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Regional food and feed self-sufficiency related to climate change and animal density – a case study from the Czech Republic

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Abstract: A new food and feed self-sufficiency model for the Czech Republic (RESTEP) was applied for the evaluation of possible adverse climate impacts uniformly reducing crop production by 5, 10, 20, and 30%. The situation was simulated for the whole country and four different agriculturally important regions. Biomass production modeling confirmed that for the whole country, the food self-sufficiency is secured up to 20% of yield decline for most crops, but even 5% yield decline of silage maize would lead to its shortage in animal feeding. On the other hand, regional results vary significantly. Regions Jižní Morava and Střední Čechy shown oversupply of feedstuff allowing them to cover the demands of cattle and pigs up to 20% or 30% decline of yield, respectively. The opposite model represents the Vysočina (VY) region which is not able to cover the demands from own sources even at the baseline scenario. The acreage extension of maize is not possible due to erosion risk restrictions at 25% of arable land at VY. The possible solution consists of extension acreage of alfalfa and clover or finding other plants sufficient for feeding as well for biogas facilities in regions rich in biomass energy consumers.

Keywords: animal farming; human nutrition; extreme weather; consumption; livestock

Food self-sufficiency (FSS) is an often-used term, but the uniform definition is usually not provided. The simplest definition that carries probably most commonly understood the idea of FSS gives FAO (1999): 'The concept of food self-sufficiency is generally taken to mean the extent to which a country can satisfy its food needs from its domestic production'. This concept excludes international food trade implying simple equation: domestic consumption is equal to 100% food production. More pragmatic approach taking the economic essence into account is the equation: self-sufficiency ratio (SSR) = production × 100/(production + imports – exports). Most SSR analyses focus on key staple crops, such as cereals and starch roots, to give an approximation of food self-sufficiency of a country (Clapp 2017). Another approach refers to the contribution to food production coming from imported production. Imported feedstuffs are a major example (O'Hagan 1976). Another way of dealing with the extent to which national consumption is met by national production is given by food energy (kilocalories, KJ) per capita.

There is a limited number of publications deal with security and self-sufficiency in the Czech Republic (CZ) using relatively simple and quick EUROSTAT methodology (balance of production and consumption, or link between domestic production by its consumption and export calculated per given commodity (Noleppa and Cartsburg 2013). While the self-sufficiency of main strategic crops in CZ corresponds

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to 130–160%, in animal production the situation is the opposite. The CZ is self-sufficient in beef (132%) and milk (133%). Pork sufficiency has been gradually decreased over the past 15 years to 55% and poultry and eggs, both to 75% (Green Report 2016).

More complex method is represented by Model VYZIVA-1 determining the composition of food for the average CZ inhabitant consisting of 87 foodstuffs items, respecting the specified minimum nutritional recommended doses (NRD) for energy and 9 essential nutrients. Furthermore, Model ZEPOS-1 (balancing-optimization model) determines the minimum size of domestic agricultural and food production (excluding imports) ensuring the required volume of food for the CZ population (IAEI, Certified Methodology 2013).

The other approach for food self-sufficiency estimation provides RESTEP (regional sustainable energy policy) model, originally developed as a tool for estimation of potential, planning, and parametrization of renewable energy sources (RES), mainly biomass. The RESTEP is based on the real values of individual crops in the area of interest. Crop representation and yields can be modified by the user. The total harvest yield is recalculated for dry matter (DM), that is important for subsequent energy conversions used for modeling and comparison of individual inputs and outputs.

The contribution to food self-sufficiency is calculated as consumption of different consumers (people, farm animals, RES) based on known factors (percentage of yield per human consumption, feeding doses, installed power).

Two available approaches, how the food self-sufficiency can be determined, were described above. To compare both principles of computing procedures, the first one (by IAEI) is highly bound to human nourishment. The second one (by RESTEP) takes into account very important part of contemporary agriculture, crops and land use for energy purposes comparing inputs and outputs as energy allowing to incorporate energy utilization of biomass as well. The advantage of RESTEP model consists of the flexibility of biomass production changes and estimation of the consumption for food, feed and existing RES representing a significant consumer of biomass.

The climate change and extreme weather events are phenomena frequently affecting crop production recently, and it is necessary to be reflected in the research of management tools dealing with potential risks in primary agricultural production. With the growing need to ensure adequate self-sufficiency in the production of basic food and biomass for RES production, ways to ensure sustainability are sought more intensely due to significant climate change, particularly with variability in rainfall (Gebler et al. 2018). Information related to the comprehensive effects of the biomass production reduction on the food, feedstuff, and energy resources is vitally important.

The objective of our study was set on the Czech regional food and feed self-sufficiency under proposed reduction of biomass yields with the special attention to the silage maize biomass production as a major supplier for livestock and RES represented by biogas facilities (BGF) and at the same time a plant with high soil erosion potential.

MATERIAL AND METHODS

In the experiment, scenarios of the biomass production reduction by 5, 10, 20 and 30% due to climate change were compared. Models were carried out for the whole Czech Republic as well as for four selected regions with different climatic conditions (Regions Středočeský (SC); Vysočina (VY); Královéhradecký (KH), and Jihomoravský (JM)) to minimize transportation costs and carbon footprint. The size of the CZ regions corresponds to the NUTS 3. Subsequently, the impacts on biomass availability in animal production and RES were monitored.

The basis for the analysis and modeling of production and utilization of agricultural biomass are data obtained within the IS RESTEP project refined in the statistical and planning module BIOMASA, which works with spatial data of the land parcel identification system (LPIS) and valued soil-ecological units (VSEU), which is a five-digit number code that expresses the soil and climatic conditions influencing the soil productive ability. The digits define the relevant climatic region, main soil unit characterized by the morphogenetical soil type, granularity, soil profile depth, skeleton grade, and grade of hydrotropism, descent, and land exposition.

Biomass production calculation methodology. RESTEP IS calculates model yields of crops based on soil and climatic conditions derived from characteristics using VSEU.

Potential yield for 34 crops is determined in the RESTEP and BIOMASA modules (www.restep.cz). To determine the total estimated yield per monitored area in the selected locality, besides the average yields bound to VSEU, it is also necessary to know the proportion of individual crops in the crop rotation.

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For the present study, information of harvest and sowing areas were taken from the Czech Statistical Office (CZSO). Data from 2014 to 2017 were used, from which the average representation of individual crop species was calculated.

The methodology of biomass consumption calculation. The approach of the IS RESTEP model is hierarchized as follows: subtracting the amount needed to ensure the required level of food self-sufficiency (human nutrition), the need of feed for livestock was subsequently determined according to their numbers in the selected area. The rest of the crop production can be used for energy purposes or export.

Consumption of human nutrition. For human nutrition, the amount of biomass consumed was determined as a relative proportion of the production of the given crop species. Thus, consumption corresponds to a defined percentage of crop production regardless of yield. The rest is used as feed for livestock, for the production of alcohol, for other energy purposes, etc. (Keller et al. 1999).

Consumption for livestock nutrition. Livestock claims for biomass consumption were determined by the number of feed days per year in each animal category, as determined by the actual number of animals from the Central Animal Register. Animals are converted into livestock units (LU). BIOMASA works with the following groups of animals: (A) polyesters: (i) calves under 1 year (0.5 LU); (ii) heifers and suckler cows 1–2 years (1 LU); (iii) bulls and steers 1–2 years (1 LU); (iv) bulls older than 2 years (1 LU); (v) dairy cows older than 2 years (1 LU); (vi) sheep (0.15 LU); (vii) goats (0.15 LU); (B) monogasters: (i) pigs (0.3 LU); (ii) sows (0.5 LU); (iii) poultry (0.01 LU). Consumption of individual crops is based on a feed dose for individual categories of animals and their numbers. The composition of feed doses of polygastres further varies according to the feeding areas (lowland, submontane, mountain). For consumption calculation purposes, the consumption of animals in the selected region is subtracted from the region's production. Determination of feed doses for animals is based on nutrient requirements for livestock (Šimeček et al. 2000).

The effect of reduction of produced biomass on cattle and pig states in individual regions was studied. Based on the observed values, the effect of climate change on the possible increase or decrease of farmed livestock was modeled to achieve self-sufficiency in the monitored regions.

Use in renewable energy. In renewable energy, primarily agricultural land products are used, especially maize and wheat, which are the substrates for biogas production in BGF. To calculate the consumption of BGF raw material, the number and total output of electric installations in each region were used. In 2018, there were 382 BGFs in the Czech Republic with a total installed capacity of 312 MWel (CZSO). In BIOMASA module, the substrate composition for average BGF is calculated as follows: (i) 68% of the energy produced is obtained from corn silage; (ii) 24% of the produced energy comes from wheat biomass; (iii) 8% of the energy produced comes from slurry biomass. The average operation time of BGF is 8 000 h/year (Anonymous 2018a). The energy yield of maize silage in the BGF has been determined empirically in the long term (Amon et al. 2007) and corresponds to about 0.44 MWhel/t green matter (fresh material (FM)).

The calculation of maize silage consumption per average MWel is following:

$$\frac{8000\ \text{h}}{0.44\ \text{MWhel}} = 18\ 182\ \text{t FM/year}$$

Considering an average 68% overall share of production, biomass consumption corresponds to 1 MWel installed:

$$18\ 182 \times 0.68 = 12\ 354\ \text{t FM/year}$$

Rounded about 12 350 t/year.

Seeds and losses. The amount of biomass used as seed and losses (SL) was, as well as the consumption for human nutrition, determined as a relative share of production (Anonymous 2018b). For analyses purposes, crops are divided into the following groups:
- Crops that are used directly and only by humans, either as raw materials for food or other products (food crops – FC);
- grain for animal feed, human nutrition and other uses – grains used as raw materials for food production, but also feeds for animals (cereals for food and feed – CFF);
- silage maize (MAIZE);
- forage crops (LIG);
- perennial grassland (PGL).

Thus, human consumption is calculated as the sum of the shares of each crop species in the group.

RESULTS AND DISCUSSION

Modeling the effect of reducing biomass production on the region's self-sufficiency. The balance

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was processed for the Czech Republic and all 13 regions. Four model regions are selected for presentation in this paper; their brief characteristics are listed in Table 1. SC and JM regions are highly productive, but animal density is relatively lower, which corresponds to the lower proportion of fodder crops on arable land. The number of BGF is lower. The JM region has a much-diversified crop production with a high proportion of cultivated fruits and vegetables. This region contains 25.5% of arable land classified as strongly erosion-endangered and slightly erosion-endangered. The VY region is largely part of ANC (areas with natural constraints), with a higher proportion of forage crops, cattle, and pigs. There is a higher density of agricultural BGF as well. The fourth model region evaluated (KH) is highly productive with highly diversified crop production; some of the farmed lands are in ANC; the proportion of erosion soils is lower (18.02%). These four evaluated regions make up almost 50% of the arable land in the Czech Republic with different climatic conditions and differing proportions of animals per ha of arable and agricultural land. Highest LU load on VY is represented by both cattle and pigs and more than 1 LU/ha of agriculture land. On the other hand, JM has the lowest total load at 0.41 LU/ha

Table 1. The production characteristics of the representative regions

	Unit	Territory (region)				
		SC	KH	VY	JM	CZ
Arable land total	(ha)	471 508	163 193	273 027	318 505	2 468 247
% CZ	(%)	19.1	6.6	11.1	12.9	100
Agricultural land	(ha)	558 770	236 531	360 716	364 191	3 560 013
% CZ	(%)	15.7	6.6	10.1	10.2	100
FC	(%)	11.9	13.2	5.3	7.0	8.4
CFF	(%)	30.1	23.1	19.7	39.0	25.2
MAIZE	(%)	9.1	11.2	13.8	10.0	10.3
LIG	(%)	9.3	11.9	19.3	9.6	11.3
PGL	(%)	6.7	16.2	14.5	3.5	16.7
BGF (installed MW)		37.4	30.0	51.4	27.8	304
Area of arable land severely or moderately threatened by erosion	(%, ha)	15.9	17.8	24.5	23.3	543 702
Cattle	(pcs)	150 607	98 298	220 052	64 678	1 415 770
% CZ	(%)	10.6	6.9	15.5	4.6	100
Cattle	(LU)	141 571	92 400	206 849	60 797	1 330 824
To arable land	(LU/ha)	0.30	0.57	0.76	0.19	0.54
To agriculture land	(LU/ha)	0.25	0.39	0.57	0.17	0.37
Pigs	(pcs)	316 763	63 563	316 819	136 968	1 557 218
% CZ	(%)	20.3	4.1	20.4	8.8	100
Pigs	(LU)	70 955	14 238	70 967	30 681	348 817
To arable land	(LU/ha)	0.15	0.09	0.26	0.10	0.14
To agriculture land	(LU/ha)	0.13	0.06	0.20	0.08	0.10
Poultry	(pcs)	4 959 820	2 780 494	602 520	3 536 790	23 572 784
% CZ	(%)	21.0	11.8	2.6	15.0	100
Poultry	(LU)	55 279	30 990	6 715	39 419	262 729
To arable land	(LU/ha)	0.12	0.19	0.02	0.12	0.11
To agriculture land	(LU/ha)	0.10	0.13	0.02	0.11	0.07

SC – Středočeský; KH – Královéhradecký; VY – Vysočina; JM – Jihomoravský; CZ – Czech republic; FC – food crops; CFF – cereals for food and feed; MAIZE – silage maize; LIG – forage crops; PGL – perennial grassland; BGF – biogas facilities; LU – livestock units

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Table 2. Production of dry matter (DM) of crops groups in Czech Republic and its modeled decrease due to climate changes (t/year)

	Crops groups	Production (DM/year)	Consumption (DM/year)					
			people	energy	seeds and losses	consumption without animals	animals	total consumption
Biomass production	Crops for food and other use	2 016 429	1 069 803	–	121 646	1 191 449	227 096	1 418 545
	Grain for feed and human nutrition and other use	6 066 996	1 448 691	377 524	396 083	2 222 297	3 028 458	5 250 755
	Silage maize	2 474 396	–	1 224 130	358 787	1 582 918	885 602	2 468 520
	Forage crops	2 722 142	–	–	188 076	188 076	2 121 324	2 309 400
	Straw	6 753 803	–	668 274	–	668 274	102 683	770 957
	Permanent grassland	4 022 045	–	–	–	0	626 239	626 239
	Total production	24 055 811	2 518 493	2 269 928	1 064 593	5 853 014	6 991 402	12 844 416

of agriculture land, including poultry. Significant differences are also in the number and performance of BGF. Overall, about the size of production areas, the highest consumption of regional biomass is the VY, the lowest density is in the SM.

Table 2 shows the total DM biomass production for the CZ. Production is calculated for crop groups based on the subsequent use of the produced biomass. The highest production corresponds to the need for grains for animal feeding and for human nutrition. Renewable energy uses mainly silage maize, and its consumption is almost 50% higher than its feeding.

Table 2 shows that in CZ the required amount of DM biomass is produced in average and in favorable years (24 055 811 tons per year). In covering the demand for food and feed materials, the situation in the Czech Republic as a whole is good, but maize is a limiting crop (Table 3). Already with 5% fall in yield, its balance is negative, and maize consumption needs to be replaced by other biomass, which is usually poorer in energy and less suitable technologically. The 20% decrease means not only the lack of maize but also the grain for feeding and forage while 30% decrease would even cause the shortage of food even though numbers of livestock and thus the consumption of some commodities have fallen significantly over the last 20 years. The decline in animal production was also reflected in the self-sufficiency of CZ in animal commodities; therefore the model also works with a possible increase of livestock numbers and, thus feed needs.

Evaluating individual regions (Table 4), the most complicated is VY, which is related to both the high density of animals and BGF. The production so far fails to meet the demand of grains to feed or of maize, implying the need to import from other regions resulting in the increased transport cost. Production decline of 10% is very risky, and in the case of 20% fall, VY would not cover the main consumers with biomass, including its production for food purposes. The opposite is the SC and JM regions, where even a 20% loss of production leads to a negative balance

Table 3. Balance or need of dry matter (DM) biomass while production decrease is modeled in Czech Republic (t/year)

	Crops groups	Standard scenario	Remaining crops in case of yield decline (DM/year)			
			5%	10%	20%	30%
Remaining biomass/standard scenario	Crops for food and other use	597 884	497 063	396 241	194 598	–7 045
	Grain for feed and human nutrition and other use	816 241	512 891	209 541	–397 158	–1 003 858
	Silage maize	5 876	–117 844	–241 564	–489 003	–736 443
	Forage crops	412 742	276 635	140 528	–131 686	–403 901
	Straw	5 982 847	5 645 156	5 307 466	4 632 086	3 956 706
	Permanent grassland	3 395 806	3 194 704	2 993 602	2 591 397	2 189 193
	Remaining total	11 211 395	10 008 605	8 805 814	6 400 233	3 994 652

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Table 4. Balance or need balance or need for dry matter (DM) biomass while production decrease is modeled in chosen regions (t/year)

Crops groups	Standard scenario (DM/year)	Remaining crops in case of yield decline (DM/year)			
		5%	10%	20%	30%
Remaining biomass/standard scenario					
Středočeský region					
Crops for food and other use	162 833	137 372	111 910	60 988	10 066
Grain for feed and human nutrition and other use	473 729	409 346	344 963	216 197	87 432
Silage maize	60 318	40 946	21 573	–17 172	–55 917
Forage crops	157 174	137 369	117 564	77 955	38 345
Straw	1 364 650	1 294 320	1 223 989	1 083 329	942 668
Permanent grassland	224 091	209 722	195 354	166 616	137 879
Remaining total	2 442 795	2 229 075	2 015 354	1 587 913	1 160 472
Královéhradecký region					
Crops for food and other use	61 164	49 939	38 714	16 264	–6 185
Grain for feed and human nutrition and other use	35 428	15 771	–3 886	–43 200	–82 514
Silage maize	–37 408	–46 905	–56 402	–75 396	–94 390
Forage crops	44 769	34 674	24 579	4 389	–15 801
Straw	175 779	155 095	134 411	93 042	51 673
Permanent grassland	233 628	219 846	206 063	178 498	150 932
Remaining total	513 361	428 420	343 479	173 597	3 715
Vysočina					
Crops for food and other use	21 222	15 183	9 144	–2 934	–15 012
Grain for feed and human nutrition and other use	–238 813	–261 165	–283 516	–328 220	–372 923
Silage maize	–64 458	–80 158	–95 858	–127 258	–158 657
Forage crops	45 396	23 426	1 457	–42 482	–86 421
Straw	545 223	513 977	482 730	420 238	357 745
Permanent grassland	245 056	228 597	212 138	179 219	146 301
Remaining total	553 626	439 860	326 095	98 564	–128 968
Jihomoravský region					
Crops for food and other use	48 029	38 791	29 554	11 079	–7 396
Grain for feed and human nutrition and other use	497 464	445 873	394 282	291 101	187 919
Silage maize	50 854	37 660	24 466	–1 922	–28 310
Forage crops	140 251	127 596	114 940	89 630	64 319
Straw	801 118	760 044	718 971	636 824	554 677
Permanent grassland	66 340	61 745	57 150	47 961	38 772
Remaining total	1 604 055	1 471 709	1 339 364	1 074 672	809 981

only for maize, but this can be relatively easily replaced by the use of biomass from PGL.

The regions' balance sheets show that the increase in livestock numbers, in particular cattle and pigs, must be differentiated taking into account regional resources and general statewide recommendations cannot be easily adopted. It is confirmed that animal numbers should be linked to the number of BGF and their long-term economic efficiency. Individual regions clearly show an unbalanced burden of the consumers (mainly livestock). Despite a significant decline in livestock production, there are regions where the feed grain balance does not cover the needs of the region, typically, the region VY, and also KH, where the representation of main pigs is significantly lower. Within CZ, the situation is similar in half of the regions, usually in those with a higher proportion of ANC areas, and soils with higher erosion risk

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(Dostál et al. 2002). Some regions show that they can effectively use PGL, which is in a strong surplus throughout the Czech Republic, so there is still the availability for meat cattle to be breed. The second way is to reduce the share of technical market crops (especially rapeseed, e.g., sugar beet (Poláková 2018), which would be suitable for the SC model region where oilseed rape representation is high (17.6%).

The most sensitive commodity concerning the self-sufficiency is the silage maize (cultivated at 222 thousand ha), its total production in CZ is 2 474 thousand tonnes DM/ha, and consumption is 2 468 thousands of tonnes of dry matter. It is evident that the total demand is covered only by a narrow margin. Its balance sheet is highly risky which is very strongly reflected in the balance of 13 individual regions. Five of them are short of the maize already in the baseline scenario. Model regions VY and KH give an example. In these regions, much more biomass from PGL or other forage has to be used. The increase in the area of this commodity is already very debatable, especially concerning the high risk of soil erosion (in the CZ, as of 1 January 2019, 23% of arable land is classified as strongly and slightly erosionally endangered) and stricter requirements of cross-compliance controls. The balance results clearly show a surplus of biomass production from PGL not only within CZ as a whole but also in individual regions. In some regions, besides silage maize, there is also a shortage of fodder production on arable land.

In regions KH and VY (Table 4), the situation is tight also in the production of feed grain. Therefore the areas of silage maize cannot be increased in these regions at the expense of densely sown cereals or maize for grain. Instead, the areas of other market crops must be reduced or, on the contrary, consumers range must not increase. We can unambiguously agree with Herout et al. (2018) that maintaining existing silage maize areas will require a wider application of soil conservation technologies. Concerning the balance of some regions, clover and alfalfa areas need to be increased to provide sufficient forage, which could lead to a higher proportion of cattle in the region. This is also very important in terms of soil erosion (Novotný et al. 2016). Perennial fodder and legumes contribute to the stabilization of soil structure and the balance of crops structure (Koukolíček et al. 2018). Increasing their area should be at the expense of market crops, especially oil seed rape. Another way is to look for new crops, for example sorghum, which better beat the drought (Paterson et al. 2009, Adamčík et al. 2016) and new technological processes for existing crops, especially soil conservation technologies (Sharafi et al. 2013), which, even with climate change, will ensure the current and above all stable production necessary for the sustainability of existing agricultural primary production.

Impact of reduction of biomass production on livestock production. When assessing the representation of selected livestock species in the Czech Republic, the highest numbers are in cattle (0.37 LU/1 ha of agricultural land), pigs (0.1) and poultry (0.07) (Green Report 2016).

In the evaluated regions, the livestock numbers differ significantly, but the highest numbers do not reach the level common in developed Western European countries. In the Netherlands, cattle numbers reach 1.99 LU/ha, for pigs 1.48 LU/ha; in Denmark, 0.68 and 0.38 LU/ha for cattle and pigs (Eurostat 2018). The higher density of farm animal per hectare of agricultural land leads to higher consumption of biomass, but also its more favorable representation on arable land (alfalfa, clover) and higher production of organic fertilizers with a beneficial effect on soil fertility.

The highest concentration of livestock is in the region VY: polygasters (0.57); monogaters (0.22), on the contrary, JM is characterized by the representation of polygastres about 0.17 and monogastres 0.17. Due to the uneven representation of individual consumers (mainly BGF animals), there is uneven consumption of biomass produced in individual regions and consequently local surplus or shortage. On average, 6.2% of grain biomass is consumed in the energy sector in, compared to VY, where consumption is more than double (14.7%) (Table 4). A greater difference is in the consumption of grain biomass by farm animals, where 49.9% is consumed in CZ and 104.6% in the VY region (Table 4). This means that the energy sector directly competes with animals. The current production of VY is not able to ensure self-sufficiency in grains. Even worse is the situation for the silage maize. Consumption of maize biomass comes to 120.5% of its production. Thus the VY region is not self-sustaining, while silage maize imports are economically demanding.

In Table 5, the possible theoretic increase of animals with the use of biomass produced in individual regions and the whole country is calculated. The calculation was made for the production of limiting crops: silage maize for cattle, grain for pigs. The calculation is made for both the current expected

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Table 5. Theoretically increase of cattle and pigs

The decline in biomass production (%)	Cattle					Pig				
	SC	KH	VY	JM	CZ	SC	KH	VY	JM	CZ
0	96 428	–59 803	–103 046	81 297	9 393	304 486	22 771	–153 496	319 742	524 634
–5	65 458	–74 985	–128 145	60 205	–188 392	263 105	10 137	–167 862	286 582	329 657
–10	34 488	–90 167	–153 243	39 112	–386 177	221 723	–2 498	–182 228	253 423	134 681
–20	–27 452	–120 532	–203 441	–3 073	–781 746	138 959	–27 767	–210 961	187 103	–255 271
–30	–89 392	–150 896	–253 638	–45 258	–1 177 316	56 196	–53 035	–239 694	120 784	–645 224

SC – Středočeský; KH – Královéhradecký; VY – Vysočina; JM – Jihomoravský; CZ – Czech Republic

production and the expected yield reduction. The results show differences between regions. While yield cuts in the SC and JM region cause problems with the availability of feed for cattle only with a significant decline in production (by 15% and 19%), in the KH and VY region, it would be necessary to increase the production of silage maize by 20% for a balance, eventually reduce its energy use. For pigs, in the SC, KH and JM regions, a smooth increase could be considered. Potential production losses in these regions cause feed shortages only after a decline of 37, 9 and 48%, respectively. The VY region is very problematic regarding grain, and already the current number of pigs means the import of grains from neighboring regions.

Figure 1 shows the regression equations characterizing the relationship of biomass production to its use for animal feeding. Equations are calculated for limiting crops for cattle: silage maize; for pigs: grains. The results show the loss of feeding for 3036–6194 pcs of cattle, by a 1% decrease in silage production. Similarly, with a 1% decrease in grain production, feeding loss for 2527 to 8276 pcs of pigs can be considered. From the regression equations, it is possible to derive the maximum possible change in production so that the feed base for the region's currently farmed animals is maintained.

Modeling the decline in biomass production about food, feed, and energy security has confirmed the food security in the Czech Republic is provided up to 20% decline in yield, but at this level, grains and silage maize are missing for animal feed. In individual regions, the situation is different. VY does not have enough own resources for animal feed and BGF operation, while the JM and SC regions can still increase cattle and pigs breeding while producing decrease by 10% and 30%, respectively.

The question of the self-sufficiency of animal production is also connected with the issue of the availability of organic fertilizers. At present, CZ is self-sufficient in the production of beef and milk, but only because of a significant decline in consumption of both commodities from domestic sources (since 1990, the consumption of beef dropped from 30 kg to the current 8 kg per capita) (CZSO). On the contrary, the small burden of cattle per unit of agricultural land is problematic compared to the Western European countries and thus also the long-term lack

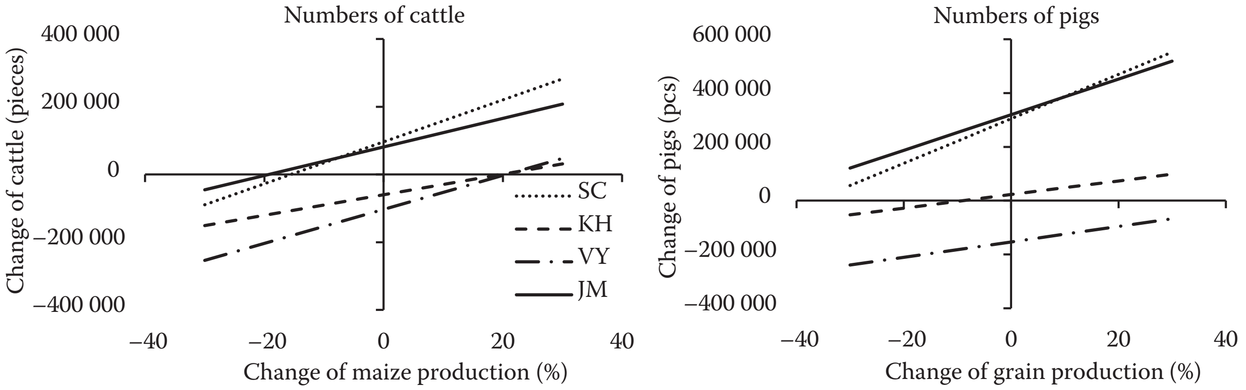

Figure 1. Parameters of regresion, dependency of production biomass change and possible increase of animals

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of manure. If the production of livestock increases, it will be reflected in the structure of crops.

Clearly risky crop is silage maize, which is used for feeding and RES, but about its growing restriction on erosion-endangered soils, further expansion of maize growing areas in both consumer-demanding regions is virtually impossible, and its energy replacement is very difficult. In these regions, it is necessary to consider the increase in clover and alfalfa, and possibly other crops suitable for feeding as well as for potential energy use.

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