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Modelling agri-environmental measures in AgriPoliS and data update

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List of abbreviations

AgriPoliS: Agricultural Policy Simulator
AWU: Annual Working Units
EAGF: European Agricultural Guarantee Fund
EU: European Union
EUR: Euro
GSS: Götalands södra slättbygder
h: hour
ha: hectares
IACS: Integrated Administration and Control System
ID: Identification number
LfULG: Landesamt für Umwelt, Landwirtschaft und Geologie
LU: Livestock Units
MIP: Mixed-Integer Programme
MP: Mittelsächsische Platte
SEK: Swedish krona (1 € = 9.4778 SEK on 22 August 2016)
UAA: Utilized Agricultural Area

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1 Introduction

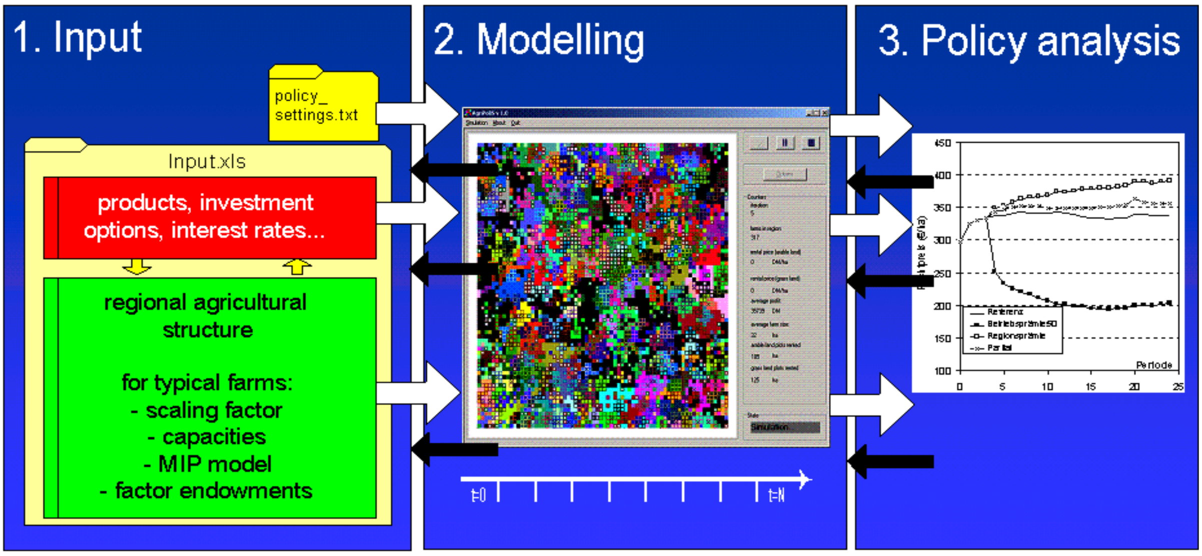
This report provides a documentation of both the update regarding production, investment and farm data for two European regions modelled in the MULTAGRI project (Götalands södra slättbygder in Sweden –"GSS" in the following; Mittelsächsische Platte in Germany –"MP" in the following) as well as the extension of the model AgriPoliS to consider the newest features of the reformed Common Agricultural Policy's (CAP)

Actually the so-called "greening measures" have been introduced with the latest reform of the Common Agricultural Policy (EU, 2013). 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 (or "greening payment" distributed in the first pillar of the CAP) are now conditioned on compliance with greening measures whereas the remaining 70% constitute a basic payment further distributed as such. Therefore in order to receive full payments, farmers must now i) comply with specific crop diversification requirements; ii) maintain permanent grassland and pastures; and iii) create EFA's on at least 5% of their arable land.

The introduction of greening measures and especially of Ecological Focus Areas (EFA's) is expected to affect farm growth and farmers' incomes at least in a short run, as farms do have to comply with a factual reduction of their arable land from 2015 at the risk of losing the greening payment. Actually after 2017 farmers might even lose up to 125% of the greening payment in case of non compliance with greening measures. On the other hand the implementation of those measures, in particular the establishment of EFA's is expected to ensure the maintenance and to some extent an increase in biodiversity on agricultural land. To this extent, several interventions are at disposal of farmers and can either be implemented on the total required EFA or as a combination in various proportions. Among those interventions, farms can choose to plant hedgerows and trees, leguminous plants, flower strips, etc. However, each of those activities is characterised by different efforts (various costs for seeds, different labour intensities and requirements for machinery, etc.) which might differ when considering regional context and farms' economic and physical situations. Because of these on-farm trades-offs between EFA measures, which are not a priori known by the policy maker, farms might opt for different interventions due to their very own structure and regional constraints in order to minimise induced costs. This in turn has consequences at the regional level. The investigation of those consequences at both individual and regional levels is the core objective of this workpackage of the MULTAGRI project. Due to the “catalogue” aspect of greening measures as to be implemented on EFA’s, this investigation necessitates considering decision-making at the individual level, its consequences on land use, ensued impacts on land markets and economic and structural consequences for agricultural producers in different landscapes. Therefore a bottom-up approach was chosen in order to take 1) individual decisions into account and 2) provide insights on impacts of EFA’s in different regional contexts. The agent-based AgriPoliS had already been adapted to numerous European regions; the model has been re-calibrated for two European regions located in Sweden and Germany.

Modelling with AgriPoliS requires the consideration of a whole process starting from initial input data collection to the analysis of simulation outputs. Basically, the process of "AgriPoliS modelling" consists of three steps or parts, the input part, the modelling and simulation part, and the policy analysis part (Figure 1).

Figure 1: Main steps of adapting AgriPoliS to a region



Source: Own figure.

The modelling or a region in AgriPoliS is not limited to pressing a button indeed. It very much involves researcher’s knowledge of not only the functioning of the model but of the regional characteristics of agriculture as well. For this latter purpose the researcher might be helped by other colleagues, local experts, available reports and handbooks. Therefore modelling with AgriPoliS is divided in three steps:

- *Step 1 - Input*: At first the input data for AgriPoliS has to be collected and compiled in input files for AgriPoliS. To adjust and calibrate AgriPoliS to a region the agricultural structure of that region is represented for a base year based on typical farms, i.e., farms one could typically find in the region. For the purpose of MULTAGRI the two chosen regions have been calibrated for the years 2008 (GSS) and 2013 (MP).

- *Step 2 - Modelling*: After the input data are fed into AgriPoliS, the model has to be calibrated and validated with regard to the case study region. During the calibration there is a constant feedback between step 2 and 1, as input data may have to be adjusted to reach a better fit between AgriPoliS and real data. For this we compare a set of model indicators with real indicators in the base year. Exemplary indicators are total production of crops, livestock, and farm exit.

- *Step 3 - Policy analysis*: When the model has been calibrated to the respective regions, policy simulations are carried out regarding different policy options. Also at this stage, there is a feedback between this task and the previous task as the implementation of certain policy options may require the adjustment of the model. For the purpose of the MULTAGRI project special attention is given to possible discrepancies between modelled and real options implemented on Ecological Focus Areas (EFA); those have to be minimal in order to validate the reference scenario to which other possible policy options will be compared.

The objectives of this report are 1) to describe the latest developments introduced in the model for the purpose of the MULTAGRI project and 2) to document input data used for modelling the two case study regions with AgriPoliS. This largely refers to the steps described above with special emphasis on step 1. Step 2 and step 3 of the modelling process will be further described in D4.3[1].

This report is structured as follows. In section 2, 3, and 4, we provide a detailed report on the tasks carried out to fulfil step 1 in the AgriPoliS modelling process. This includes a detailed description of the selected case study regions in section 2. Section 3 shows results of applying the methodology to adapt AgriPoliS to the two case study regions. Application of this procedure leads to a set of typical farms and corresponding scaling factors. In section 4 we further elaborate on the representation of individual typical farms. As each typical farm determines

[1] Title of D4.3: “Possible trajectories of agricultural development depending on policy measures.”

its behaviour based on a linear programme, we present the key production activities and investment options identified for the two exemplary regions Mittelsächsische Platte (MP) and Götalands södra slättbygder (GSS).

2 Description of the MULTAGRI study regions

The main objective of Workpackage 4: "Land use conflicts and impacts on agricultural development trajectories in rural areas" is to evaluate how policies that aim at enhancing ecosystem services and public goods affect agricultural development and the economic performance of farms. In particular, it is analysed how environmental measures affect farm growth and farmers' income situation. Thereby, conflicts of different land-uses and positive effects of environmental measures on agriculture are to be considered. Furthermore, the work achieved in WP4 shall provide insights on whether policy measures should be specified according to differences in local conditions.

The case study regions used in the MULTAGRI project have been chosen because of the high degree of potential conflict between the production of agricultural commodities on the one hand and the conservation of rural landscapes and biodiversity on the other hand. For instance in eastern Germany animal production is being progressively abandoned in favour of crop farming. As large farm structures are predominant due to historical reasons, these farms constitute very competitive production units. However, the concentration of similar agricultural production 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 decline in biodiversity in cultivated landscapes we observe today. The plains of Scania in southern Sweden are a specialized and highly productive arable cropping region. Intensive crop production occurs on large, interconnected fields where historical removal of field boarders and other impediments have resulted in a simplified 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. Similar to Germany, these developments have led to nitrogen leaching, soil degradation, and declines in biodiversity and mosaic values.

Table 1 gives an overview on the two selected regions for the project.

Table 1: Size and structure of the case study regions

	GSS	MP
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)	72.15	196
Proportion of grassland of total UAA (%)	3.7%	10.5%

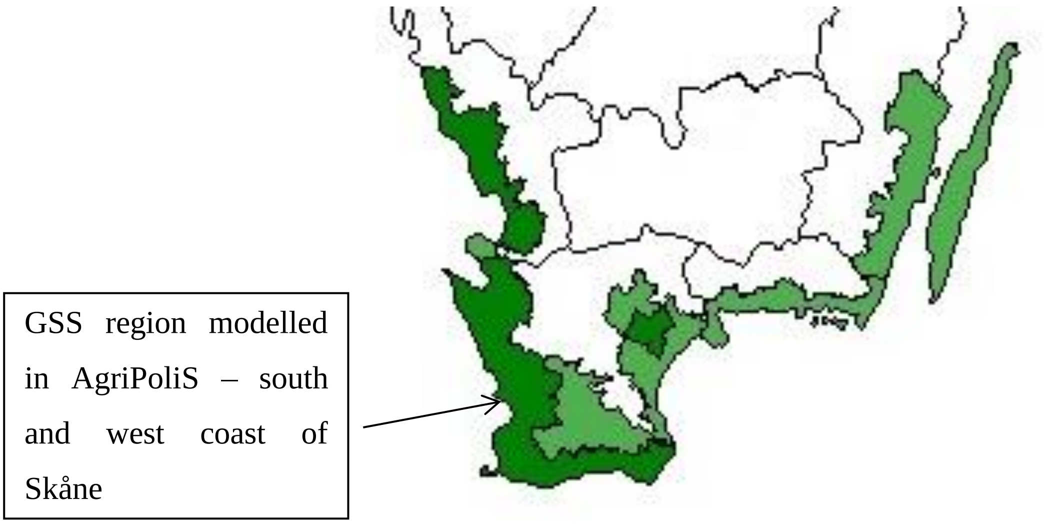
Source: LfULG 2013 (on request); SJV (2009).

Following subsections provide more information on each of those two regions.

2.1 Sweden: Götalands södra slättbygder (GSS)

Before describing the regional characteristics in detail, note that we model and calibrate a sub-region of the whole Götalands södra slättbygder (GSS) region. The subregion occupies the southern plains of the south and west coasts of Skåne (Figure 2). We only focus on the area within Skåne where intensive agricultural production with high incomes, is distinctive. Hence, all the statistics correspond to a subregional level but reflect the total regional characteristics. The presented regional statistics are for 2008 at which we calibrated the model.

Figure 2: Production regions in south Sweden and Skåne



Source: Statistics Sweden (2012).

Climate: The region is dominated by a climate, which is marked by a growing season of more than 220 days, with around 600-800 mm average annual rainfall and an average annual temperature of 8-10 °C (SMHI, 2016).

Landuse: Out of the total 201,577 ha UAA, 96 % is used as arable land for mainly growing cereal crops but also sugarbeet (Table 2). Seminatural grazing land is less dominat land use.

Table 2: Size and structure of GSS

Utilised agricultural area - UAA (ha)	**201,577**
Arable land (ha)	**194,082**
Cereals (ha)	114,650
Protein crops (ha)	4,594
Oilseed crops (ha)	13,588
Sugarbeet (ha)	24,587
Potatoes (ha)	2,668
Grassland (ha)	14,704
Fallow land (ha)	11,028
Other crops (ha)[a)]	8,262
Semi-natural grazing land (ha)	**7,495**
Livestock number	
Number of cattle	**22,833**
Beef cattle	7,088
Dairy cows	3,376
Suckler cows	4,843
Calves under 1 year	7,526
Number of sheep and lamb	**3,027**
Number of sows	**14,920**
Number of fattening pigs	**73,675**

Source: SJV (2009).
Note: a) other crops group horticulture and other unspecified crops.

Agriculture: The landscape in GSS is characterized by large open fields on interconnected plains where crop production is the dominant agricultural activity. Due to the favourable climate production conditions and fertile soils, the region is the most productive in Sweden , having the highest standard yields in the country (8 t/ha and 6 t/ha for winter wheat and spring barley compared to 6.2 t/ha and 4.3 t/ha for the country) (Statistics Sweden, 2009).

The dominance of crop farms in GSS is clearly apparant from the farm structure[2] presented in Table 3. They occupy almost 90% of the arable land. Granivore production is an important activity in terms of number (Table 4), but is concentrated to a few number of farms (Table 3).Since most feed is purchased and manure-spreading contracts are generally signed with neighbouring crop farms, pig producers are not dependent on having their own land for pro-

[2] The `type of farming` is based on Swedish typology definition to ensure that the classification by `type of farming´ covers the whole variety of different lines of production in the region.

duction. The average livestock density per hectare is 0.95 LSU/ha and above the national average[3], which is due to the high number of granivores.

Table 3: Type of farming in GSS (number of farms and percentage shares)

Type of farming	Total number	in %	Arable land	in %
Field crop	**1,735**	**65**	**175,146**	**90**
Livestock management	**238**	**9**	**14,051**	**8**
- dairy	34	1	2,406	1
- beef	135	5	3,291	2
- pig	46	2	5,486	3
- sheep	23	1	2,868	2
Mixed	**196**	**7**	**2,351**	**1**
Small farms	**521**	**19**	**2,534**	**1**
Total	*2,690*	*100*	*194,082*	*100*

Source: SJV (2009).

Table 4: Number of different livestock by size of herd in GSS

Dairy cows		**Ewes and rams**		**Sows**		**Fattening pigs**	
Size of herd	Nr. of heads	Size of herd	Nr. of heads	Size of herd	Nr. of heads	Size of herd	Nr. of heads
<= 49	319	<= 49	572	<= 49	1,122	<= 99	1,107
50-99	693	> 50	2,455	50-99	1,728	100-249	3,501
100-199	743			100-199	2,483	250-499	6,713
>= 200	1,622			>= 200	9,586	500-749	6,481
						>= 750	55,873
	3,376		**3,027**		**14,920**		**73,675**

Source: SJV (2009).

An important regional feature is the high share of small farms (< 20 ha) which can be considered as hobby farms. However, the land area managed by this type of farms is small (Table 5). Rather, the majority of the arable area is farmed in medium to large farms, i.e., > 50 ha. Making the average size farm, compared to the Swedish regional or nationwide average farm size in 2008, be larger by 17% or 98% (Statistics Sweden, 2009).

[3] Regional livestock density index is obtained from the modelled typical farms where as national average from Eurostat database (EUROSTAT, 2016).

Table 5: Number of farms in GSS in different size classes

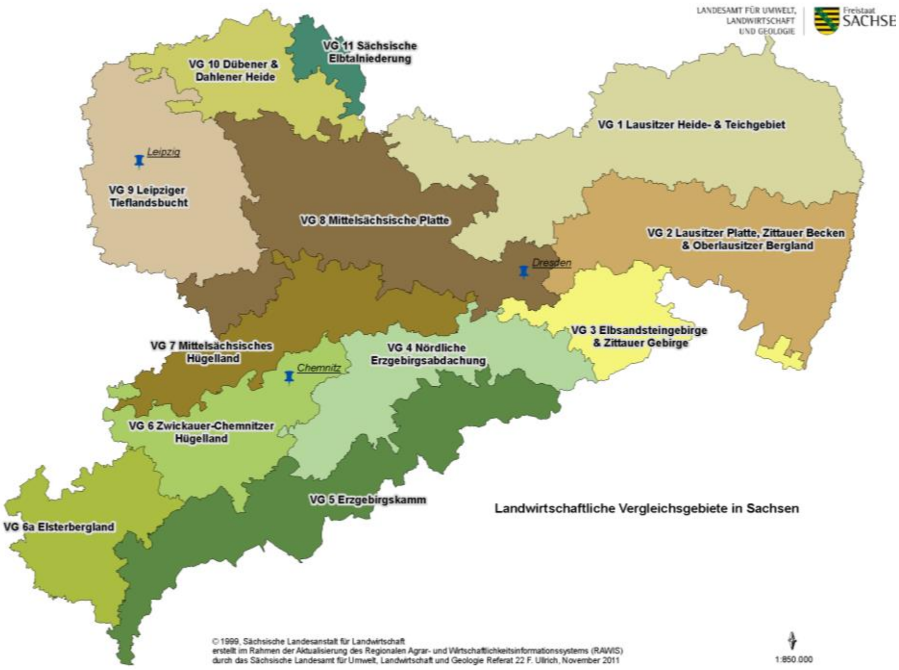
	Farms		Arable land		Av. size
Size class	*Nr*	*%*	*ha*	*%*	*ha*
<= 20 ha	1,113	41	9,611	5	8.64
20-50 ha	530	20	14,552	7	27.46
50-100 ha	491	18	46,121	24	93.93
100-200 ha	336	13	40,283	21	119.89
200-300 ha	114	4	25,871	13	226.94
300-500 ha	58	2	22,456	12	387.17
> 500 ha	48	2	35,188	18	733.09
Total	*2,690*	*100*	*194,082*	*100*	*72.15*

Source: SJV (2009).

2.2 Germany: the region Mittelsächsische Platte (MP) in Saxony

The second study region is a subregion inside the federal state "Saxony" (Sachsen, Germany) in the southern part of the former GDR (estern Germany). Saxony has been divided into 11 zones ("Vergleichsgebiete") which are comparable in terms of climatic, soil and altitude conditions as important characteristics for local agriculture (LFL SACHSEN, 1999). The study region is congruent to the so called "Vergleichsgebiet 8" which stretches from the east of Leipzig from its western part till Dresden to the east and bordered by moorlands in the north and low mountain ranges to the south (Figure 3). The zone consists of loess-loam soils traditionally used for rather intensive field crop farming due to favourable pedo-climatic conditions. Agricultural landscapes with field crop productions spread on low knolls are characteristic for the region. However, heavy rains might lead to high erosion grades on the most sloped fields.

Figure 3: Location of the subregion Mittelsächsische Platte ("VG 8 Mittelsächsische Platte", dark brown) in the federal state of Saxony (left) and location of the federal state Saxony in Germany (right).



(1 cm = ca. 200 km)

(1 cm = ca. 20 km)
Source: LfULG (2011).

Climate: The climate is characterised by little rainfall of between 590 mm/a. up to 700 mm/a in the southern part of the studied area as well as by an almost continental climate with cold winters and hot summers. In the most fertile zone of the area yearly temperatures are comprised between 8.3°C and 8.8°C.

Landscape: The focussed region is also called "Mittelsächsische Platte" and is characterised by very fertile soils (chernozem) which allow the cultivation of all superior plants (e.g. wheat, rapeseed, maize, but sugar beets as well). The favourable natural conditions in this region are also reflected in high shares of cereals, especially winter wheat, inside the crop rotation (Table 6).

Table 6: Land use in the region Mittelsächsische Platte in 2010

	Area (ha)	**Percentage of total UAA (%)**
Arable land	**151,287**	**88.1%**
Cereals	87,754	51.1%
Wheat	*54,258*	*31.6%*
Triticale	*2,222*	*1.3%*
Rye	*4,168*	*2.4%*
Winter barley	*19,289*	*11.2%*
Summer barley	*1,408*	*0.8%*
Oat	*518*	*0.3%*
Grain maize	*5,552*	*3.2%*
Root crops	7,087	4.1%
Potatoes	*1,976*	*1.2%*
Sugar beets	*5,059*	*2.9%*
Pulses	1,246	0.7%
Peas	*956*	*0.6%*
Field beans	*264*	*0.2%*
Industrial crops	32,166	18.7%
Winter rapeseed	*31,178*	*18.1%*
Horticultural products	2,823	1.6%
Green fodder	18,135	10.6%
Leguminous plants	*2,223*	*1.3%*
Grass on arable land	*3,094*	*1.8%*
Maize silage	*12,003*	*7.0%*
Set aside	704	0.4%
Permanent crops	**2,312**	**1.3%**
Orchards	1,893	1.1%
Permanent grassland:	**18,202**	**10.6%**
Meadows	5,589	3.3%
Pastures	11,254	6.6%
Total UAA	***171,808***	***100.0***

Source: Statistisches Landesamt des Freistaates Sachsen (2010).

Agriculture: The intensity of field crop farming in this subregion is much higher than in the other subregions of Saxony, which grounds the nickname of “Saxony’s breadbasket” given to the Mittelsächsische Platte (MP) region. Especially the central areas “Lommatscher Pflege” and “Döberlner Pflege” are renowned for their fertile soils where field crops farms dominate the landscape. In 2013, among 858 farms operating on a total of 168,259 ha (of which 10.5% grassland), 52% were exclusively oriented towards field crop farming on slightly more than 50% of the total UAA of the MP region (Table 7). The low livestock density score of 0.51 LU/ha places the case study region among the three last subregions of Saxony to this extent.

Table 7: Type of farming (number of farms, landuse and percentage shares)

	Farms		**UAA**		**Av. size**
	Nr	*%*	*ha*	*%*	*ha*
Field crop	445	51.9	85,179	50.6	191.4
Grazing livestock (incl. Dairy)	143	16.7	17,634	10.5	123.3
Granivore	10	1.2	469	0.3	46.9
Mixed	147	17.1	50,920	30.3	346.4
Others1)	113	13.1	13,987	8.3	123.8
Total	*858*	*100.0*	*168,189*	*100.0*	*196*

Source: own calculations based on LfULG (on request).
1): of which permanent crops, horticulture, sheep and non classifiable farms.

Favourable natural conditions are accompanied by large scaled farm- and plotsize-structures. The average yield of cereals adds up to approximately 83.1 dt/ha[4] in 2014 compared to 80.1 dt/ha in the whole federal state of Saxony (STATISTISCHES LANDESAMT DES FREISTAATES SACHSEN, 2014). The average farm size is 196 ha/farm of which 191 ha/farm in the class of field crop farms and 346 ha/farm in the class of mixed farms respectively[5]. In all other classes the average farm size related to the acreage size is significant lower.

The majority of farms (54%) is smaller than 50 ha; however those farms only farm 5% of the total UAA (Table 8). On the other end of the distribution farms larger than 1,000 ha occupy about 63% of the total UAA in the MP region but only represent 11.4% of the farm population. It is to mention that a high share of farms (42.5%) is classified as part-time farms; however those farms only manage 5.3% of the total UAA (Table 9). On the other hand, agricultural land is predominantly managed by legal entities (49.1% of the total UAA) followed by full-time farms –or professional family farms (24.6%) and partnerships (21%).

[4] Yield calculated based on yields observed in 2014 in the districts Mittelsachsen, Meißen, Dresden and Nordsachsen over which the region MP is spread. Yields in 2014 were particularly high; in Germany they amounted to 80.5 dt/ha whereas the average over five years amounts to 70.1 dt/ha (calculated for the years 2010-2014, STATISTISCHES LANDESAMT DES FREISTAATES SACHSEN, 2014).

[5] A lot of large companies, mostly in the legal form of co-operatives, were counted as `mixed farms` because this kind of legal form can be characterised by the following - hypothetical and non-generalised - features: These co-operatives exist since collectivisation (~1950ies). Therefore, they are relatively large. They also pursue to ensure their members` employment and that's a main reason not to quit livestock production although knowing about a (possible) lack of profitability in this production sector. At last, the internal rights of co-determination of each co-operative member sometimes prohibit necessary changes towards a higher degree on specialisation (inflexibility of management and non-hierarchical decision-making).

Table 8: Number of farms and total UAA and percentage shares in different farm size classes

Size class	Number of farms	Share of farms (%)	Total UAA (ha)	Share of UAA (%)
< 10 ha	166	19.3	968	0.6
10 – 50 ha	297	34.6	7,412	4.4
50 – 100 ha	91	10.6	6,620	3.9
100 – 200 ha	100	11.7	14,288	8.5
200 – 500 ha	106	12.4	33,393	19.8
500 – 1,000 ha	62	7.2	44,294	26.4
1,000 – 2,500 ha	32	3.7	48,457	28.8
> 2,500 ha	4	0.5	12,828	7.6
Total	*858*	*100.0*	*168,260*	*100.0*

Source: own calculations based on LfULG (on request).

Table 9: Number of farms, total UAA and percentage shares as well as average farm siez by farms' legal forms

Legal form	Number of farms	Share of farms (%)	Total UAA (ha)	Share of UAA (%)	Ø – Size (in ha)
Legal entities	115	13.4	82,642	49.1	718.6
Partnerships	101	11.8	35,404	21.0	350.5
Full-time farms	277	32.3	41,363	24.6	149.3
Part-time farms	365	42.5	8,851	5.3	24.2
Total	*858*	*100.0*	*168,260*	*100.0*	*196.1*

Source: own calculations based on LfULG (on request).

As a conclusion, the regional farming structure is characterised by a predominance of large-scale legal entities and partnerships most of which are either field crop or mixed farms. Even though farms oriented towards those productions farm over 80% of the total UAA, family farms (full and part-time farming) constitute most of the farm population in the region but are smaller in average (149.3 ha for full-time farms; 24.2 ha for part-time farms).

3 Selection and weighting of typical farms in the study regions

In AgriPoliS a region is represented by selecting farms from a farm sample and weighting them to match the regional characteristics. A detailed description of this "upscaling" procedure used for this analysis can be found in KELLERMANN et al. (2008) and SAHRBACHER and HAPPE (2008). Hence this method delivers two kinds of results for the case study regions:

1) The farms which are selected and their weighting factor

2) The quality of the representation of the real region by virtual region.

Regions for which statistics are collected are characterised by general features (number of farms, total UAA, total number of livestock) as well as characteristics, which describe the structure of the region (amount of arable and grassland, number of farms in different size classes, number of animals in different herd sizes). The quality of the upscaling procedure to represent the regional characteristics depends on the deviation of the upscaled farm characteristics to the real structural characteristics of the region. The smaller the deviation, the better the region is represented. To some extent this depends on the representativeness and variety of the farms in samples derived from the Farm Accounting Data Network (FADN) used as data source. However it can be necessary to sort out marginal productions and/or farm types from available regional statistics in order to maximise chances to find a suitable set of typical farms representative of regional main agricultural productions.

Table 10 gives an overview on farm samples from which farms available from FADN were selected for both regions modelled in MULTAGRI. Moreover the table shows how many farms were selected in each region from the respective farm samples, including selected farms' technical orientation.

Table 10: Description of farm data samples for case study regions

Country	**Region**	**Typical farms**	**Nr. of farms in sample**	**Number of farms per FADN farm type** (FADN type number in brackets)				
				FC (13,14,60)	D (41)	GL (42,43,44)	M (71,72,81,82)	G (50)
Sweden	GSS	27	564	8	4	6	1	8
Germany	MP	39	1,356	14	5	5	15	0

Notes: FC – Field crops, D – Dairy, GL – Grazing livestock, M – Mixed, G – Granivore.
Source: own figure.

In the following both farm samples (further called "typical farms") as well as their coverage of regional characteristics will be described and commented for each region.

3.1 Representation of GSS' farm structure

3.1.1 Selected farms

Initial input data to represent the regional structure is set to the calibration year 2008. In the typical farm type selection procedure, the areas of arable land and semi-natural grassland were rounded to make the UAA divisible by the grid or the plot size of the region (3 ha).

The typical farm selection procedure resulted in 27 typical farm types. Table 11 show the typical farms selected in the region and the major categories of indicators used in the "upscaling" procedure. The characteristic weight is how often each selected farm occurs in the virtual region and the farm number is used to identify the farm type in AgriPoliS-simulations.

According to the FADN definition of organisational forms all farms are categorized as individual (or family) farms - holdings at which the economic result covers the compensation for the unpaid labour input and own capital of the holder/manager and their family (European Commission, 2002).

From the table, it is noticeable the regional agricultural structure which we described in the earlier section. Although in terms of proportion of typical farms there is a slight dominance by livestock farms over the specialized crop farms, still the crop farms obtain some of the highest weightsMeaning, it corresponds to the structure presented inTable 3 (dominance by crop farms). With respect to the size clases in terms of land and livestock, we were also able to convey and capture almost all ranges.

Table 11: Selected 'Typical farms' in GSS

Farm No.	Farm type[a)]	Weight	Number of farms	Total UAA	Arable land	Seminatural grazingland	Beef cattle[1)]	Suckler cows	Dairy cows	Sheep	Fattening pigs[2)]	Sows[3)]
3	FC	286	57	9	9	0	0	0	0	0	0	0
4	FC	332	66	102	102	0	0	0	0	0	0	0
9	FC	110	22	213	213	0	0	0	0	0	0	0
10	FC	50	10	603	603	0	0	0	0	0	0	0
12	FC	173	35	60	60	0	0	0	0	0	0	0
13	FC	60	12	357	357	0	0	0	0	0	0	0
20	FC	514	103	24	24	0	0	0	0	0	0	0
27	FC	307	61	99	99	0	0	0	0	0	0	0
1	D	18	4	57	54	3	19	0	38	0	0	0
8	D	6	1	384	375	9	131	0	259	0	0	0
25	D	29	6	19	16	3	4	0	11	0	0	0
26	D	11	2	111	102	9	37	0	69	0	0	0
2	GL	26	5	48	24	24	18	20	0	0	0	0
7	GL	228	46	21	12	9	6	7	0	0	0	0
11	GL	35	7	105	102	3	0	0	0	22	0	0
16	GL	13	3	267	90	177	108	120	0	35	0	0
18	GL	358	72	11	6	5	3	4	0	0	0	0
19	GL	52	10	38	33	5	0	0	0	38	0	0
5	G	5	1	165	165	0	0	0	0	0	1500	170
6	G	17	3	75	72	3	0	0	0	22	391	104
14	G	9	2	3	3	0	0	0	0	0	727	0
17	G	5	1	3	3	0	0	0	0	0	3614	860
21	G	18	4	12	12	0	0	0	0	0	0	42
22	G	21	4	81	81	0	0	0	0	0	137	317
23	G	15	3	3	3	0	0	0	0	0	2043	0
24	G	31	6	3	3	0	0	0	0	0	0	56
15	M	92	18	12	12	0	3	0	0	0	12	4

Source: own results.
Notes: [a]) **FC**: Field crop farms; **D**: Dairy farms; **GL**: Grazing livestock farms; **G**: Granivore farms, **M**: Mixed farms.[1]) Beef cattle older than one year. [2]) Fattened pigs of 20 kg or more. [3]) Breeding sows of 50 kg or more. Source: derived from FADN-data

3.1.2 Representation of the regional characteristics

As mentioned at the beginning of section 3, the upscaling procedure also delivers other results, which show the accuracy of the representation of the regional characteristics. These results are evaluated exemplary for the region GSS in Table 12. The second column shows the value for each characteristic, which we obtained from the Swedish Board of Agriculture 2012 yearbook (Statistics Sweden, 2012). These numbers are real data. The column upscaling results are the weighted characteristics of the selected farms data after which follow the relative and absolute deviations between the real and calibrated data. Examining the deviations relative to the general charateristics, it is noticable that the region is more or less well represented with smaller than 10% deviation. Although the deviation between the number of farms in the real and virtual region is 5%, we had to accept such deviation level in order not to under represent the regional characteristics. The deviations regarding the structural chatracteristics are also well represented. At some points, deviations can vary and are larger than 10% deviations, but these are of less importance. Overall, the deviations in terms of farm size classes and herd size are small as possible. This depends on the representativeness of the farms in samples derived from FADN data.

Table 12: Upscaling results GSS

General characteristics	Regional Data	Upscaling results	Relative deviation	Absolute deviation
Number of farms	2,690	2,821	5%	131
Utilized agricultural area (UAA; ha)	201,577	192,978	-4%	(8,599)
Number of beef cattle older than 1 year	7,088	7,181	1%	93
Number of dairy cows	3,376	3,313	-2%	(63)
Number of suckler cows	4,843	4,844	0%	1
Number of eves and rams	3,027	2,988	-1%	(40)
Breeding sows with more than 50 kg	14,920	16,376	10%	1,456
Fattening pigs with more than 20 kg	73,675	73,384	0%	(291)
Structural characteristics				
Area (ha)				
Arable land	194,082	185,598	-4%	(8,484)
Semi-natural grazing land	7,495	7,380	-2%	(115)
Total	201,577	192,978		
Number of farms in different size classes				
<= 20 ha	1,113	1,102	-1%	(11)
20-50 ha	530	592	12%	62
50-100 ha	491	529	8%	38
100-200 ha	336	372	11%	36
200-300 ha	114	116	2%	2
300-500 ha	58	60	3%	2
> 500 ha	48	50	4%	2
Total	2,690	2,821		
Number of dairy cows in different livestock units				
<= 49	319	319	0%	-
50-99	693	684	-1%	(9)
100-199	743	756	2%	14
>= 200	1,622	1,554	-4%	(68)
Total	3,376	3,313		
Number of ewes and rams by herd size				
<= 49	572	574	0%	2
> 50	2,455	2,414	-2%	(41)
Total	3,027	2,988		
Number of breeding sows with more than 50 kg				
<= 49	1,122	1,124	0%	2
50-99	1,728	1,736	0%	8
100-199	2,483	2,618	5%	135
>= 200	9,586	10,898	14%	1,312
Total	14,920	16,376		
Number of fattened pigs with more than 20 kg				
<= 99	1,107	1,104	0%	(3)
100-249	3,501	2,877	-18%	(624)
250-499	6,713	6,647	-1%	(66)
500-749	6,481	6,543	1%	62
>= 750	55,873	56,213	1%	340
Total	73,675	73,384		

Source: Regional data (SJV 2009).

3.2 Representation of MP's farm structure

3.2.1 Selected farms

The regional structure for the region MP in AgriPoliS has been built based on regional statistics for the year 2013. Based on those data (see next section), 39 farms out of available samples from the Farm Accountancy Data Network (FADN) used in past projects have been selected and weighted in order tho represent regional characteristics best (see Günther 2015 for more details on samples used). Table 13 below lists the characteristics of the typical farms selected out of the initial samples at disposal in order to represent the region MP best.

Table 13: Production capacities and weights of typical farms chosen for the region MP

Legal form	Farm ID	Weighting factor	Farm type	Farm UAA (ha)	Arable land	Grass-land	Fatten-ing bull (>1 year)	Dairy cows	Suckler cows	Breeding sows	Fatten-ing pigs (>50 kg)
Full-time farms	HE-FB1	20	GL	36		36			28		
	HE-GE2	1	M	39	39					271	
	HE-GE3	37	M	78	48	30			23		
	HE-GE4	9	M	117	117						1,006
	HE-GE5	3	M	564	432	132	16		98		
	HE-MF6	37	FC	30	21	9			12		11
	HE-MF7	31	FC	96	96						
	HE-MF8	54	FC	144	144						
	HE-MF9	8	FC	360	360						
	HE-MF10	11	FC	1,110	1,110						
	HE-MI11	14	D	108	54	54		52			
Legal entitities	JP-FB12	4	GL	135	90	45		100			
	JP-FB13	4	GL	261	36	225	34		155		
	JP-GE14	1	M	294	252	42	14	78		51	540
	JP-GE15	22	M	840	837	3		256			
	JP-GE16	6	M	2,187	1,758	429	115	1,200			125
	JP-GE17	1	M	3,849	3,429	420	218	1,026		419	1,283
	JP-MF18	16	FC	363	363						
	JP-MF19	17	FC	561	561						
	JP-MF20	5	FC	1,038	1,038						
	JP-MF21	3	FC	2,886	2,724	162		228		614	3,632
	JP-MI22	3	D	528	291	237		115	43		
	JP-MI23	4	D	1,794	933	861	84	578	53		
Part-time farms	NE-FB24	73	GL	9		9			10		
	NE-FB25	6	GL	51	24	27	42	8		25	
	NE-GE26	23	M	12	3	9	12	7			
	NE-GE27	12	M	24	24						210
	NE-GE28	10	M	33	3	30	17				
	NE-MF29	44	FC	9	9						
	NE-MF30	158	FC	39	39						

Legal form	Farm ID	Weighting factor	Farm type	Farm UAA (ha)	Arable land	Grass-land	Fattening bull (>1 year)	Dairy cows	Suckler cows	Breeding sows	Fattening (>50 kg)
	PG-GE31	5	M	141	141			34			
	PG-GE32	4	M	435	435					111	845
	PG-GE33	4	M	624	225	399	5		96		
Partner-ships	PG-GE34	5	M	693	693			159			
	PG-MF35	1	FC	186	186						
	PG-MF36	56	FC	270	264	6					
	PG-MF37	4	FC	1,431	1,281	150		368			
	PG-MI38	5	D	90	75	15		51			
	PG-MI39	7	D	528	291	237		115	43		

Notes: GL: grazing livestock, M: mixed, FC: field crops, D: dairy.
Source: own figure, based on Günther (2015), derived from FADN data.

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In the table selected typical farms have been classified by their legal form. In the second column, an ID has been attributed to each of those typical farms. The third column indicates farms' weight in the model, i.e. how many times each typical farm will be found in the modelled MP region in order to represent the agricultural structure best. Farm type is mentioned in the fifth column; further columns provide an overview on each typical farm's main characteristics (land use, animal production).

3.2.2 Representation of the regional characteristics

In the following initial as well as actually used regional data for the selection of typical farms for the region MP are presented. Regional data were collected based on the IACS[6] database provided by the LfULG for the sake of the MULTAGRI project. IACS is aimed at ensuring that transactions in the framework of the European Agricultural Guarantee Fund (EAGF) are implemented correctly. The system ensures a unique identification of each farmer as well as of all agricultural parcels of land and, if needed, of animals. From this database aggregated data regarding land use, farms' legal forms, size, type and animal productions for the region MP have been used to calibrate in AgriPoliS for the year 2013. In a first query all farms listed in the IACS database for the region MP were considered and shape the regional structure as describes in Table 7, Table 8 and Table 9. However, in a second query some farm types have been removed out of the database because of their low number or UAA. Actually those types were considered as marginal in the region and could possibly threat the quality of upscaling results. Therefore permanent crops, horticulture, sheep farms as well as non classifiable farms have been removed, together with part-time dairy farms and partnerships oriented towards grazing livestock. Table 14 below reports the differences between the real regional data and the ones used for upscaling and modelling in AgriPoliS.

[6] IACS stands for " Integrated Administration and Control System" and is a database used to ensure that 1) CAP payments are made correctly, 2) irregularities are prevented, revealed by controls, followed up and 3) amounts unduly paid are recovered. IACS is operated in the Member States by accredited paying agencies. The system ensures a unique identification of each farmer as well as of all agricultural parcels of land and, if needed, of animals. The system covers also the processing of the aid applications.

Table 14: Original data characterising the region MP and regional data actually used for upscaling (year 2013)

Characteristics		Original regional data		Used regional data	
		Number of farms	UAA (ha)	Number of farms	UAA (ha)
Total number of farms		**858**	**168,259**	**735**	**153,732**
By legal form:	Legal entities	115	82,642	89	75,127
	Partnerships	101	35,404	90	34,318
	Full-time farms	277	41,363	230	35,976
	Part-time farms	365	8,851	326	8,310
By farm size:	< 10 ha	166	968	120	796
	10 - 50 ha	297	7,412	268	6,724
	50 - 100 ha	91	6,620	78	5,586
	100 - 200 ha	100	14,288	88	12,552
	200 - 500 ha	106	33,393	88	27,961
	500 – 1,000 ha	62	44,294	59	42,138
	1,000 – 2,500 ha	32	48,457	30	45,148
	> 2,500 ha	4	12,828	4	12,828
By farm type:	Field crops	445	85,179	445	85,179
	Permanent crops	22	2,118	-	-
	Grazing livestock	143	17,634	143	17,634
	Horticulture	9	168	-	-
	Not classifiable	59	10,403	-	-
	Sheep breeding	23	1,298	-	-
	Mixed	147	50,920	147	50,920
	Granivore	10	469	-	-
Legal entities	Field crops	41	28,872	41	28,872
	Dairy	7	8,825	7	8,825
	Grazing livestock	9	1,579	9	1,579
	Mixed	32	35,852	32	35,852
	Granivore and other farms[1)]	26	7,514	-	-
Partnerships	Field crops	59	22,108	59	22,108
	Dairy	11	3,863	*	3,863
	Grazing livestock	*	*	*	9
	Granivore	*	*	-	-
	Mixed	18	8,339	18	8,339
	Other farms[1)]	10	970	-	-
Full-time farms	Field crops	142	27,824	142	27,824
	Dairy	16	1,611	16	1,611
	Grazing livestock	21	710	21	710
	Granivore	7	329	-	-
	Mixed	51	5,832	51	5,832
	Other farms[1)]	40	5,058	-	-
Part-time farms	Field crops	203	6,375	203	6,375
	Dairy	*	*	*	-
	Grazing livestock	76	1,030	76	1,030
	Granivore	*	*	-	-
	Mixed	46	898	46	898
	Other farms[1)]	38	530	-	-

Notes: 1) of which permanent crops, sheep breeding farms, horticulture and not classifiable farms. * no data available, -: not considered.
Source: Günther (2015) based on LfULG (on request).

Because of those removals total regional UAA decreased from 168,259 ha to 153,732 ha (8.6% less), of which 138,053 ha arable land and 15,322 ha grassland (10% of the total UAA in the model region).

Animal husbandry has been adapted accordingly to the removal of farms (Table 15). The table shows the distribution of animals and corresponding farms keeping those animals relative to herd sizes. This will be useful in order to allocate correct building sizes to typical farms during the initialisation of AgriPoliS.

Table 15: Animal husbandry in the region MP in 2013 and data used for modelling with AgriPoliS

Characteristics	Number of farms[1]	Number of heads	Number of farms[1]	Number of heads
Fattening pigs >50 kg				
<50	70	424	66	406
50-200	10	1,025	7	734
200-500	8	2,764	7	2,554
500-1,000	7	5,405	5	4,280
1,000-2,500	9	13,830	10	20,642[4]
2,500-5,000	*	*	-	-
more than 5,000	0	0	-	-
Breeding sows > 1st farrowing				
less than 100	43	807	24[2]	600
100-200	*	*		
200-500	5	1,299	5[3]	2,583
500-1,000	*	*		
Dairy cows				
less than 50	22	468	18	401
50-150	30	2,549	27	2,349
150-250	7	1,431	7	1,431
250-500	20	6,981	19	6,631
500-1,000	6	3,921	4	2,635
more than 1,000	6	8,202	6	8,202
Total				
Fattening bulls (>1 year)	281	2,137	264	2,088
Dairy cows	90	23,552	81	21,649
Suckler cows	225	4,743	212	4,547
Breeding sows > 1st farrowing	51	3,615	29	3,183
Fattening pigs >50 kg	107	33,309	95	28,616

Notes: 1) number of farms keeping animals of the corresponding category; 2) less than 200 sows; 3) more than 200 sows; 4) 1,000 heads and more.
Source: LfULG (on request).

The upscaling procedure enables the selection and weigting of typical farms based on whcih regional capacities can be represented best in AgriPoliS. Table 16 shows differences in selected regional characteristics and results of the upscaling procedure. Results show that 99% of farms are represented. We can observe a deviation of only 1% in total UAA. This difference is due to an underestimation of arable land (-3%) as well as an overestimation of grassland (+15%).

Regarding farm structures large deviations (superior to 10% in absolute terms) are mostly due to regional characteristics which are rather seldom, for instance the number of legal entities (9 farms) specialised in grazing livestock (8 such farms in the modelled region) or the number of full-time farms and partnerships specialised in dairy farming (16 farms and 11 farms respectively) which turn out to become 14 farms and 11 farms in the model, respectively. Similarly, large herds (between 500 and 1,000 dairy cows, more than 2,500 pigs for fattening) are difficult to represent accurately in the model as the representation of those characteristics heavily depends on other regional characteristics as well, like grassland or total number of heads for each livestock category.

Table 16: Differences between selected regional characteristics and upscaling results in the MP region

Characteristic	MP region	Upscaling	Relative deviation
Number of farms	**735**	**728**	**-1%**
Legal entities			
Field crops	41	41	0%
Dairy	7	7	0%
Grazing livestock	9	8	-11%
Mixed	32	30	-6%
Partnerships			
Field crops	59	61	3%
Dairy	11	12	9%
Grazing livestock	2	-	-
Mixed	18	18	0%
Full-time farms			
Field crops	142	141	-1%
Dairy	16	14	-13%
Grazing livestock	21	20	-5%
Mixed	51	50	-2%
Part-time farms			
Field crops	203	202	0%
Dairy	1	-	-
Grazing livestock	76	79	4%
Mixed	46	45	-2%
Total UAA (in ha)	**153.732**	**152.133**	**-1%**
Arable land	138.053	134.508	-3%
Grassland	15.322	17.625	15%
Legal entities (UAA in ha)			
Field crops	28.872	29.193	1%
Dairy	8.825	8.760	-1%
Grazing livestock	1.579	1.584	0%
Mixed	35.852	35.745	0%
Partnerships (UAA in ha)			
Field crops	22.108	21.030	-5%
Dairy	3.863	4.146	7%
Grazing livestock	9	-	-
Mixed	8.339	8.406	1%

Full-time farms (UAA in ha)			
Field crops	27.824	26.952	-3%
Dairy	1.611	1.512	-6%
Grazing livestock	710	720	1%
Mixed	5.832	5.670	-3%
Part-time farms (UAA in ha)			
Field crops	6.375	6.558	3%
Dairy	7	-	-
Grazing livestock	1.030	963	-7%
Mixed	898	894	0%
Number of farms by size class			
< 10 ha	120	117	-3%
10 - 50 ha	268	261	-3%
50 - 100 ha	78	79	1%
100 - 200 ha	88	87	-1%
200 - 500 ha	88	89	1%
500 – 1,000 ha	59	61	3%
1,000 – 2,500 ha	30	30	0%
> 2,500 ha	4	4	0%
Livestock (number of heads)			
Fattening bulls > 1 year	2.088	2.160	3%
Dairy cows	21.649	22.111	2%
Suckler cows	3.183	3.177	0%
Breeding sows > 1st farrowing	28.616	28.830	1%
Fattening pigs >50 kg	4.547	4.525	0%
Fattening pigs >50 kg (heads)			
<50	406	407	0%
50-199	734	750	2%
200-499	2.554	2.520	-1%
500-999	4.280	3.920	-8%
1,000-2,499	10.781	10.337	-4%
2,500-5,000	9.816	10.896	11%
Breeding sows > 1st farrowing (heads)			
100-200	600	645	8%
200-500	2.583	2.532	-2%
Dairy cows (heads)			
<50	401	379	-5%
50-150	2.349	2.611	11%
150-250	1.431	1.479	3%
250-500	6.631	7.104	7%
500-1,000	2.635	2.312	-12%
> 1,000	8.202	8.226	0%

Source: based on Günther (2015).

In the following details about data used in both case study regions regarding production activities will provided. Those data will feed the Mixed Integer Programmes (MIP), built for each region, which serves as decision rule for all modelled farms in AgriPoliS.

4 Representation of typical farms in study regions

As explained in sections 3, the representation of the selected farms requires on the one hand the capacities of the individual farms, which are shown in Table 11 (GSS) and Table 13 (MP) and on the other hand additional data about:

- *production activities*: gross margins, variable costs, (coupled) subsidies, technical coefficients on factor use (feeding requirements, liquid capital demand, labour demand, crop rotation, nitrogen production/uptake), average annual milk yield per cow, percentage of variable costs bound during a production period, crop rotations

- *investment options*: investment costs, typical share of equity bound in investments, size/capacity of the investment, useful life, average work requirement per unit, estimates on maintenance costs

- *financing activities*: interest rates for long-term and short-term borrowed capital, savings interest,

- *labour activities*: wages of unqualified farm-labour, wages of unqualified off-farm labour

All these data are compiled in tables in the following. Those tables shall provide an overview on data used for designing the MIP in each of the two case study region investigated in the MULTAGRI project. The tables about the production activities illustrate yields, prices, costs etc. for each region. Before that, a short introduction on the basic functioning of the MIP (which determines the rule of farms' household income maximization) will be provided as well as specific parameters considered in each modelled region.

4.1 Short introduction to the Mixed Integer Programm (MIP)

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.

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, the solution to which gives the optimal combination of action possibilities subject to the given framework conditions. Table 17 shows an exemplary matrix of the optimisation problem in AgriPoliS.

Table 17: Exemplary scheme of a mixed-integer programme matrix

Mixed-integer programme		**Short term loans/saving**	**Buy/sell variable labour**	**Hire contractor**	**Plant production**	**Livestock production**	**Keep/sell heifers**	**Buy/sell manure**	**Sell crop products**	**Decoupled payment**	***Investment activities***	***Buy/sell fixed labour***		
	Continuous/integer activity	**c**	**c**	**c**	**c**	**c**	**c**	**c**	**c**	**c**	***i***	***i***		***RHS***
	Objective function	***Gross margin***												
Factor capacities	Liquidity (€)	x		x	x	x	x				x	x	≤	L
	Min. equity capital reserve (€)				x	x	x				x	x	≤	EC
	Labour (h)		x		x	x		x			x	x	≤	W
	Utilised agricultural area (ha)				x			x					≤	A
	Winter fodder (ha)					x							≤	F
	Livestock capacities (places)					x					x		≤	LS
	Machinery (ha)			x	x						x		≤	M
Other restrictions	Organic N-balance (kg N/ha)				x	x							≤	0
	Rapeseed max. (% of UAA)				x								≤	0
	Sugar beet max. (% of UAA)				x								≤	0
	Yield crop products (dt/ha)				x				x				≤	0
	Recruitement heifer (head/year)					x	x						≤	0
	Direct payments (€)				x	x				x			≤	0
	Stocking density (LU/ha)				x	x							≤	0
	Activity levels	a	b	c	d	e	f	g	h	i	j	k		HH

Notes: c = continuous activities; i = integer activities; RHS = right-hand side (farm capacity limit or balance of activities); HH = household income; L, EC, W, A, F, LS, M = farm capacities; a to k: activity levels as a result of the optimization problem.
Source: adapted from Happe (2004).

In this scheme, investments and fixed labour are considered non-divisible. They are therefore introduced as integer activities (indicated with an "i" in the figure). The set of constraints consists of on-farm production capacities (classified as "Factor capacities"), but some constraints also reflect political framework conditions, such as limits on livestock density or on fertilizers applications (classified as "Other restrictions"). For further formal details on the optimisation problem as well as on behavioural foundations of farms in AgriPoliS please see Kellermann et al. (2008).

Under the constraints as defined in the MIP and considering their own capacities, farms individually decide which production activities and which investment portfolio maximize their profit/household income. Empirical data from textbooks, online statistics or special requests by agricultural offices feed the MIP for regions to be modelled in AgriPoliS. The programme will first be tested using each typical farm's capacities. Shall results deviate from empirical farm data, i.e. the tested typical farm invests too much (or not enough), or important losses in profits occur or activities chosen strongly deviate from reality, there has to be a calibration to be operated either on original regional data (prices/costs) or directly at the farm level. Those changes are generally minor and shall be kept as such; in any case they are documented where necessary (SAHRBACHER 2008).

4.2 Model assumptions for each region

Each new region modelled in AgriPoliS means that several parameters have to be adapted accordingly to local specific characteristics.

Table 18: Overview of general parameters introduced in AgriPoliS for each case study region

	Mittelsächsische Platte (MP)	Götalands södra slättbygder (GSS)
Calibration year	2013	2008
Generation change	25 years	25 years
Labour (p.a)		
Hired labour (€/AWU)	20,700	155,520 SEK /AWU
Off-farm labour (€/AWU)	17,000	142,560 SEK / AWU
Labour (on an hourly basis)		
Hired labour (€)	12.65	192 SEK
Off-farm (€)	8.5	144 SEK
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 (p.a.)	€16,000	200,000 SEK
Managerial ability variation	0.95-1.05	No variation
Length of rental contracts	12 to 24 years	9 to 18 years

Source: own figure.

When generation change occurs, the opportunity costs of labour are increased by a certain percentage to reflect the higher opportunity cost of the new generations labour. Plot size is adjusted to the scale of production in the region to capture the regional characteristics and consequently minimizes the loss of land at regional level during the modelling.

Land rental contracy vary but once the contract finishes the land is returned to the land rental market where it goes to the highest bidder or is abandoned. Land rental market is modelled through endogenous price function (Kellermann *et al.,* 2008). The price changes relative to policy changes and the development of the market.

Besides the listed specific parameters in Table 18, another key parameter in AgriPoliS is the teiler factor 2 and 5 in MP and GSS regions, respectively, i.e. the weighting factors for each typical farm are divided by this factor in order to speed up computation and reduce simulation time.

4.3 Input data for the region GSS

4.3.1 Production activities

Plant productions

The production activities for both regions reflect the most common crop and livestock activities observed in the study regions and used in in the upscaling procedures. Most data for specifying the farm activities has been sourced from Agriwise (2015) regional enterprise budgets for the respective base years for which the regions are calibrated. These budgets contain specific information on gross margins, variable costs, subsidies, labour input, capital depreciation, machinery input per activity and other technical data on factor use. These input data are included in the MIP so that variable costs are disaggregated into specific costs for energy, fertilizers (nitrogen, phosphorous and potassium) and pesticides, capital depreciation and labour which allows for evaluation of the effects of policy on these inputs (e.g., energy and fertilizer input use is related to environmental damage). Further inorganic fertilizer and animal manure can be used as substitute inputs. Variable costs for owned machinery are modeled relative to cost of 1 ha winter wheat. Hence, the costs listed in Table 19 are the other variable costs which are to some extent fixed (insurance, consulting, veterinary medicine, recruitment, concentrates, etc) and are not included via the market activities. Fixed costs for owned machinery are separated and treated differently (see 4.3.2).

The supply of protein crops depends on a production contract with the Swedish processor Findus, thus we consider all associate variable costs in order to calibrate the production area to the base period. A distinguishable characteristic for the region is the decoupled premiums per ha. GSS farmers get much higher support compare to the other agricultural production regions in Sweden[7], which to a certain extent puts the farmers in a favourable position.

Table 19: Crop production activities and input data for GSS region

Crop production	**Other cost**	**Premium at 2008**	**Yield**	**Price**	**Crop rotation limits**	**Machinery requirements**
	SEK/ha	SEK/ha	kg/ha	SEK/kg	% arable land	ha
Winter wheat high	699	3,000	7,900	1.54	66	1
Other grain high[1)]	522	3,000	5,700	1.19	66	0.9
Other grain low	522	3,000	4,600	1.19	66	0.9
Rape seed high	1,582	3,000	3,600	3.25	20	0.66
Rape seed low	1,500	3,000	3,400	3.25	20	0.66
Sugar beet high	4,032	3,000	515	27.54	18.5	2.27
Protein crop high[2)]	979	3,000	4,100	1.84	-	0.52
Protein crop low[3)]	481	3,000	238	18.95	-	0.52
Grass silage high	1,912	3,000	6,000	2.39	75	1.07
Grass silage low	1,402	3,000	5,000	1.89	75	1.07
Arable pasture low	120	3,000	4,800	1.18	-	0.5
Seminatural grazing-land	0	1,500	1,800	0	-	0.05
Fallow land high	220	3,000	0	900	-	0.2
Fallow land low	220	3,000	0	900	-	0.2

Note: 1) Course grains such as: barley, oats, triticale, maize. 2) Mainly peas and beans. 3) Clover.
Source: Agriwise (2015). Data is based on actual levels for 2011.

From the Table 19 it is noticeable that we define different soil qualities on arable land in order to distinguish the specific crop production activities. We define high and low land quality which is reflected by different yields for each specific crop and consequently the obtained revenue from crop production The high quality land is mainly used for cultivating winter wheat, rape seed and sugar beet, whereas the low quality land is devoted for temporary rotational grass and fodder production as well as barley production. The produced animal feed is not sold on the market and is used on the farm. Potato and vegetable production are not included in the model because are not of great interest for the regions.

To reflect normal crop rotations in the regions we implement limits on the maximum percentage of a specific crop that can be grown a farms total arable area. These limits are set to the observed average values in the reference year. In addition to this limit, we also set an

[7] Farmers in Jönköping, Västerbotten and Götalands mellanbygder (GMB) receive around 1,200, 1,065 and 1,827 SEK per ha decoupled support, respectively.

upper limit of maximum nitrogen application from animal manure which is set to 204.8 kg N/ha.

Animal productions

Although crop production is dominating, to capture the different types of livestock production we model beef cattle, bullock and bulls from suckler cows as cattle production activities (Table 20).

As beef fattening is important in Sweden, it is differentiated into the fattening of bullocks and bulls (from dairy calves) and bull sucklers. Bullocks are fattened on-pasture until they reach 280 kg, where by bull sucklers are young bulls from suckler cows, raised on-pasture till a weight of 350 kg and then fattened in a stable. To ensure balance between production of calves and numbers of beef cattle, a regional calf market was introduced, where specialist dairy farms can sell their excess calves to farms that specialise in beef production. Recruitment calves are kept for replacing the dairy herd through heifer breeding activities (20% of dairy calves and 10% of suckler calves are kept for this purpose). Furthermore, heifer breeding is also explicitly modelled where replacement is included in the variable costs.

Table 20: Livestock production activities and input data in GSS region

Livestock production	**Other costs**	**Weight**	**Milk yeald**	**Animals per year**	**Price**	**Revenue**	**Coupled premium***
	SEK/head	kg	kg	number	SEK/kg or place	SEK/place /year	SEK/head
Bullock dairy	434	280		0.5	24.05	3,367	942
Beef cattle	1,646	300		0.75	24.71	7,991	1,327
Bull suckler cow	782	350		1	27.00	9,450	1,327
Heifer suckler cow	531			1	7,990	0	0
Heifer dairy cow	1,869			1	9,870	0	0
Suckler cow	676			1	754	1,659	0
Dairy cow	11,086		8,235	1	3.35	29,015	0
Sheep	787	19.5		2	43.36	1,778	0
Fattening pigs	2,004	85.8		3.25	13.14	4,030	0
Sows	2,480			23	484	12,683	0

Note: *Decoupled after 2012
Source: Agriwise (2015). Data is based on actual prices and levels for 2011.

The livestock revenues, feed rations and variable costs, are annualised in AgriPoliS compared to the enterprise budgets in Agriwise which are calculated over the entire production period. For example, bullocks are kept for 24 months but we model the activity based on annual revenues, feed rations and variable costs per place. Additionally, the economic data for sheep, and sows includes 2 lambs and 23 piglets respectively (**Table 20**) and a place for fattening pigs turnsover 3.25 pigs per year. Note that revenues include revenue from sale of the primary product plus revenues from slaughter of old breeding stock. Similar as for the crop production, we separate the variable cost and only consider other costs that are not explicitly considered through the model markets (Table 20).

Table 21 displays the specific requirements for each livestock activity but also the nitrogen level from manure which to a certain limit is used in crop production. We also assume that only 20% of the nitrogen in manure is available for plant growth.

Table 21. Input data on fodder requirement and nitrogen excretion

Livestock production	**Fodder requirement**			**Nitrogen excretion**
	Grass silage	Grass pastures	Seminatural grazing land	
	%/yield	%/yield	%/yield	kg/year
Bullock dairy	0.20	0.36	0.93	40
Beef cattle	0.23	0.22	0.59	36
Bull suckler cow	0.31	-	-	36
Heifer suckler cow	0.32	0.29	0.75	34
Heifer dairy cow	0.17	0.19	0.49	34
Suckler cow	0.39	0.55	1.44	22
Dairy cow	0.40	0.25	0.65	128
Sheep	0.07	0.06	0.16	14
Fattening pigs	-	-		45.5
Sows	-	-		36

Source: Agriwise (2015); SJV (2010). Data is based on actual prices and levels for 2011.

Other activities

Labour activities are represented through a labour input for each crop and livestock production activity (Table 22). Besides the family (unpaid) labour input, farms have the possibility to hire additional farm labour for 192 SEK/hour or work off-farm for 144 SEK/hour (Table 18). The labour inputs for livestock are calculated per place and vary according to stable size, the larger the stable the less labour required per place. The standard labour input for a stable place is based on the input for the largest capacity. Similarly, a standard labour input for field operations for each crop is presented for a farm size of 70 ha which is assumed to decrease with increasing farm size, since farmers can use larger and more efficient machinery. The relevant adjustments to the standard labour input hours to reflect different stable and machine capacities are presented in the next section 4.4.2.

Table 22: Production activities labour input per ha and place

Crop production	*hours/place*	**Livestock production**	Standard capacity	*hours/place*
Winter wheat	11.6	Bullock dairy	55	13.5
Other grain	10.5	Beef cattle	55	11
Rape seed	7.5	Bull suckler cow	55	8.5
Sugar beet	36	Heifer suckler cow	55	13.5
Protein crop	10.9	Heifer dairy cow	55	8
Grass silage	10	Suckler cow	38	15
Arable pasture	7	Dairy cow	120	38
Seminatural grazing land	2	Sheep	200	3.8
Fallow land	2.4	Fattening pigs	800	0.98
		Sows	60	15

Source: Agriwise (2015). Data is based on actual prices and levels for 2011.

As mentioned above the dairy calf market is modelled in the following way:

$$p_t = p_{t-1}(1+\beta \frac{ED_t}{S_t}) \quad (2)$$

where ED is excess regional demand and S is the total supply of dairy calves in period t (Samanidou *et al.,* 2007). The parameter β reflects the speed of price adjustment which allows the market price to smoothly adjust over time. In our case we set 0.5 to allow for a fairly slow adjustment over time. Thus, in cases when there is excess demand the price should increase proportionally to the ratio of excess demand and the price adjustment speed andhen there is excess suppply, the price will fall.

4.3.2 Investment options

In AgriPoliS all selected farms are initialised with stable and machinery capacities corresponding to the number of different livestock and machinery identified for each typical farm. After the initial simulation period farms can re-invest to maintain their initial endowment or expand their production capacities through new investments. The potential investment options for each region are listed in Table 23 and are based on analyses of what could be expected in the region. To represent the investment options data on investment costs (buldings and equipment) for specific livestock activities and capacities obtained from the Swedish Board of Agriculture was used. Since data on asset vintages is not available, AgriPoliS assigns a random age during the initialisation stage so that the residual value and the depreciation of the stables can be calculated in each simulation period. For the investments, economies of scale are considered through the labour demand which decreases with an increase of the stable or machinery size (Additional labour column in Table 23).

Table 23: Investment options in GSS

No.	Investment type	Unit	Capacities	Useful life	Investment cost SEK/place	Additional labour[1]
1	Cattle barn 1	Places	20	25	31,350	-4.5
2	Cattle barn 2	Places	55	25	28,050	-4.5
3	Cattle barn 3	Places	110	25	26,250	-2.0
4	Cattle barn 4	Places	220	25	22,890	-1.0
5	Cattle barn 5	Places	330	25	20,362	-0.5
6	Cattle barn 6	Places	440	25	18,934	0.0
7	Suckler cows 1	Places	20	25	28,000	-6.5
8	Suckler cows 2	Places	38	25	24,300	-6.5
9	Suckler cows 3	Places	75	25	19,200	-1.6
10	Suckler cows 4	Places	150	25	16,000	-0.5
11	Suckler cows 5	Places	300	25	14,875	0.0
12	Dairy barn 1	Places	45	22	85,000	-12.0
13	Dairy barn 2	Places	90	22	80,000	-11.0
14	Dairy barn 3	Places	180	22	70,500	-6.0
15	Dairy barn 4	Places	300	22	57,500	-1.0
16	Dairy barn 5	Places	600	22	51,500	0.0
17	Ewe 1	Places	50	25	7,000	-1.4
18	Ewe 2	Places	100	25	6,400	-1.2
19	Ewe 3	Places	200	25	5,300	-1.0
20	Ewe 4	Places	400	25	4,500	-0.3
21	Ewe 5	Places	800	25	4,300	0.0
22	Fattening pigs 1	Places	100	25	65,882	-0.7
23	Fattening pigs 2	Places	400	25	28,000	-0.6
24	Fattening pigs 3	Places	800	25	21,300	-0.4
25	Fattening pigs 4	Places	1,200	25	20,400	-0.3
26	Fattening pigs 5	Places	1,600	25	19,800	-0.3
27	Fattening pigs 6	Places	3,200	25	16,830	-0.1
28	Fattening pigs 7	Places	6,400	25	14,306	0.0
29	Sows 1	Places	44	25	60,128	-7.0
30	Sows 2	Places	60	25	54,333	-6.0
31	Sows 3	Places	140	25	50,307	-4.5
32	Sows 4	Places	200	25	48,500	-3.0
33	Sows 5	Places	330	25	45,270	-2.0
34	Sows 6	Places	660	25	41,829	-1.0
35	Sows 7	Places	1,320	25	39,655	0.0
36	Machinery 1	ha	30	20	22,000	-4.3
37	Machinery 2	ha	60	20	19,500	-3.3
38	Machinery 3	ha	100	15	16,000	-2.7
39	Machinery 4	ha	150	15	15,500	-2.0
40	Machinery 5	ha	200	12	12,800	-1.4
41	Machinery 6	ha	300	12	10,100	-1.0
42	Machinery 7	ha	500	12	9,400	-0.5
43	Machinery 8	ha	800	12	8,750	0.0

Note: 1) Additional labour demand per unit relative to the labour demand of the largest investment option.
Source: Based on Agriwise (2011), SJV (2014) and expert consultation.

Similarly the investment cost per place or hectare diminishes with size. Thus farms can achieve economies of scale through larger investment objects.

If it is not profitable to invest in any of the given investment options, the farms also have the possibility to contract machinery services at a cost of 4,575 SEK/ha. In addition, farms have the option to disinvest if they do not use all stable places. When disinvesting, a farmer gets a certain amount of labour back that he can use as either off-farm or for other on-farm activities (Kellermann *et al.*, 2008).

4.3.3 Policy framework

Since GSS region is calibrated to 2008 the default policy framework in the model is devided in two parts: old CAP 2008-2014 and new launched CAP 2015-2020.

The old CAP is related to the so-called *Mid Term Review* (MTR) 2005 reform where decoupling of the support was introduced. Meaning majority of the production-linked direct support turn into the single payment (decoupled), support which farmers receive per ha of land or as farm specific payment, independent on the production of food. In addition to this a cross compliance (minimum requirements) is introduced, to regulate the plant protection and the environment as well as maintain the human and animal health. These rules must be followed by the farmer in order to be able to get the full payment of the single payment scheme (SPS). The new rules introduced by the SPS deal about how users should manage their agricultural land, pasture and hay meadows (so called land management conditions). The principle is that they should keep the land in good agricultural and environmental condition (GAEC). For example, the pasture vegetation must be grazed by animals each year while arable land can be managed with the mowers to keep close to vegetation. Instead of focusing on ensuring a certain price for the farmer, the current CAP concentrated to directly support the users' incomes and guarantee a certain environment.

The second period of the policy framework from 2015 and onwards, is related to main feature of the changes from Pillar 1 payments, *i.e.* even distribution of support or national equalization including livestock coupled support and greening of the CAP with greater focus on the environment. Ceiling or “capping” of the support as well as young farmers payments are also considered.

Sweden has chosen to equalize farm subsidies within the country and exploit fully the possibility of special animal premiums (13% of the country's payment). As consequence of the equalization from 2015 all farms receive the same aid per hectare of arable and pastureland for a four-year phase-in (€ 193 / ha untill 2019) and farms with cattle also a livestock premium equal to € 91 (800 SEK) per animals over one year old (Table 24). According Ds (2014), the coupled livestock support is mainly seen as a transitional measure (to alleviate the effects of equalization for the dairy and beef sectors). Therefore, this support should disappear by 2020.

After being equalized the paymets are devided into basic and a greening. The majority (70 percent) go to the decoupled income support. The remaining 30 per cent of farm payments are conditional on the mandatory environmental measures (crop rotation, permanent grassland and ecological focus areas (EFA's)). Thus, the payments in GSS are modelled as follows:

Table 24: CAP support in GSS region

Year	Basic payment (€)	Greening payment (€)	Cattle Support (€)
2008	330	-	-
2009	330	-	-
2010	330	-	-
2011	330	-	-
2012	330	-	-
2013	330	-	-
2014	330	-	-
*2015	228	58	91
2016	205	58	91
2017	182	58	91
2018	158	58	91
2019	135	58	91

Source: Ds (2014).

The ceiling reform requires limits on farm payments to large individual farms to improve the distribution of payments and is set to €150,000 and will be reduced by five percent if exceeds this amount, but without deduction of salary costs. Greening support in the scheme is not subject to the ceiling. The funds released should be transferred to the rural development program

A special farm supprt for young farmers starting agricultural activity (where young people are defined as those who are younger than 40 years old), is set to 25 per cent surcharge on the national payment scheme to a maximum of 90 ha and be paind in five years. This will complements the already exciting start-up aid for young farmers under 40 years in the rural development program is currently SEK 250 000.

4.4 Input data for the region MP

4.4.1 Production activities

Foreword

Most data used for building the MIP for the region MP have been collected and put at disposal by the LfULG. Those data consider natural and structural features typical for the federal state of Saxony. In this databank, different levels of performance for each production activity are provided and heavily depend on equipment and productivity. However, for each production activity, data on costs and revenues were calculated as averages over those performance groups, as differences in performance and productivity will be calculated at the individual level via the random attribution of management factors to each farm (see section 4.2). In total, 15 different plant production activities and 7 animal productions have been considered (Table 25 and Table 26).

Table 25: Gross margins and production data for plant productions in the region MP

	Yield (dt/ha)	**Market price** (€/dt)	**Revenue** (€/ ha)	**Vari-able costs** (€/ ha)	**Gross margin** (€/ha)	**Fixed energy costs** (€/ha)	**Variable energy costs** (€/ha)	**Costs plant pro-tection** (€/ha)	**Costs fertili-zers** (€/ha)	**Gross margin in MIP** (€/ha)
Pflanzenbau										
Winter wheat	75.0	17.2	1,288	643	645	93	19	188	211	-132
Winter barley	73.3	15.0	1,100	587	431	92	20	157	146	-172
Rapeseed	40.0	38.5	1,540	665	875	95	12	198	198	-162
Sugar beets	690.0	3.5	2,566[4)]	1.211	1.354	177	119	221	273	-421
Field peas	42.5	-	-	590	-590	91	111	79	80	-229
Maize silage	440.0[4)]	-	-	945	-945	151	40	60	372	-321
Maize grain	92.0	16.5	1.513	947	566	92	339	60	192	-264
Summer barley	60.0	15.0	900	469	431	90	15	78	146	-141
Alfalfa	229.0[4)]	-	-	691	-691	91	66	0	267	-267
Fallow	-	-	-	29	-29	17	-	-	-	-12
Flower strips	-	-	-	129	-129	23	-	-	-	-106
Catch crops	-	-	-	97	-97	18	-	-	-	-79
Grass silage	170.0[1)]	-	-	544	-544	90	39	17	184	-214
Pasture	63.0[1);2)]; 240.0[1);3)]	-	-	305	-305	55	15	17	122	-96
Set aside	-	-	-	116	-116	23	-	-	-	-94

Notes: [1)] Net yield fresh matter [2)] Grass silage [3)] Grass pasture [4)] incl. 137 € yield from pressed pulps.
Source: LfULG 2014, Deimer 2014, own calculation.

Table 26: Gross margins and production data for animal productins in the region MP

	Output	**Market price**	**Revenue** (€/ place)	**Costs** (€/place)	**Gross margin** (€/ place)	**Costs for fodder** (€/ place)	**Costs additional heifer** (€/ place)	**Revenue sale female offspring** (€/ place)	**Gross margin in MIP** (€/ place)
Animal productions[1)]									
Breeding sows	25.5 piglets/year	32.10 €/piglet	1,470	1,114	356	-	-	-	355
Pigs for fattening	93.2 kg slaughter weight 3.23 turnovers/year	1.54 €/kg	463	432	31	-	-	-	22
Dairy cows	9,000 kg mik/year	0.33 €/kg	3,117	1,562	1,555	460	541	9	2,020
Beef for fattening	301 days fattening, 377.0 kg slaughter weight	3.50 €/kg	1,628	1,090	538	159	-		640
Suckler cow	0.96 veal	1.85 €/kg	659	269	390	-	-	124	700
Heifer dairy cow	Reproduction rate 33 %	-	-	317	-317	124	-	-	-281
Heifer suckler cow	Reproduction rate 20 %	-	-	405	-405	-	-	-	-299

Notes: [1)] values per place, calculated per year (except first column „Output").
Source: LfULG 2014, Deimer 2014, own calculation.

Gross margins do not necessarily entail all costs and revenues related to specific production activities, as some features are calculated directly in the model. For instance, outputs of several plant activities can be either consumed on-farm or sold. When those two possibilities are introduced in the MIP, the corresponding gross margin equals variable costs. Furthermore, in order to consider differing uses of plant protection and energy according to soil quality and prices for nitrogen, costs for production activities have been further disaggregatd. The possibility to buy fertilizers and crop protection on the market as well the consideration of variable (dry and storage) and fixed costs (fuel and lubricants) for energy have been introduced in the MIP. Additional restrictions define to which extent plant activities can require those resources. Those restrictions have been calculated such that costs for plant activities calculated in the MIP are comparable to data of the LfULG.

Regarding animal productions, feed costs are calculated in the MIP (see section “Animal productions” below). Furthermore, cattle replacement (heifers either produced on-farm or bought on the market) as well as calves sales are considered in the MIP. Regarding the latter, calculated costs might slightly differ compared to those provided by the LfULG. Apart from this we estimate cost of cattle replacement to be equivalent to buying a new heifer. In the MIP farms can choose between producing own heifers or buying new ones on the market. Costs for keeping grazing livestock are mostly influenced by labour and feed costs. As feed costs depend on the choice of feed products in the MIP, they might differ from LfULG data. However, those data sources consider neither the use of own-manure nor costs saved through on-farm produced feed; which is the case in the MIP.

Plant productions

As indicated in Table 6, in addition to dominant field crop productions like winter wheat (31.6 %) and winter barley (11.2 %), winter rapeseed (18.1 %), maize silage (7 %) and sugar beets (2.9 %) occupy almost 30 % of regional arable land. Grassland can either be intensively used (grass silage) or extensively with the provision of pastures for suckler cows. Apart from this the possibility to keep fallow land on grassland has been introduced in the MIP, as some farms do not necessarily use their whole grassland to feed their animals. It is to mention that activities described below also include plant activities relevant for the provision of EFA. Information on policy requirements linked to those production activities will be provided later on in section 5.

Table 27 shows gross margins, requirements in machinery, fertilizers and labour and average bound capital for each plant production activity. Average bound capital is calculated based on variable costs for each plant activity. It is assumed that variable costs are bound at the level of 40 %, 60 % and 80 % for summer crops, winter crops and alfalfa respectively. Values for requirements in fertilizers originate from datasets of the LfULG.

Table 27: Characteristics of plant productions in the region MP

	Gross margin in the MIP (€/ha)	Average bounded capital (€/ha)	Nitrogen requirement (kg/ha)	Phosphate requirement (kg/ha)	Potassium requirement (kg/ha)	Labour requirement (h/ha)	Machinery requirement (ha[1])
Winter barley	-172	103	99	48	36	14.9	1.00
Winter wheat	-132	79	158	60	45	14.2	1.00
Rapeseed	-162	97	134	72	40	15.2	1.00
Sugar beets	-421	168	124	69	173	12.6	1.20
Field beans	-199	80	-	52	60	13.1	0.88
Maize silage	-321	128	190	80	225	16.1	1.00
Maize grain	-264	106	124	72	45	15.0	1.00
Summer barley	-141	56	99	48	36	13.2	1.00
Alfalfa	-267	213	-	70	325	15.8	1.00
Fallow (arable land)	-13	5	-	-	-	6.6	0.20
Flower strips	-106	42	-	-	-	4.9	0.30
Catch crops	-79	32	-	-	-	2.5	0.20
Undersown crops	-60	24	-	-	-	2.0	0.10
Grass silage	-214	86	97	42	104	17.2	0.60
Pasture	-96	38	84	36	34	14.6	0.20
Fallow (grassland)	-94	37	-	-	-	5.9	0.20

Notes: 1) This value equals to 1 for winter wheat. Other values are calculated with reference to machinery requirement for one hectare of wheat.
Source: LfULG 2014, Deimer 2014, own calculation.

Costs for fertilizers for each production activity in the MIP are calculated based on prices for fertilizers as published by the LfULG. Those are set at 0.85€ for nitrogen, 0.80€ for phosphates and 0.65€ for potassium and are calculated as the average over 5 years of price notations for fertilizers as provided by statistics of the federal state of Saxony and considering current market trends. Maximal quantities of fertilizers (170 kg nitrogen per ha) to be brought on fields are introduced as restrictions in the MIP (see section 4.1). Labour requirements as included in datasets of KTBL (2009) and LfULG (2014) only include operative work, not time allocated to planning or maintenance purposes. This means that labour requirements found in

LfULG (2014) are somewhat underestimated compared to accountancy statistics. Therefore, they have been increased in the MIP; original data from the LfULG can be found in Günther (2015).

Regarding production activities introduced in the MIP which are eligible as EFA’s, several assumptions have been made in order in the calculation of gross margins. At first, alfafa is assumed to be planted for 3 years (planted in the first year; harvested in the second and third years). Therefore revenues and costs have been calculated as averages over those three vegetation years. Similar assumptions have been made for fallow and flower strips, whereas those plant productions are assumed to be planted in general on less productive soils for five years - which decreases variable costs compared to one year vegetation periods. Catch crops and undersown crops differ regarding their respective gross margins. Whereas grass seeds can be used as undersown crops, rather expensive mixes of at least two plants have to be sown as catch crops. Moreover undersown crops can de sown together with the main crop, which dramatically decreases labour and machinery costs.

Restrictions regarding crop rotations have been introduced in the MIP as well in order to reflect regional specificities (Table 28). The proportion of cereals (winter wheat, winter and summer barley) has been limited to 66% of arable land; field beans and alfalfa shall not exceed 20% of arable land. For agronomic reasons sugar beets and maize grain are limited to 3% and 5% of arable land respectively. Herewith crop proportions observed in the region MP in the year 2013 are reproduced in the model.

Table 28: Crop rotation restrictions for the region MP in the MIP

Crop	Maximal proportion of arable land (%)
Cereals	66
Winter wheat	40
Protein plants	20
Sugar beets	3
Rapeseed	30
Maize grain	7
Maize	50

Source: Ostermeyer 2014; Deimer 2014, Günther (2015).

Animal productions and fodder restrictions

In Germany most protein needs for animal feeding are covered by imported postextraction soya meals. Local leguminous plants hardly are used for feeding animlas both because of their low returns compared to other crops and because of erratic yields (TLL 2010). Leguminous crops are in competiton with other crops on arable land. With the introduction of compulsory EFA’s leguminous crops can potentially become interesting for on-farm uses. In order to assess those new potentials additional restrictions have been introduced in the MIP. New feed restrictions have been introduced for fattening beef, dairy cows and heifers for which leguminous crops (as fodder or grain) can be potentially relevant. For simplification reasons no restrictions have been introduced for fattening pigs and breeding sows. For economic reasons suckler cows are assumed to be fed on pastures and preserved green fodder from grass and hay (DLG 2009). Therefore only those two options have been introduced to feed suckler cows; each option shall cover half of the energy required to feed one head during one year.

Table 29 shows how livestock shall be fed in the MIP. Actually costs for feed and concentrates are calculated separately in the programme. Each farm chooses a composition of feed which enables it to reach the highest profit/income considering feed restrictions and animal needs.

Table 29: Representation of feed restrictions in the MIP

	Animal production 1	Animal production 2	Plant production 1 (PP1)	Plant production 2 (PP2)2	Sale of 1 dt of PP1	Sale of 1 dt of PP2 2	Feeding 1 dt of PP1	Feeding 1 dt of PP2		
Objective function	GM	GM	Cost	Cost	Price	Price	0	0		RHS
Yield PP1 (dt/ha)			$-Y_1$		1		1		<=	0
Yield PP2 (dt/ha)				$-Y_2$		1		1	<=	0
min. restriction 1	m_1	m_2					$-y_1$	$-y_2$	<=	0
max. restriction 2	$-M_1$	$-M_2$					y_1	y_2	<=	0

Note: x_1, x_2= requirement for the corresponding animal production.
m_1, m_2, M_1, M_2 = maximum/minimum limits for each animal production.
y_1, y_2= supply of PP1 and PP2
Y_1, Y_2= yield of PP1 and PP2
RHS = Right-hand side.
Source: own figure based on Günther (2015).

Actually each animal has physiologic needs which have to be covered by a combination of different crops. Those crops reach certain yields per year; in the MIP those harvested quantities can either be sold or fed on-farm. Those two possibilities do not exist for grain leguminous crops (field beans in the region MP) as they are not traded on commodity futures markets (LLfG 2012). It is therefore assumed that field beans produced are fed on-farm, which prevents too much of it to be produced at the regional level compared to what could actually be consumed.

Table 30 shows limits and requirements introduced in the MIP regarding livestock feeding (for more details see Günther 2015). Those values are calculated for one calendar year, as one production period is equal to one year in AgriPoliS.

Table 30: Limits introduced in the MIP regarding livestock feeding

	Beef for fattening >1 year	Dairy cow	Heifer dairy	Suckler cow	Heifer suckler
min. energy intake MJ ME/year	22,748		22,813	49,562	26,686
min. energy intake from grass silage MJ ME/year				22,303	12,009
min. crude protein intake XP/year	364		260		
min. energy intake MJ NEL/year		41,000			
min. usable crude proteins nXP/year		938			
min. intake crude fibres kg/year	309	1,086	434		
max. intake dry matter (DM) kg/year	2,806	6,388	2,555		
max. ruminal nitrogen balance (RNB) kg/year	18	18	18		
min. undegraded feed protein (UDP) kg/year	91	337	78		
max. field beans kg DM/year	642	1,285	321		
min staple feed kg DM/year	1,684				
min maize silage kg DM/year	842				

Notes: MJ ME: megajoules of metabolizable energy; MJ NEL: megajoules of net energy content for lactation; DM: dry matter.
Source: Günther (2015) based on LfULG (2014); LfL (2014).

At first, energy needs have to be covered in order to ensure milk production or live weight increase. This requirement is indicated on the first line of the table (energy intake in MJ ME) except for dairy cows, for which this requirement is expressed in megajoules of net energy content for lactation (MJ NEL, fourth line in the table). It is assumed that suckler cows and suckler heifers are stabling during the winter, therefore energy intake has to be provided by grass silage half of the year.

A similar approach is used for protein intake. Whereas this value is expressed as minimum requirement in crude proteins (XP) for beef for fattening, suckler cows and heifers, protein requirements for dairy cows are expressed in usable crude proteins (nXP). Usable crude proteins are directly absorbed in dairy cows' small intestine. It is composed of microbial proteins produced in the rumen as well as of Undegradable Dietary Proteins also called UDP (Stangl et. al. 2014). However at some periods (lactation by dairy cows, first year of life by young cattle), protein synthesis in the rumen might not cover animals' needs. Therefore a lower limit in UDP has been introduced in the MIP for each livestock branch considering specific requirements (for more details see Günther 2015). Moreover, field beans are less rich in UDP (very important to provide animals with a high diversity of proteins), but richer in energy compared to postextraction soya meals. Therefore an upper limit of 2 kg, 4 kg and 1 kg of field beans per day has been introduced for beef for fattening, dairy cows and dairy heifers respectively.

In the rumen microbial proteins are optimally produced when Rumen Nitrogen Balance (RNB) value lies between 0 and 50 g per day. Therefore feeding activities have to be combined in order not to exceed limits indicated in Table 30.

A minimal quantity of fibres in the diet ensures sufficient periods of cud chewing and rechewing, which helps regulating pH and therefore prevents the rumen to become too acid. Fibres content have to be at least equal to 11% (beef for fattening) and 17% (dairy cows, dairy heifers) of feed rations' total dry matter (see Table 30). All animals' feed intake capacity relates back to dry matter (DM), which is an indicator of whether animals' intake of feed is sufficient. Dry matter content will also affect feed intakes especially fresh and preserved forage. Animals' needs in feed vary depending on age and performance. Restrictions introduced in the MIP assume that dairy cows, beef for fattening and dairy heifers would need 17.5 kg, 8 kg and 7 kg of feed in dry matter equivalent, respectively; values in Table 30 are calculated for one year. Moreover, regarding beef for fattening an additional restriction requires 60% of needs in dry matter to be covered by either alfalfa or maize silage.

Table 31 shows nutritive values delivered by crop activities in the MIP. Feed intakes for each livestock production branch can be calculated based on those data.

Table 31. Nutritive values of crops used as animal feed in the MIP

	Maize silage	Grass silage	Field beans	Barley	Alfalfa	Soya meals	Maize grain	Pasture
Energy delivery MJ ME/dt	375	349	1199	1130	325	1210	1170	188
Quantity of crude proteins XP/dt	2.8	6.0	26.2	10.9	4.6	44.9	9.3	
Energy delivery MJ NEL/dt	226	207	758	711	190	759	738	
Usable crude proteins nXP/dt	4.6	5.0	17.2	14.4	5.7	27.3	16.4	
Fibre content kg/dt	7.0	9.0	7.8	5.0	7.2	5.9	2.3	
Dry matter kg/dt	35	35	88	88	35	88	88	
RNB kg/dt	-0.28	0.21	1.50	-0.53	0.42	2.82	0.79	
UDP content kg/dt	0.43	0.88	5.3	2.7	0.9	15.7	4.4	

Notes: MJ ME: megajoules of metabolizable energy; XP: quantity of crude proteins; MJ NEL: megajoules of net energy content for lactation; DM: dry matter.
Source: Günther (2015) based on DLG (1997).

Dairy production is dominant livestock production in the MP region. Table 32 shows data introduced in the model regarding each livestock production relevant for the MP region. Variable costs linked to buying inputs (energy, fertilizers and pesticides) are assumed to be bounded at the level of 50% during production. This proportion is assumed to be of 22% and 21% for the production branches breeding sows and pigs for fattening, respectively. Heifer breeding is a separate activity in the MIP. No capital is bound in dairy production, but 120% of variable costs are bound in dairy heifer production. The same level is considered in the production branch suckler heifer. Regarding beef for fattening and suckler cows, variable costs are bound at the level of 74% and 80%, respectively.

Nutrients contained in animals’ excretions are partially available for crops. Those are considered in the restrictions imposing minimal requirements for crop growth. On the other hand a limit in organic fertilizers is introduced in the MIP and serves as genreal limit in nitrogen her hectare.

Table 32: Requirements and deliveries of livestock production systems modelled in the MP region

Livestock branch	Gross margin (€)	Average bounded capital (€)	Nitrogen available for crops (kg/ha)	Phosphates available for crops (kg/ha)	Potassium available for crops (kg/ha)	Total nitrogen (kg/ha)	Labour requirement (h/ha)
Breeding sows	355	245	14,8	13,5	11,3	26,0	21,1
Pigs for fattening	22	92	6,1	5,5	4,9	10,8	1,6
Dairy cows	2.020	709	22,7	15,2	35,9	35,0	13,3
Beef for fattening	640	41	34,4	16,5	71,0	53,0	31,3
Suckler cows	700	0	83,2	44,0	145,0	128,0	43,8
Dairy heifers	-281	336	29,2	16,0	63,0	45,0	24,5
Suckler heifers	-299	359	52,0	27,0	108,0	80,0	21,8

Source: Günther (2015) based on LfULG (2014).

Herd growth in the MIP (dairy and suckler cow production) either results from purchases of heifers on the market or from heifers produced on-farm produced. It is assumed that dairy and suckler cows produce 0.5 heifers per year (i.e., one heifer every two years). Regarding breeding it is assumed that dairy cows and suckler cows produce 0.33 and 0.2 female calves which will be recruited for herd maintenance per year, respectively (Table 33). Calves which are not kept on the farm can be sold on the market. Calves in the dairy production are sold after birth; calves in the scukler cow production are first sold as weanlings with a liveweigth of 250 kg. As no prices were available in the LfULG database, the purchasing price for one heifer in suckler cow production was based on sales data available for heifers belonging to the Simmental Fleckvieh breed (1,600 €/head).

Table 33: Breeding as introduced in the model for the MP region

Livestock production system	Number of female calves (head/year)	Number of female calves used for breeding (head/year)	Purchase of heifers (€/head)	Sale price female calf (€/head)
Dairy cows	0.5	0.33		110
Suckler cows	0.5	0.2		460
Heifer dairy			1,640	
Heifer suckler			1,600	

Source: Günther (2015) based on LfULG (2014)

Other activities

To cover short-term capacity shortages or to optimally use capacities in excess, a number of additional activities are considered. In the MP region these activities include hiring labour, putting family labour at disposal for working outside the farm and machinery lease from a private contractor. Table 34 lists additional activities and their effect on farm factor capacities.

It is assumed that a farm short of machinery capacity can hire additional machinery capacity offered by a private contractor. Moreover, farms have the possibility to hire labour or offer family labour on a short-term per hour basis. In addition, or alternatively, labour contracts can also be made on a fixed basis. Regarding fixed contracts, one annual work unit (AWU) is assumed to correspond to 1,800 hours.

Table 34: Additional activities introduced for the MP region

	Revenues or costs[a)] (€)	Labour (h)	Liquidity €	Machinery ha
Machinery lease (1 ha)	-307	-	-	1
Hire labour (€/h)	-12.65	1	-	-
Off-farm family labour (€/h)	8.5	-1	-	-
Hire 0.5 fixed labour (h)[b)]	-10,350	900	-	-
Lease 0.5 fixed labour (h)[b)]	8,500	-900	-	-
Interest on short-term borrowed capital (1 €)	-0.08	-	1	-
Savings interest (1 €)	0.04	-	-1	-

Notes: a) Costs have a negative sign; b) one year contract assumes labour trained in agriculture.
Source: Own figure based on based on Günther (2015) and HAPPE (2004), DEUTSCHE BUNDESBANK (2013).

Capital required for production and investments is considered in three forms: short-term borrowed capital, long-term borrowed capital, and equity capital. Short-term credit is taken up by farms in the case of short-term liquidity shortages. To bridge those shortages, farms can take up short-term credit at 8 % interest rate. The amount of short-term borrowed capital is not explicitly limited but interest is higher than for long-term borrowed capital (interest rate of 5.5%), which therefore sets a kind of natural limit for borrowing in the short-term. Likewise, the savings interest rate on excess liquidity is 4 %.

4.4.2 Investment options

Table 35 shows investment options introduced in AgriPoliS with respect to production activities modelled in the MIP. On the one hand those options will allow farms in the model to access to buildings and machinery matching the production activities they will invest in. On the other hand individual farms'capacities (livestock production and physical size) as contained in the empirical data will help to attribute the right-sized investment (stable and/or machinery) to each typical farm.

Table 35: Investment options introduced in the model for the MP region

Stable types	Stable places (heads)	Investment costs (€)	Economic useful life (years)	Investment costs per place (€)	Annual costs per place (€/year)	Labour substitution (h/year)
Breeding sows	1,580	2,986,200	20	1,890	158	0
	800	1,520,000	20	1,900	159	-80
	672	1,286,880	20	1,915	160	-202
	336	648,480	20	1,930	161	-168
	252	529,200	20	2,100	176	-176
	170	374,000	20	2,200	184	-170
	128	294,400	20	2,300	192	-320
	64	160,000	20	2,500	209	-288
	40	104,000	20	2,600	217	-260
Pigs for fattening	10,800	3,564,000	20	330	28	0
	5,400	1,809,000	20	335	28	-162
	2,000	686,000	20	343	29	-200
	1,000	357,000	20	357	30	-210
	600	216,000	20	360	30	-180
	400	168,000	20	420	35	-160
	200	102,000	20	510	43	-160
	100	56,000	20	560	47	-157
Beef for fattening	500	1,050,000	25	2,100	156	0
	200	430,000	25	2,150	159	-300
	100	240,000	25	2,400	178	-600
	40	104,000	25	2,600	193	-428
Suckler cows	100	180,000	25	1,800	134	0
	40	76,000	25	1,900	141	-160
	10	20,000	25	2,000	148	-50
Dairy cows	480	1,766,400	25	3,680	273	0
	240	907,200	25	3,780	280	-720
	120	499,200	25	4,160	309	-1.080
	60	328,200	25	5,470	406	-720
	30	174,000	25	5,800	430	-510
Breeding	300	249,600	24	832	63	0
	200	172,400	24	862	65	-200
	100	99,900	24	999	76	-200
	50	58,850	24	1,177	89	-150
	20	27,680	24	1,384	105	-80
	10	15,910	24	1,591	121	-50
Machinery (equivalent ha of wheat)	1,000	700,000	12	700	102	300
	500	400,000	12	800	117	0
	200	200,000	12	1,000	146	-80
	100	120,000	12	1,200	175	-80
	50	70,000	12	1,400	205	-180
	30	48,000	12	1,600	234	-108
	15	33,000	12	2,200	322	-62

Source: Günther (2015).

Several investment sizes have been introduced for each production system. Increasing investment sizes allow economies of scale, i.e. investment costs per place of per hectare decrease as well as labour requirement per year. The last column named “labour substitution” in Table 35 mimicks this assumption and the negative sign means that the larger the investment, the more labour is set free compared to small investment objects. The “saved” labour can therefore be used where else on-farm for other activities or off-farm in case family labour becoming available reaches better returns in another sector.

4.4.3 Policy framework

Since the last CAP 2014-2020 reform, direct payments are divided into a basic payment and a greening component. In addition to this, there is the possibility for young farmers to receive a top-up to support their entry in the agricultural sector. Apart from this there is a possibility for EU member states to implement redistribution schemes (either degressivity of direct payments or first hectare payments) as well as to grant small farmers with an additional payment (BMEL 2015).

On November 4, 2013, the German Council of Agricultural Ministers (AMK), representing the federal government and the federal states' governments, agreed on rules to implement the reformed CAP. Accordingly, Germany will introduce first hectares payments of 50 €/ha for the first 30 ha and additional 30 €/ha for the next 16 hectares considering a national average farm size of 46 ha. These payments are supposed to redistribute 6.9 % of the basic payments (AMK, 2013) and is motivated by the aim to support small farms as well as to compensate them for the abolition of the previous progressive modulation of direct payments which disfavoured larger farms and was in favour of smaller farms (BMELV, 2013). The AMK also agreed to support younger farmers which take over a farm by additional 50 €/ha for up to 90 ha and five years.

Regarding the first hectares payment, farms receive 50 €/ha for the first 30 ha and 30 €/ha for the next 16 ha. The young farmer payment of 50 €/ha is paid for maximum 90 ha, i.e. the max young farmer payment is of 4,500 €. Young farmers receive them only during five years (time span young farmer). In AgriPoliS a farm is handed over to a successor every 25 years. The eligibility for young farmer payments is determined by updating the "farm age" (time span somebody is managing a farm) on the right hand site (RHS). Furthermore, only natural persons are eligible for the young farmer payment. Thus, farm age of legal persons is always set to 25. The solutions of the columns "Max young farmer payment", "Older farmers" and "Young farmers" have to be integer (i), whereas they can be continuous (c) for all other columns.

Table 36: Exemplary MIP for first hectares and young farmer payment

	Production activity I	Production activity II	Total basic payment	First hectares	Next hectares	Young farmer payment	Max young farmer payment	Older farmers	Young farmers		
	c	c	c	c	c	c	i	i	i		
Objective function	GM	GM	1	50	30	1	0	0	0		RHS
Basic payment	-174	-174	1							<=	0
First hectares				1						<=	30
Next hectares					1					<=	16
Count hectares	-1	-1		1	1					<=	0
Max young farmer payment						1	-4,500			<=	0
Ha-payment young farmer	-50	-50				1				<=	0
Farm age								-20	-1	<=	**-farm age**
Payment condition							1	1		<=	1
Time span young farmer									1	<=	5

GM: gross margin; RHS: right-hand side.
Source: Balmann and Sahrbacher (2014).

Since January, 1st 2015 German farmers have to comply with greening requirements in order to receive the full direct payments (basic payment + greening component). In case of non compliance with those greening requirements in 2015 and 2016, farmers were not eligible to receive the greening component. However, if those requirements are not fulfilled from 2017 onwards, farmers would even lose up to 125% of the greening compenent and therefore see their basic payment reduced. Greening requirements apply to all areas declared as eligible for the basic payment by the farmer, and this from 2015 onwards (MLU 2015). The basic payment is calculated at the federal state level. Between 2017 and 2019, differences between federal states inherited from the former direct payment regulation shall be progressively reduced, such that from 2019 onwards, all German farms across federal states receive the same payment per hectare (Table 37). On the other hand, the greening payment is the same for all federal states from 2015 onwards. Dotations in Pillar 1 decrease between 2015 and 2019 in order to transfer 4.5% of the Germany national ceiling of total subsidies to Pillar 2. Therefore the greening component slightly decreases together with the basic payment between 2015 and 2019 to fulfil this budget requirement.

Table 37: Basic and greening payment in Saxony from 2013 until 2019

Year	Basic payment	Greening payment
2013	298	-
2014	298	-
*2015	187	87
2016	186	87
2017	182	86
2018	178	85
2019	175	85

Quelle: Eigene Darstellung nach BMLU 2015
* from 2015: estimations.

In order to receive the greening payment, farms have to fulfil three main requirements: the maintenance of permanent grasslands, crop diversification and the introduction of EFA's on arable land. Those measures have been introduced in the model and further details are provided in the next section.

5 Modelling greening measures in the MULTAGRI regions

5.1 Background

After several years of intensive discussions, in September 2013, European Commission (EC), Parliament (EP) and Council agreed finally on the Common Agricultural Policy (CAP) for the financial period 2014 to 2020 (EU, 2013). Accordingly, the level of direct payments among member states will partly be harmonized. Moreover, direct payments to be paid per hectare will be split into basic payments of 70 % and a greening component of 30 % of the total payments distributed in the first pillar of the CAP. The greening component is subject to farmers' compliance to measures aiming at supporting a sustainable European agriculture. Those measures consist in: 1) maintaining permanent grassland and pastures, 2) crop diversification and 3) the introduction of Ecological Focus Areas (EFA) on at least 5% of farm's arable land. In some cases, like in Germany for instance, converting permanent grassland in arable land will only be possible on official request in certain conditions. Regarding crop diversification, farms fulfilling precise criteria are exempted, for instance farms smaller tham 10 ha, or farms managing less than 30 ha arable land and having grassland on more than 75% of total UAA. Farms between 10 and 30 ha have to grow at least two different crops where the main crop shall not exceed 75% of total arable land. All other farms with more than 30 ha of arable land have to grow at least three different crops where the main crop does not exceed 75% of farm's total arable and and the two main ones nom ore than 95% of total arable land. Similarly, there are exemptions to the creation of EFA on arable land for farms smaller than 15 ha, farms with grassland of green fodder on more than 75% of their UAA and for farms growing green fodder, grass, fallow and/or leguminous plants on at least 75% of their arable land and having less than 30 ha of arable land apart from this.All other farms have to create 5% of EFA on their arable land and plant or grow crops and landscape elements contributing to the maintenance or improvement of biodiversity. Conversion factors have been introduced to convert, for example, the length of a hedge in metres or an isolated tree to square metre equivalents to calculate its contribution to the overall EFA area (Matthews 2015). However, provided those plants/elements do not contribute to the maintenance or improvement of biodiversity to the same extent, weighting factors have been introduced in order to assess the 'biodiversity equivalence' of different measures (Table 38).

Table 38: Weighting factors of EFA measures and corresponding area to be considered for each measure (in ha) in Germany and Sweden

	Germany		Sweden	
	Weighting factors	Area after weighting (ha)	Weighting factors	Area after weighting (ha)
Fallow	1	1	1	1
Terraces	1	1		
Landscape elements:				
- Heges and hedgerows[1)]	2	0.5		
Single trees[1)]	1.5	0.75		
Field copses[1)]	2	0.5		
Other elements like field stonebanks[1)]	1.5	0.75		
Field edges[2)]	1.5	0.75	9 times multiplied by each meter	0.09
Buffer stripes along waters	1.5	0.75		
Stripes along forest edges	1.5	0.75		
Agroforestry	1	1		
Short rotation coppice	0.3	3	0.3	3.33
Reforestation	1	1		
Catch crops, green cover	0.3	3.3	0.3	3.33
Nitrogen fixing plants	0.7	1.4	0.7	1.4

Notes: 1): under cross-compliance; 2): not under cross-compliance.
Source: BMEL 2015, SJV 2015.

Member States were allowed to make use of them for chosen EFA measures with the constraints to make them mandatory whenever one EFA measure would receive a weighting factor inferior to 1. In Germany for instance, fallow land has a weight of 1, a hedge is given a weighting of 1.5 and areas with catch crops or green cover a weighting factor of 0.3. In other words, EFA measures with a weight inferior to one, say a, have to be implemented on an area of 1/a hectares, which is more than one hectare. Similarly; a weight superior to 1, say b, implies that farmers have to implement the measures on only 1/b ha, which is less than one hectare.

5.2 Greening measures in AgriPoliS

In addition to EFA's farms have to comply with the maintenance of permanent grassland and crop diversification. In AgriPoliS as it is not possible to convert grassland into arable land, the requirement to maintain permanent grassland is already fulfilled *per se*. Moreover, crop rotation restrictions in the MIP have been set such that the crop diversification requirement is fulfilled (see Table 28 for the MP region and Table 19 for the GSS region).

In order to assess impacts of EFA's on farm structures, the MIP had to be extended. Several options can be selected by farms in order to reach 5% of EFA on their arable land. Table 39 shows relevant activities and restriction introduced in the MIP so far regarding the German region. As indicated in the table farms with less than 15 ha do not have to implement EFA's. Similarly farms with more than 75% of permanent grassland or green fodder producing farms are exempted from EFA's. 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's as well.

Table 39: Implementation of EFA's 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).

The next subsections provide some additional information about greening measures modelled in each case study region.

5.3 The case of Germany: greening measures in the MP region

Four EFA options have been introduced in the MIP for the MP region: fallow land, flower strips, nitrogen-fixing plants and catch crops and green cover. It is assumed that those activities can take place on the whole arable land in the region. Weighting factors are introduced in the MIP as indicated in Table 38. The following subsections provide some additional details on greening measures selected for the MP region extending information already delivered in section 4.3.1 and Table 27.

5.3.1 Catch crops and undersown crops

Catch crops designate plants which are grown between the vegetation periods of two main crops. There is a difference between summer catch crops and winter catch crops. Winter catch crops are often sown in late summer-early autumn subsequent to the harvest of after a main crop and serve as stubble intercrop. The year after, the winter catch crop can either be incorporated in the ground or harvested and used as a first feed for livestock. Summer catch crops are rather used as undersown crops in an early crop or as stubble crop after the main crop. In this latter case summer catch crops help using the end of the vegetation year for fodder purposes or as a green cover. Harvest or incorporation is generally executed before the winter (Voigtländer and Jacob, 1987). However, if undersown crops are to be eligible as EFA they cannot be harvested before the 15th of February of the subsequent year. Undersown crops are often combined with maize plantations but it is possible to sew them together with other cereals or leguminous plants, however more problems can be expected than with maize.

Grasses and grass clover mixes are often chosen as undersown crops. The winter coverage of fields enhances soil fertility and prevents from nutrients leaching. Long-term experiments show that up to 40 kg nitrates can be kept on-field (LWK Niedersachsen 2015).

The three main winter catch crops are oil radish, mustard and phacelia. To be eligible as EFA, catch crops have to be a mix of at least two plants with no more than 60% of the main plant inside. After a catch crop used as EFA only late field crop like mais or root crops can be cultivated. However summer crops, linseeds and leguminous plants like peas or field beans can possibly be grown as well. Preceding crops have to be harvested and removed before 1st October so that it is possible to sew a catch crop: winter barley, winter rapeseed and winter wheat are plausible options (SMUL, 2000). Some years where harvest could be done early might allow to plant catch crops after maize; however if he harvest was late there will be no possibility to sew a catch crop after a winter wheat for instance.

In the MIP catch crop and undersown crops do not necessitate the use of one hectare of arable land and are therefore not eligible for basic payment (Table 39). Catch crops can only be planted before or sown after specific field crops. In the MP region, catch crops are sown after winter wheat, winter barley, rapeseed and leguminous plants. They can precede sugar beets, summer barley, legumniousplants, maize silage and maize grain in the crop rotation. In the model undersown crops can only be sown together with maize silage and maize grain. After harvest of the main crops they have to remain on the field until 15th February of the following year.

5.3.2 Leguminous plants

Regarding alfalfa we assume a cultivation period of three years (a first sewing year plus two main vegetation years). This means that subsequent crops can only be cultivated every three years. To be eligible as EFA, alfalfa (leguminous plant) has to be followed by a winter crop or a catch crop. An additional restriction in the MIP ensures this requirement to be fulfilled if alfalfa should be grown as EFA.

5.3.3 Fallow land and flower strips

A cultivation period of five years is assumed for fallow land and flower strips. It is to note that those production activities are implemented on low quality soils not productive enough for agricultural activities. The pluriannual cultivation of those plants has an impact on variable costs which are lower than if one-year cultivation periods were considered.

5.4 The case of Sweden: greening measures in the GSS region

From Table 38 it is noticeable that there are five EFA measures being considered in Sweden. We already introduced details on two EFA measures (fallow land and protein crops) in section 4.3.1. These two production activities already exists, thus from 2015 they were assigned the weighting factors and were considered part of the total EFA area (row “Greening yes>15ha” in Table 39).

The choice of two distinctive protein crops (peas and clover) was in order to reflect the soil heterogeneity where it is assumed that peas is grown on the high and clover on the low fertile land. We did the same approach also for short rotation coppice where we chose two distinctive approaches of willow production to reflect the soil fertility and consequently yield variability. Hence, willow cut every fith year yields 23 tons wood for energy and is frown on high productive land. Contrary, willow which first cut is after five years yields 16 tons is grown on low productive land (Table 40).

Contrary to Germany where ley is undersown together with maize, in Sweden it is a common practice and is considered as EFA to grown lay together with cereals (mainly barley). Sowing the crops together allows to take advantage by saving costs (labour, machinery and energy) making a bit cheaper than having a catch crop alone. Since there is not yet available economic data on cost of having a field margins, in this particular case we had to assume that the costs are similar to fallow land. A bit more expensive than fallow land to be able to capture the mechanical and chemical weed control applied between two shifts or the possibility to sown flowers on them.

Table 40: Greening measures in GSS region

EFA	**Other costs**	**Yield**	**Price**	**Machinery requirements**	**Labour input**
	SEK/ha	kg/ha	SEK/kg	ha	hours
Protein crop high (peas)	979	4,100	1.84	0.52	10.9
Protein crop low (clover)	481	238	18.95	0.52	14.5
Fallow land	220	-	900	0.2	2.4
Willow high	5,504	23,000	0.465	0.09	1.85
Willow low	5,050	16,000	0.465	0.28	5.79
Catch crop	720	-	-	0.12	2.5
Grass undersown with barley	547	-	-	0.1	2
Field margins	226	-	-	0.2	2.4

Source: Agriwise (2015). Data is based on actual prices and levels for 2011.

Regarding crop rotational limits we exclude at any of the EFA measures because would like to investigate the pure effect of the EFA constraint. Depending on the environmental benefits we analyse with AgriPoliS, in some cases it is important to consider crop rotation at fallow land. For biodiversity having a rotational fallow land is more beneficial (nesting habitat, winter food for seed eating birds) where as permanent fallow land is more beneficial for carbon sequesteration, nitrogen leaching, reduced loses of sediments, etc (Hart, 2015).

6 Conclusion

This report documented data and updates implemented in the model AgriPoliS in order to further analyse impacts of greening measures on farm structures and agricultural incomes in both study regions Götalands södra slättbygder (GSS) in Sweden as well as Mittelsächsische Platte (MP) in Germany. Further research will be conducted and documented in deliverable D4.3: "Possible trajectories of agricultural development depending on policy measures" in the framework of the MULTAGRI project as well as in other papers currently in preparation.

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