017; Lakner et al. 2017, Schüler et al. 2018).

EFA and AECM are partly overlapping, since some EFA options are also available as voluntary agri-environmental scheme with a reduced payment rate (Zinngrebe et al. 2017). In Lower Saxony, about 10,762 ha has a *double function* in both schemes, as about 18.6% of flowering strips, 6.2% of buffer strips and 6.9% of catch crops within AECM are at the same time used as option to fulfil the greening requirement (see table 2).

**Table 2: Double function agri-environmental measures used as Ecological Focus Area 2016**

	<b>Total AECM area</b>	<b>of which are EFA</b>	<b>Share EFA</b>
<b>Catch Crops (AL 2)</b>	63.986	4.433	6,9%
<b>Flowering strips all</b>	17.917	3.359	18,7%
<i>Flowering Strips (BS1)</i> (one year) (BS1)	16.768	3.112	18,6%
<i>Flowering Strips (BS2)</i> (multiannual)	1.149	247	21,5%
<b>Buffer strips all (BS3-BS7)</b>	2.975	195	6,2%

**Source:** Own calculations based on Data from the Ministry of Agricultura Lower Saxony (2016)

### 3 Methods and Data

The analysis approach starts from by estimating the potential impact of key EFA and AECM options on biodiversity. To this end, we introduce weighting factors based on a survey among 88 agro-ecologists across 17 European countries. Experts were asked to assess the potential impacts of all EFA-options on biodiversity, from highly effective (+5) to highly ineffective (-5). Beyond the published assessment, identifying fallow land, buffer strips and landscape elements as most effective in supporting (aboveground) biodiversity (Pe'er et al. 2017a), experts could also list the three key biodiversity provided by each EFA option. The former information was used to develop weighting factors for each EFA option, accounting for effectiveness and area covered by the measures. Table 3 below shows the weighting factors used for the calculations of potential biodiversity effects in AECM and EFA:

**Table 3: Assessed potential ecological impact of the Ecological Focus Area on biodiversity**

EFA Option	Mean effects on biodiversity
Catch crops	0,4100
Buffer strips	2,4696
Fallow land	2,4343
Nitrogen fixing crops	0,7214
Landscape features (mean value of different types of LF)	1,6566

Source: figures from Pe'er et al. 2017a

To calculate the weighted values for EFAs, we multiplied the biodiversity effect with the area per county and divided this value by the hectares in the county (as in Lakner et al. 2019). We used the scoring done by the ecologists, combined with regional uptake levels of EFA and AECM, to calculate a standardized 'ecology score' per 100 ha. Using the regional uptake of the different EFA and AECM-areas for each county, we obtained an aggregated indicator (ecology points), describing the ecological benefit of these two instruments. We divide this sum of scores-points per county by the total arable land area (in ha) to obtain the 'ecology score per 100 ha' per county, as presented in the following form:

$$Ecology\ Score\ (ES) = \frac{EFA * Ecological\ Effect}{Agricultural\ land} * 100 \quad (1)$$

There are comparable agri-environmental measures in 2012 (flower strips (A5 and A6), catch crops (A7, W3, W5) and fallow land (D)) in NAU/BAU 2007-13) and 2016 (catch crops (AL2), flower strips (BS1, BS2) and buffer strips (BS3-BS7) 2014-2020), which contain stricter farming requirements. The objective of the 'ecology score' is to model the potential the spatial effects of



EFA/AECM on biodiversity. The ecology score reflects the total effect of EFA or AECM per 100 ha. As an example, the outcomes of this approach are shown for one county in table 7 in the appendix.

To investigate the interaction of EFA with AECM and to identify regions with lower performance, we looked into data on the county level for 2016, and counted the number of counties, and the respective arable land, which falls into one of four categories:

**1) Complementary effects:** If the new EFA achieves overproportionate ecological effects in regions, where effects of AECM are lower. In such a case, EFA is compensating the low uptake of AECM. From a programming perspective, this effect suggests coherence between AECM and EFA.

**2) Reinforcing effects:** If EFA achieves overproportionate ecological in regions, where also AECM have high effects. In this case, EFA adds to existing high effects of AECM.

**3) Synergistic effects:** In some regions, EFA achieves ecological effects below average, however AECM has a strong uptake and therefore overproportionate effects. In this case, AECM is providing ecological effects, where EFA remains weak. This effect might be also regarded as functioning coherence between AECM and EFA.

**4) Low performance:** In some regions, we find low ecological effects by both, AECM and EFA.

We will investigate the effects using the following simple matrix:

**Table 4: System to evaluate potential coherence of AECM and EFA in Lower Saxony**

		Agri-environmental & climate measure	
		> Average	< Average
Ecological Focus Area	> Average	<i>Reinforcing</i>	<i>Complementary</i>
	< Average	<i>Synergistic</i>	<i>Low Performance</i>

Source: own presentation

In the last step of the analyze, we model influencing factors on the Ecology Scores on the county level, using the shares of the different EFA-options as variables. Due to problems of multicollinearity, we could only estimate a quite restricted model, which describes mainly the structural influence of animal density (AU/ha) and the soil-quality (EMZ) on the county level:

$$y = x_1 + x_2 + u \quad (2)$$

with  $x_1$  as the average animal density per hectare and  $x_2$  as the average soil quality (EMZ), both at the county level. Both variables reflect the value added in Western and Eastern Lower Saxony due to animal and arable farming, which might both influence the uptake of effective EFA and AECM. The data are provided by the Statistical Office of the Federal States (2019b).

## 4 Results

### 4.1 A more detailed view into implementation of AECM and EFA

The area, allocation of costs and potential biodiversity impacts (based on ecology scores) for AECM and EFA in 2012 and in 2016 are shown in table 5:

**Table 5: Area, costs and impacts of EFA and AECM in Lower Saxony 2016**

	Unit	2012	2016		
		Agri-environmental measures	Ecological Focus Area <sup>1) 2)</sup>	Agri-environmental measures	Total for AECM & EFA
Area	ha	142,464	304,014	84,879	388,893
Total payment (arable land)	(EUR)	14,183,577	114,049,947	20,629,524	134,679,471
Sum of ecology scores (ES)	ES	77.951	191.196	67.234	258.430
Payment per ecology score	EUR/ES	181.95	596.51	306.83	521.15
Ecology score per EUR	ES/EUR				
Ecology score per hectare	ES/ha	0.55	0.62	0.79	0.66

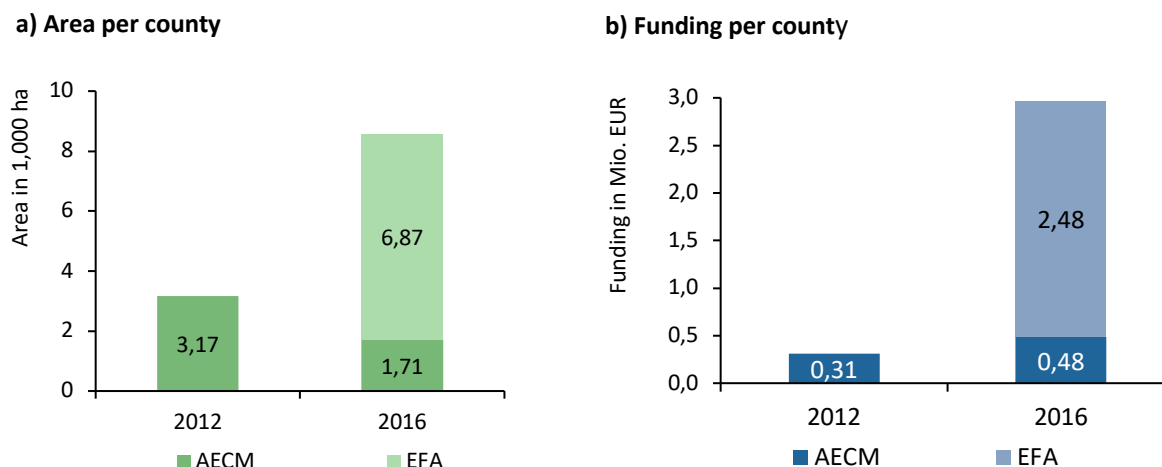
**Source:** Own calculations; Data from the Ministry of Agriculture 2017b and Dahl 2016.

**Note:** 1) For a conservative calculus, we assume that only 50% of the spending for Greening in Lower Saxony is used for EFA. The other 50% is used for the conservation of grassland and for crop diversification. 2) Greening costs is calculated by multiplying the total sum of agricultural land in Lower Saxony with 50% of the greening payments, which is 43.25 EUR/ha (BMEL 2015).

One can see that, despite lower ecology score and lower efficiency of EFA, they achieve in total a larger ecological effect due to their larger area. Additionally, the combination of AECM and EFA results in a higher affected area as well as larger total ecological score.

The results for AECM in Lower Saxony show that, in 2012, about on 231,516 ha arable land were registered as agri-environmental programs (i.e. a share of 12.1% of the total), whereas in 2016 the area was halved to 120.203 ha, i.e. 6.3% of arable land (Table 5 and Figure 2).

From an ecological perspective, our calculations result in 77,951 scores for AECM in 2012 compared to 67,234 scores in 2016, whereas the cost per effect increased (table 5).



**Figure 2: Change in area and funding in AECM and EFA from 2012 to 2016**

Source: Own calculations; Data from the Ministry of Agricultura Lower Saxony 2017.

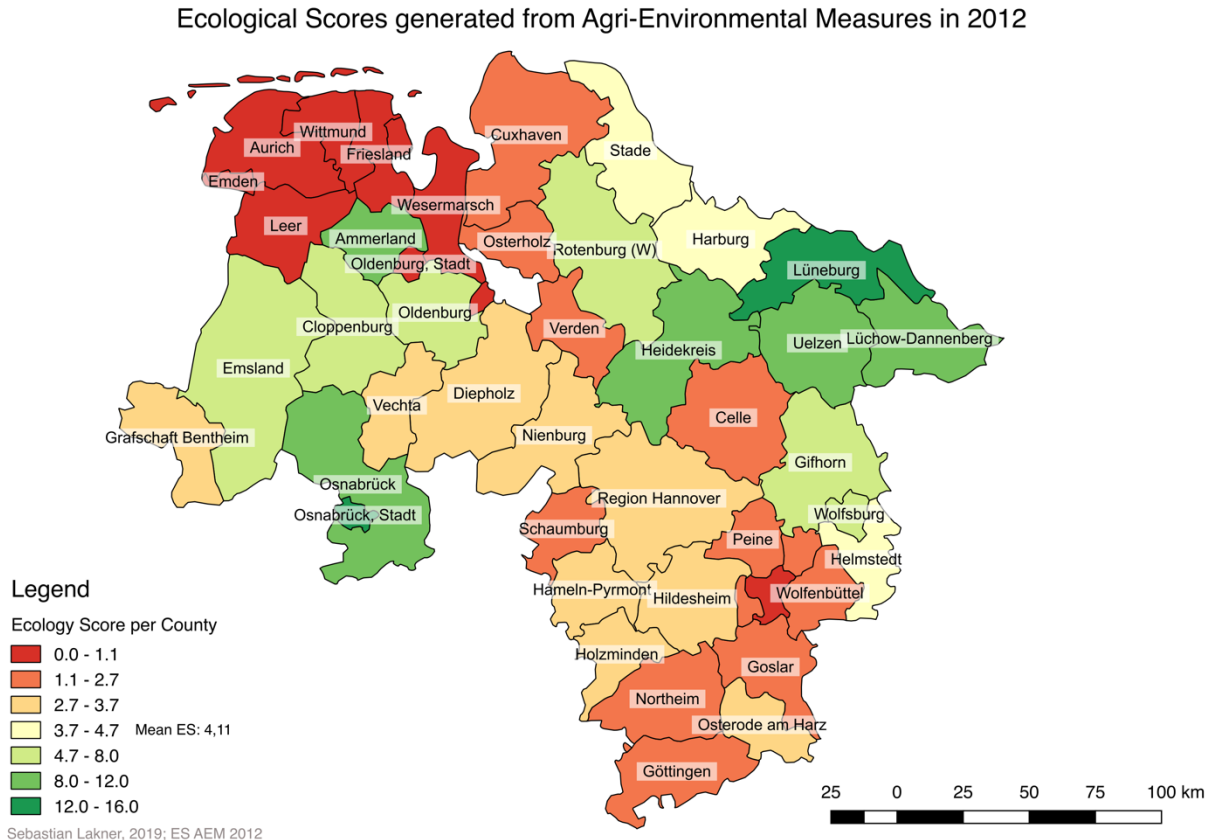
The change in AECM as a response to the introduction of EFA does not end with budget and area but also in the contents, namely the options offered to farmers. In the 2014-2020 CAP, a larger proportion of AECM budget was allocated to flowering- and buffer strips in arable regions. This resulted in a higher payment per score point (increasing from 182 EUR/ES point to 307 EUR/ES in 2016), which suggests, that the AECM 2016 are more complex and focused on outcomes. This might be explained through the enlargement of offered variation of flower and buffer strips: In 2012, *two options* were offered and contributed to 9,931 ha. This was increased to *nine options* with a total of 20,892 ha (+110%). Adding to the increment of area, the average payment rate for buffer strips in 2012 was 536 EUR/ha, which was increased to 727 EUR/ha.

On the other hand, catch crop areas under AECM reduced from 132,478 to 59,553 ha, effectively leading to the total reduction in area and scoring of AECM on arable land. These effects lead to a situation where a lower area for AECM is applied, however, for a higher payment and more strict requirements. Contrary, the Ecological Focus Area clearly took the niche of covering light green measures. Farmers in Lower Saxony have mainly chosen catch crops and green cover (ca. 86% of EFA 2015-2018, see figure 1). Both effects can be summarized as a shift toward dark-green AECM measures and that in Lower Saxony, EFA took over the role of 'light green' measures.

The financial resources used to pay for the ecological effects, was comparatively high, with an average payment rate for EFA being 377.29 EUR/ha. Note however, that the implementation of weighting factor entails that the payment effect is differentiated such that farmers receive 113 EUR/ha Catch crops (WF: 0.3) and 565 EUR/ha for buffer strips (WF: 1.5).

## 4.2 Spatial distribution of ecological effects

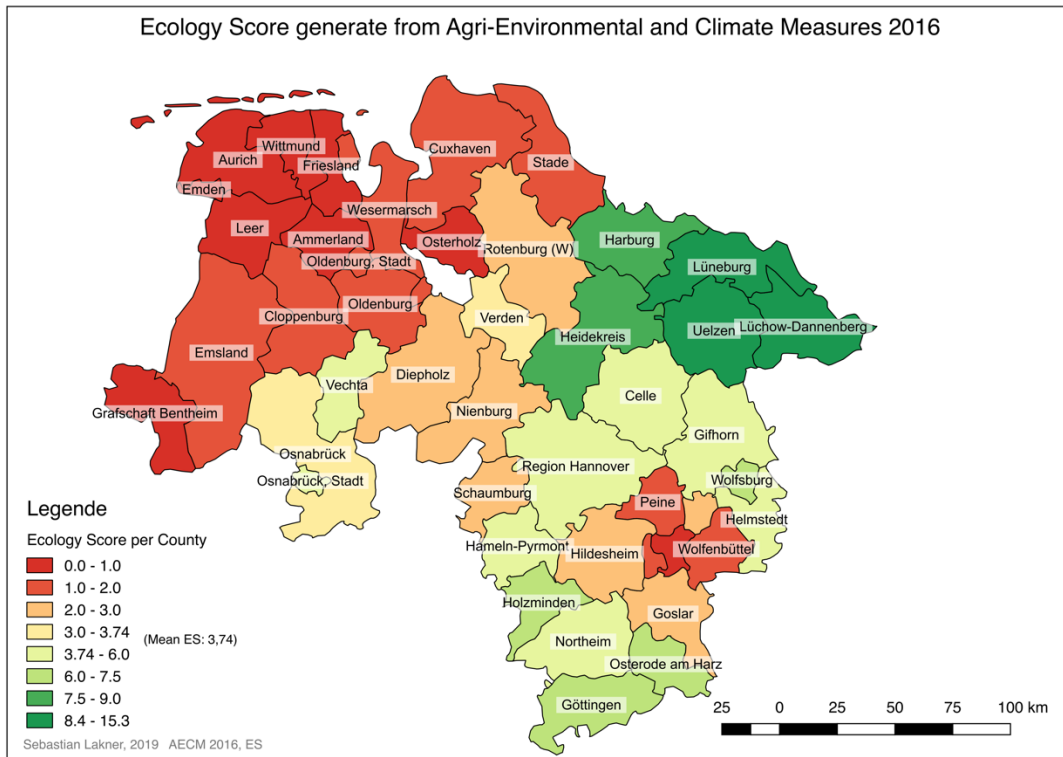
The map of ecological scores for 2012 (i.e., under AEM only; Figure 3) shows a spatial pattern where AEM have a higher share (and hence higher impact) in several counties on the northeastern parts of Lower Saxony (Lüneburg, Uelzen, Lüchow-Dannenberg, Heidekreis), characterized by extensive arable production on rather poor soil qualities, and in western Lower Saxony, mainly in the county Ammerland and Osnabrück, to be rather characterized by animal production.



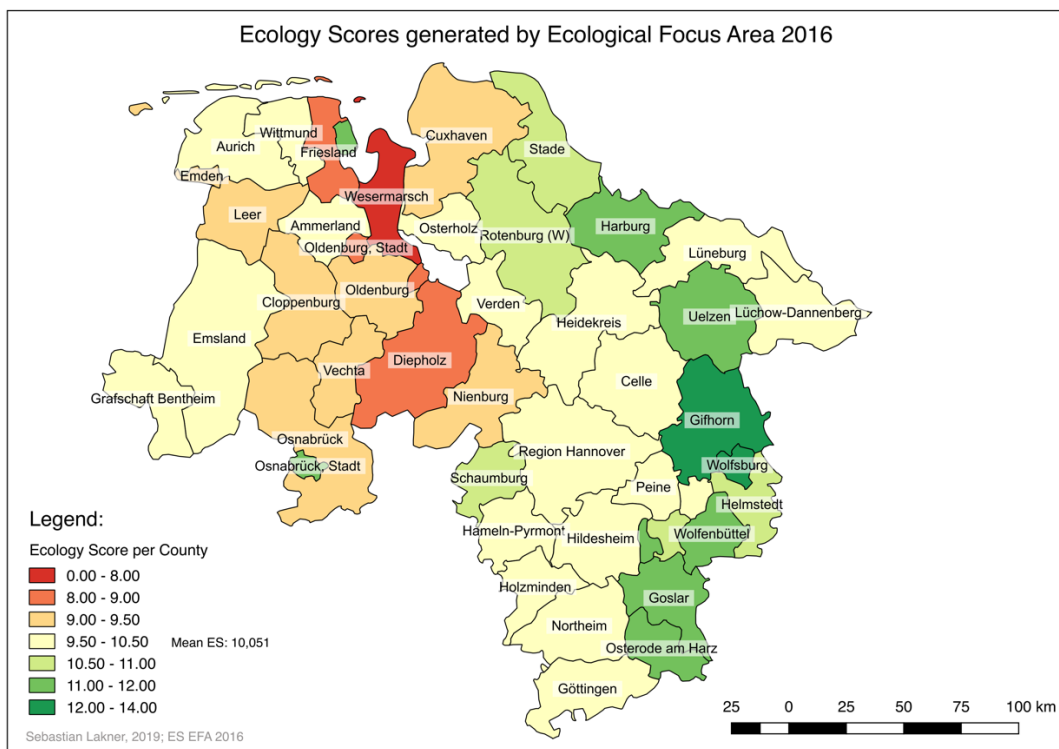
**Figure 3: Ecology Score per 100 ha of Agri-Environmental Measures (AEM) on arable land in Lower Saxony for 2012 (within the implementation period of 2007-2013)**

*Source: own calculations; Data from the Ministry for Agriculture 2017;*

The modelled ecological effect by Agri-Environmental and Climate Measures (AECM) in 2016 (Figure 4a) shows still a high ecology scores due to AECM uptake northeast Lower Saxony (Lüneburg Uelzen, Lüneburg, Lüchow-Dannenberg, Harburg). Adding to this, one can see an increase in ecological effects in 2016 in the southern parts of Lower Saxony (e.g. Göttingen, Osterode and Holzminden) due to slightly higher uptakes of AECM, still with moderate effects. However, in large part of western Lower Saxony (Weser-Ems), there is a substantial decrease in uptake and accordingly in ecological effects.



a)



b)

**Figure 4: Ecology Score per 100 ha of a) the agri-environmental and climate measures (AECM) and b) the Ecological Focus Area (EFA) on arable land in Lower Saxony**  
Source: own calculations; Data a) Ministry for Agriculture 2017 and b) from Dahl 2016.

The ecological impacts of EFA (Figure 4b) distribute across much larger parts of the whole of Lower Saxony compared to AECM (also in accordance with the larger total ecology points, Table 5). We can see effects of EFA especially in the arable regions of East Lower Saxony with good to very good soil qualities (Braunschweig, Wolfenbüttel, Goslar), we find high modelled ecological effects. In Southern Lower Saxony we can also ecological effects above average, however rather with a reinforcing structure. In northeast Lower Saxony (Gifhorn, Uelzen, Harburg), we can also observe a *reinforcing* pattern, where EFA and AECM are achieving ecological effects above average. On the other hand, the ecological effects on Biodiversity remain low in Western and northwestern Lower Saxony (Diepholz, Vechta, Cloppenburg). Due to high value creation per hectare in the animal sector and high land rents, farmers are generally reluctant to participate in AECM and they mainly use catch-crops to comply to the EFA.

### 4.3 Coherence between the two instruments

To investigate the collaboration between AECM and EFA in different regions, we analyzed counties with ecology scores of EFA and AECM above and below average using the matrix-system presented in table 4. The following table 6 shows the results:

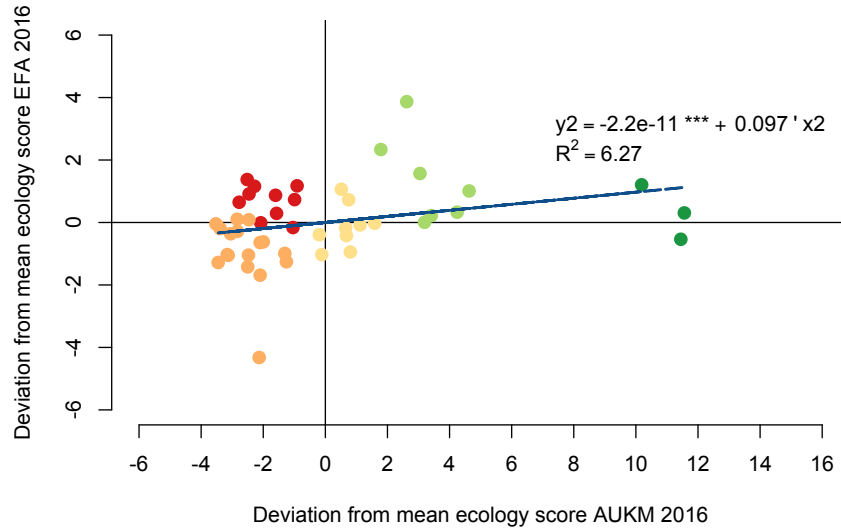
**Table 6: Collaboration between EFA and AECM in Lower Saxony 2016**

		Agri-environmental & climate measure (AECM)	
		> Average ES	< Average ES
<b>Ecological Focus Area (EFA)</b>	<b>&gt; Average ES</b>	<b>Reinforcing:</b> Counties: 11 Area: 391.379 ha Share land: 20.5%	<b>Complementary:</b> Counties: 10 Land: 294.694 ha Share land: 15.4%
	<b>&lt; Average ES</b>	<b>Synergistic:</b> Counties: 6 Area: 332.943 ha Share land: 17.4%	<b>Low performance:</b> Counties: 19 Area: 894.761 ha Share land: 46.8%

**Source:** own calculations; **Note:** the average ecology score for EFA is 10.05 and for AECM is 3.74

Table 6 indicates that in 19 out of 46 counties (i.e. 41% of counties) and 46.8% of land, we find a **low performance** of both measures achieving ecology scores, which are in both measures below average. Only in six of 46 counties (13%), with about 17.4% of land, we found **synergistic** effects with ecology scores below average in EFA, however, large ecology score in AECM. Three of these counties are in regions with favorable soil qualities like Hameln, Hannover or Northeim. In 10 counties with about 15.4% of land, we find **complementary** effects: Here, the AECM play a minor role and EFA achieves higher ecology scores, thereby over-compensating for the low uptake in AECM. From an agricultural policy effect, this might be a favorable effect from a programming perspective. In 11 counties (20.5% of land), both measures achieving effects on biodiversity,

which are above the average. This ‘reinforcement effect’ might be seen positive with regards to ecological effectiveness, however such this effect signals a kind of ‘double payment’, which will reduce the efficiency. This effect shows missing coherence of the programming approach of EFA, since one would add effects in a region, where the AECM is already in place. The following Figure 5 shows the quantitative relation between ES for AECM 2016 and EFA 2016:



**Figure 5: Relation between Ecology score for AECM 2016 and EFA 2016**

*Source: own calculations.*

This figure suggests that the main trend goes from “**weak performance**” to a “**reinforcing trend**”, in other words, we find strong performance of EFA in regions, where the uptake of AECM is already substantial; And on the other hand, where we find weak performance in AECM and EFA simultaneously. Note, that overall, the trend is quite weak (+0.097\*) with a low R2, suggesting that the development is quite heterogenous throughout the regions. A short cluster analysis shows however, that a **complementary trend** can be statistically identified (the red observations), whereas the counties with **synergistic tendencies** rather fall into the general trend described above and are negligible.

#### 4.4 Determinants of ecological effects

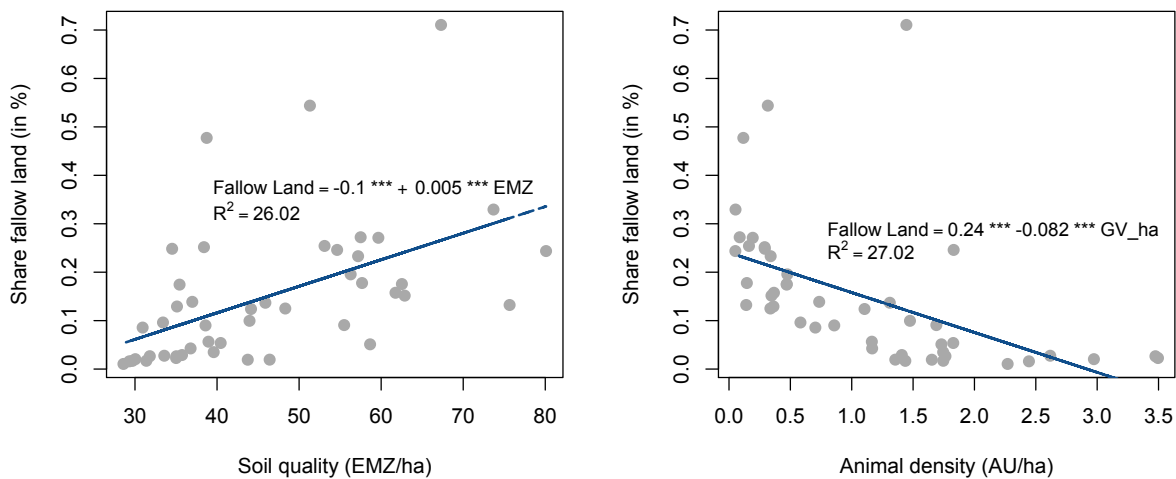
The following table 7 presents the coefficients explaining the ecological effects due to EFA:

**Table 7: Influencing Factors for the ecological impacts of EFA in Lower Saxony**

	Coefficient	Std. error	t-value	Probability (> t )
Constant	2.9497***	0.2564	11.51	0.000
Animal density (GV/ha)	- 0.0882***	0.0174	-5.07	0.000
Soil quality (EMZ)	- 0.1803***	0.0686	-2.63	0.012

Source: own calculations;  $R^2$  is 37.63; Residual standard error is 0.1055;

The results suggest, that in regions with higher animal density, farmers tend to choose less effective EFA-options. The same relation can be found for soil-quality: The higher the soil quality, the lower potential ecological effects. Both effects can be explained by high value added per ha and high opportunity costs of ecological measures. An overview of all variables is shown in figure 7 in the appendix. Both factors also influence the uptake of fallow land, displayed by Figure 6:



**Figure 6: Determinants of the share of fallow land in Lower Saxony**

Source: own calculations.



## 5 Discussion

With Cioloş-reform of 2013 and the introduction of Greening, the agri-environmental support was change to a large extent. The presented results in Lower Saxony suggest a number of conclusions:

**1. Substantial changes within AECM due to EFA:** The introduction of greening and of EFA has enlarged the agricultural area under environmental requirements. This is reflected by an increase in the calculated ecology score (ES), which reflects the potential effects of the CAPs designated instruments on biodiversity (and some Ecosystem Services (ESS)). The comparison of AECM funding-data between 2012 and 2016 show that the registered area for AECM was reduced (from 142 to 85 k ha), whereas the funds were increased (14.2 to 20.6 Mio. EUR). At the same time, the effects of AECM was substantially outweighed by the introduction of the EFA leading to larger area taken for EFA (ca. 304 k ha) and adding about 114 Mio. EUR of funds.

**2. The main ecological effect of EFA is achieved by the 'light-green' catch crops.** The calculated Ecology Score (ES) by AEM was reduced from 77,9 k score points in 2012 to 67.2 k in 2016. On the other hand, the introduction of EFA added about 191 k score points. This change in ecological impact is mainly caused by a reduction of catch crops in AECM (from 132 to 64 k ha), which mostly moved to EFA. Between 2015 and 2018, catch crops dominated the implementation of EFA in Lower Saxony by a share of >85%. The results of Pe'er et al. (2017a) suggest, that catch crops exhibit a low effectiveness for the support of biodiversity. The weighting factor estimated by ecologists is 0.4100, suggesting a 'light-green' effect for biodiversity by the introduced EFA. Based on the weighting factor of 0.3, farmers have to register rather large area of Catch crop to fulfil their obligation, which explain the large share of catch crops in the net EFA, as shown in figure 1.

**3. Programming lead to a rather 'dark-green AECM' in Lower Saxony:** Lower area with higher funds suggests that the programming lead to a shift of rather dark-green programs within AECM. Additional funds were available, since Germany took the decision and moved 4.5 of direct payments into the Rural Development Funds (BMEL 2015). These shifts from P1 were mainly dedicated to AECM and they came free from the obligation to co-finance, which might also explain parts of this effect. On the other hand, flowering and buffer strips were enlarged, from 10 k to 21 k ha. Moving in this direction, the government followed the suggestions of the Court of auditors (ECA 2011) or scientists (Armsworth et al. 2012, Batary et al. 2015). Notably, the increase in ecological scoring points (ES) from 2012 to 2016 is both due to the introduction of EFA in the Cioloş-reform of 2013 and the reformulation of AECM in the 2014-2020 period in Lower Saxony. However, given the presented data, it remains unclear, to what extent this shift within AECM was due to the introduction of Greening or political priorities alone, or a combination of both.

#### **4. Spatial analysis show more ecological effects the arable regions of Eastern Lower Saxony.**

Considering the spatial results, we can see, that EFA rather contributes in the unfavorable regions of Eastern Lower Saxony (Gifhorn, Uelzen, Harburg) and in parts of the favorable regions of Eastern Lower Saxony (e.g. Wolfenbüttel, Helmstedt, Salzgitter). In Western Lower Saxony, the ecological effects of both, AECM and EFA are comparatively low, which can be explained by high value added of animal production, causing high opportunity costs of agri-environmental actions.

**5. Collaboration of EFA and AECM shows large room for improvement.** The modelled ecological effects are heterogeneous in space. Analyzing the ecological effects of both instruments, we can see, that EFA shows overproportionate results in regions, where also AECM shows high ecological effects (denominated as ‘reinforcing effect’). On the other hand, we find many regions, where both instruments show low ecological effects (‘low performance’). This main trend can be found in 30 of 46 of counties with 67.3% of the arable land in Lower Saxony. Using a cluster analysis (figure 6) we can identify a third, rather small effect in regions, where we find weak AECM but over proportionate ecological effects by EFA, which we can see in 10 counties with 15.4% of land. This effect can be found in some of the favorable arable regions, where AECM might have been regarded as unattractive in the past, and where the obligatory character of EFA has produced this effect. The ‘synergistic effect’ (weak EFA but rather strong AECM) could not be identify by our cluster analysis.

From a **programming perspective**, this type ‘complementary effect’ of EFA could increase the efficiency of spending, since we achieve effects in regions, where AECM was traditionally weak. The analysis of collaboration shows, that the largest part of EFA does not correct the spatial mismatch of AECM, which is due to high opportunity costs in favorable arable region or in Western Lower Saxony due to animal production. Adding to this, the qualitative upgrade, where AECM is combined with EFA is only done on about 8.000 ha. This combination-option could be improved in order to strengthen the effectiveness of both, AECM and EFA.

**6. The results suggest a rather low efficiency of EFA.** The method of ecology scores allows to relate the invested funds to an overall ecological effect. In 2012, the costs per score point within AEM were about 182 EUR/ES. This changed due to the described shift towards the darkgreen measures: In 2016, the average ecology score costs about 307 EUR/ha, which can be explained be a larger share of flowering- and buffer strips, which are more costly in the implementation. However, the EFA results with costs of 597 EUR/ha show that any ecological effect by EFA is even more costly. The substantial increase in ecology scores, as described above, come at very high costs, suggesting that greening is an inefficient agri-environmental instrument. This finding is consistent with the literature (as e.g. Schmidt et al. 2014, Lakner & Holst 2015, Pe’er et al. 2017b).

## 6 Conclusive Remarks

Following the CAP-reform 2013, the amount of funds for agri-environmental programs has been reduced by 8% throughout the EU. Overall, spending priorities on agri-environmental policies do not reflect the effectiveness of measures, where we can see high spending for Greening, lower spending for AECM and lowest spending for measures supporting Natura 2000 (Pe'er et al. 2017b). On the other hand, with Greening the EU has introduced an instrument, which shows only moderate ecological effects (Pe'er et al. 2017a) and low efficiency. The results presented in this study are consistent with other studies. The presented method is appropriate to reflect the biodiversity impacts of EFA and AECM simultaneously: One can see e.g. similar spatial effects of the biotope-index as an ecological indicator (see Lakner et al. 2019), which gives a similar spatial pattern within Lower Saxony as the ecology scores presented in figure 4.

The results show some scope for improvement for the coherence of AECM and EFA. In most of the regions, AECM and EFA achieve impacts in the same direction, both being positive or negative. This pattern is found for 67.3% of arable land. From a programming perspective, this is incoherent and thereby inefficient. This type of missing coherence stems mainly from the one size fits all-approach of greening. The Germany implementation has too little regional adjustment.

Still, on 15.4% of the arable land in Lower Saxony one can find 'complementary effects'. This result highlights the importance for a consistent regional implementation and programming of agri-environmental measures within both pillars. The actual debate on the CAP-reform post 2020 (EC 2018) introduces the conditionality, the eco schemes and agri-environmental schemes. For an increased efficiency, policy has to seek complementary and synergistic effects between different measures. The complementarity still shows, that Greening and EFA could achieve better results.

The model-results show that the uptake of the fallow land, which is regarded as an effective and practical (Pe'er et al. 2017a), is influenced by the value added per hectare. A high animal density and high soil quality both reflect a high value added per hectare and higher opportunity costs for environmental measures. According to the literature, economic drivers are influencing AECM (Niens & Marggraf 2010, Batary et al. 2015). The results of this study suggest that similar factors are driving the development of both, AECM and EFA measures, which are also described by interviews in Zinngrebe et al. (2017) or Schüler et al. (2018). Therefore, improvements can be achieved by using regional specific payments which better reflect opportunity costs, and which are attractive for farmers. This warrants also a further research based on single farm-data.

To improve the synergy between EFA and AECM, agri-environmental policies have to be consistent and with lower administrative burdens. Some studies suggest, that administrative burdens are a substantial (Fährmann & Grajewski 2015), if not the most important determinant for farmers' decision leading to low uptake of ecologically-effective EFA and AECM option

(Zinngrebe et al. 2017; Schüler et al. 2018). The literature also shows that administrative complexity is also a particular problem within the classical AECM (Niens & Marggraf 2010, Batary et al. 2015). This suggest that reducing administrative burdens within AECM, improving farmers' benefits from participating in (dark-green) AECM and streamlining EFA with AECM can yield significant improvements. In addition, so far only two MSs (Poland and the Netherlands) adopted the option of collaborative implementation by farmers. AECM are also missing landscape-approaches, which could provide better support for biodiversity (X). Identifying lanes to reinforce and expand landscape-level implementation can certainly improve performance given the robust evidence indicating its higher effectiveness and efficiency.

Finally, there are many studies on AECM suggesting a shift of additional funds from direct payments into rural development programs, in increase financial resources of AECM (see Scientific Council 2018; Pe'er et al. 2017a, 2017b, Lakner & Oppermann 2018). Shift money to Pillar II and differentiate payments e.g. according land quality, e.g. corrected by the EMZ-factor. Adding to this, policy could strengthen the financial options of AECM by shifting more funds to the programs of rural development programs (RDP; P2), which would support the described shift towards dark-green programs (Lakner & Oppermann 2018). Parts of greening will remain within the enhanced conditionality (EC 2018), however, policy might reflect, whether a similar uptake of catch crops can be also achieved at lower costs. An increased efficiency of agri-environmental programs remains as important task for the CAP post 2020.

The modelled effects reflect the full effect of EFA, however, only parts of the AECM. We excluded environmental-friendly slurry application on arable land, organic farming and AECM on grassland, since there are no ecological weightings factors. Therefore, the low values for ecology scores for AECM are due to the narrow scope within this study. It might be subject for further research to include the beneficial effects of organic farming and extensive grassland farming. Additionally, the study cannot model single farm behavior. County data cannot fully reflect the adjustment of farmers behavior; therefore, it will be subject to further research to model farm-specific determinants of EFA and AECM uptake in order to explain the final decisions in detail, which are described with the presented method.

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**Table 8: Calculation method of the ecology score of EFA for one county**

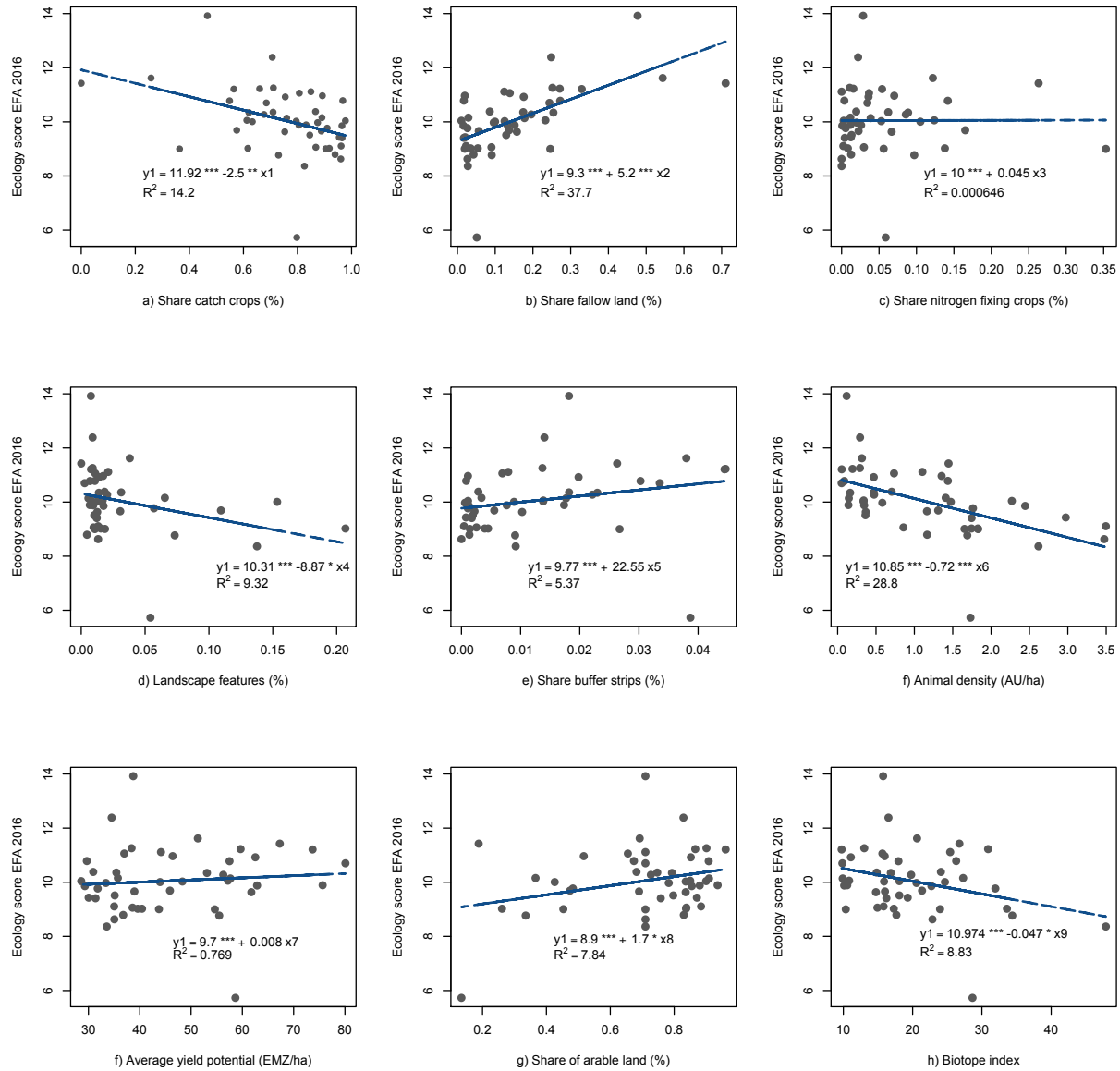
EFA Option	EFA Area in a county (in ha)	Ecological Weighting factor*	Ecology Score Points
Catch Crops	3.141	0,4100	1.288
Nitrogen Fixing Crops	635	0,7214	458
Fallow land	1.195	2,4343	2.909
Landscape Element	86	1,6566	142
Buffer strips	71	2,4696	175
<b>Sum</b>			<b>4.973</b>
<b>Agricultural land in the County</b>			<b>49,443</b>
<b>'Ecology Score per 100 ha'</b>			<b>10,06</b>

**Source:** own calculations, based on Lakner et al. 2019; The ecological weighting factors are taken from Pe'er et al. 2017a; Data on EFA taken from Dahl 2016



**Table 9: Counties with different types of collaboration between EFA and AECM 2016**

		Agri-environmental & climate measure	
		> Average	< Average
<b>Ecological Focus Area</b>	<b>&gt; Average</b>	<b>Reinforcing</b> Göttingen Osterode am Harz Holzminden Wolfsburg Gifhorn Helmstedt Harburg Lüneburg Heidekreis Uelzen Osnabrück	<b>Complementary</b> Braunschweig Salzgitter Goslar Peine Wolfenbüttel Schaumburg Osterholz Wilhelmshaven Rotenburg (W) Stade
	<b>&lt; Average</b>	<b>Synergistic</b> Northeim Region Hannover HamelN-Pyrmont Celle Vechta Lüchow-Dannenberg	<b>No impact</b> Diepholz Hildesheim Nienburg Cuxhaven Verden Delmenhorst Emden Oldenburg, Stadt Aurich Friesland Grafschaft Bentheim Leer Wesermarsch Wittmund Ammerland Cloppenburg Emsland Oldenburg Osnabrück



**Figure 7: Factors influencing the ecology scores of EFA in Lower Saxony 2016**

Source: own calculations.