GREENHOUSE GAS EMISSIONS IN THE COUNTRIES OF THE VISEGRAD GROUP: AN ANALYSIS OF SUSTAINABLE AGRICULTURE AND ENVIRONMENTAL MANAGEMENT

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Abstract

Our study analyses the greenhouse gas emission intensity of the main agricultural products in the Visegrad Four. The time interval under consideration is 2000-2017. According to the statistical calculation, the GHG emission intensity of the production of the Visegrad Group's agricultural products was similar for most of the products that we examined. In the case of lamb production and egg production, we found significant differences between the countries emission data. All countries except the Czech Republic have reduced their emissions in respect of the production of cereal products, with the same variability. We have observed a steady decline in pork production emissions in all member states except Slovakia. All countries have reduced GHG emissions intensity in terms of emissions related to the production of cow's milk.

Differences between countries can be due to the differences in the market conditions and the different structures of agricultural sectors of the four member states.

Keywords: Visegrad Four, agri-environment, emissions intensity

Összefoglalás

Tanulmányunkban számba vettük a főbb mezőgazdasági termékek üvegházhatású gáz kibocsátási intenzitását a Visegrádi Négyek tekintetében. A vizsgált időintervallum 2000-2017 közötti időszak. Statisztikai számítások elvégzését követően elmondható, hogy az országok mezőgazdasági termékeik előállításának ÜHG kibocsátás intenzitása legtöbb vizsgált termék esetében hasonlóképpen alakult. Bárányhús előállítás, valamint a tojás termelés esetében tapasztaltunk jelentősebb eltéréseket az országok kibocsátási adatai között. Gabona termékek előállítása tekintetében azonos hullámvonalak leírása mellett - Csehország kivételével- mindegyik ország csökkentette kibocsátását. Sertéshús előállításának kibocsátása tekintetében folyamatos csökkenést figyelhettünk meg - Szlovákia kivételével- minden tagország esetében. Tehéntej előállításával kapcsolatos kibocsátások tekintetében pedig kivétel nélkül mindegyik ország csökkentette ÜHG kibocsátás intenzitásának mértékét. Az országok közötti különbségekért a piaci viszonyok eltérő alakulása és a mezőgazdaság eltérő felépülése is felelős.

Kulcsszavak: Visegrádi Négyek, agrár-környezet, kibocsátás intenzitás

Introduction

Agriculture is a major emitter of gases responsible for climate change. It is important to examine the evolution of emissions in details whereas agriculture is a major cause and a victim of climate change. We examined the extent of the emissions of the gases responsible for climate change

in the framework of previous studies. We placed special emphasis on the analysis of emissions from agriculture, we dealt with the examination of the proportion of GHG emissions by agriculture per produced product. We tried to explore the correlations between macroeconomic indicators and environmental indicators in light of climate change. Being an area defined by environmental policy, we also paid attention to the policy indicator throughout the preparation of the study. The research seeks answers to the following questions: Which product is produced in the most GHG- intensive sector? How did the emissions values develop in the case of the members of the Visegrad Group? What differences and similarities can be observed?

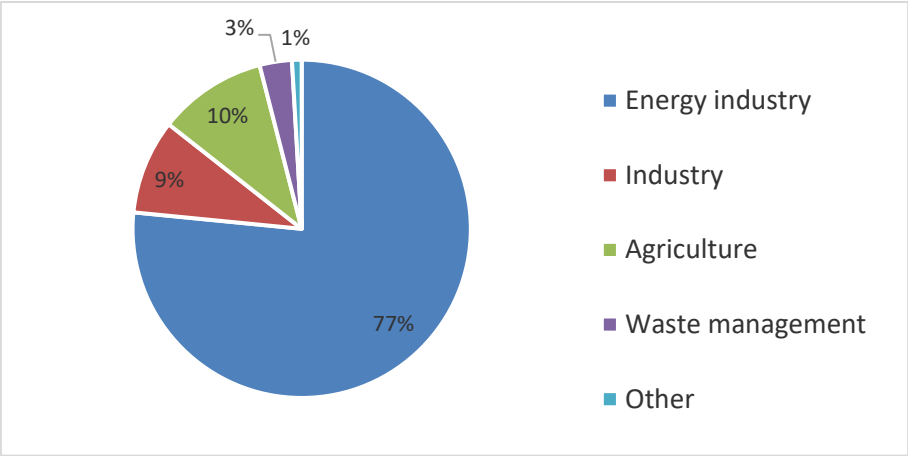

Figure 1 GHG emissions of V4s by sectors in 2018 (Source: EUROSTAT,2020)

Agriculture accounts for ~ 10% of GHG emissions (Figure 1). Agriculture GHG emissions in all member states showed a steady slow increase from 2000 to 2018, while emissions from the economy, on the whole, decreased over this period. Based on this, the role of agriculture in reducing emissions cannot be neglected.

Agriculture accounts for a 10% share of all GHG emissions. Of the greenhouse gases, the primary sector is responsible for a significant, about 80-90% of ammonia emissions. The largest emitters are livestock farming and manure management (Pogány, 2011). In addition, the

activities of these sectors are responsible for a significant part of N_2O emissions. More than that, a large part of methane emissions is due to the production of livestock sectors. By correct management and efficient disposal of emission by-products, GHG emissions can be reduced (Sárváry, 2011; Szaktudás Kiadó Ház Zrt, 2008; Hongdou et al., 2018).

An assessment of the environmental impacts of livestock production was carried out by Williams et al., in 2006. In the course of the analysis products with a detrimental effect on the environment of the entire population of rotating farm animals were taken into account. Inputs and outputs were defined for units of animal products. In their study, they listed more important environmental burden values than GHG production at CO_2 equivalent (Balogh, 2021).

In addition to livestock production, the role of crop production is also paramount, as plants also absorb and emit CO_2 during their lifetime. As well as soil being one of the largest carbon reservoirs, its proper use is essential for emission reductions (Sárváry, 2011).

The climatic effect of crop production is two-way. Due to photosynthesis, it allows the sequestration of CO_2, however, CO_2 emissions from plant respiration also occur. Furthermore, fertilizers used by crop production increase the NO_x content of the atmosphere. In addition, it indirectly contributes to air dust pollution through the use of crop-growing machines (Taylor & Entwistle, 2015) CO_2 emissions from crop production are mainly due to emissions from agricultural machinery. Nitrogen fertilizers, animal and green manure are responsible for NO_x emissions (Szabó, 2010; Foley et al., 2011).

Increasing the sustainability of agriculture and combating climate change are some of the main objectives of the CAP 2020 reform. The European Green Deal is all intended to promote safer and more climate-friendly food production through the Farm to Fork Strategy and the Biodiversity Strategy. The CAP will develop its support systems for the post-2020 period, with a focus on these. The European Commission proposes that member states allocate at least 40%

of the funding to help to green during the organization of funding for the next 2021-2030 period (European Commission, 2020).

Materials and methods

The data is accessed from FAOSTAT's database (FAOSTAT METADATA, 2021). It was carried out an examination of the GHG emission intensity of the goods included in the agri-environmental indicators. This indicator shows greenhouse gas emissions per unit of product. Data were available for a variety of agricultural products. The time interval examined was 2000-2017. The indicator is calculated and published based on FAOSTAT's data. It is defined as the quotient of production and output data. In addition to taking into account external and internal factors, it is important to note that the indicator only includes data that are produced within farms. The objective of environmental indicators is to facilitate national and regional agri-environmental trend analysis and to provide member states with reference information. In our study, we tested the products we considered most important. Our data were organized in a Microsoft Excel database manager and evaluated using statistical calculations (CV, percentage change determination, average). Furthermore, we compared the intensity of the countries' CO_2 equivalent calculated GHG emissions.

Results

We primarily examined GHG intensity emissions from crop production. The highest values for the development of emissions per kilogram of cereals were found for Poland at 0,3265 kg CO_2 per kg of cereals in 2006. While Hungary observed the lowest value for the minimum value of 0.1316 kg CO_2 eq/kg of cereals in 2005. Based on the analysis of the country averages, we calculated the highest average CO_2 intensity for Poland with 0.2598 kg CO_2 eq/kg of cereals,

followed by the Czech Republic with 0.2354 kg CO_2 eg/kg of cereals. Slovakia had an average of 0.2059 kg CO_2 eq/ kg of cereals in the time period studied, while Hungary had only 0.16695 kg CO_2 eq/kg of cereals.

The Czech Republic had the highest variability with a CV of 15.36%, followed closely by Hungary with 14.56%. Slovakia is the third with 13.04% and Poland is the fourth with 9.88%. The differences between countries are not considered significant, but the data are very volatile. In addition to variability, the Czech Republic was the only country to see an increase of +12% from 2000 to 2017. The observed increase was caused by a 115% increase in cereals and an increase in 130% emissions. By contrast Hungary (-11.11%), Poland (-5.2%) Slovakia (-7.8%)was declined. Hungary, the decrease in GHG emissions intensity is due to a 139% increase in GHG emissions with an increase of 124%. For Poland, a 129% increase in emissions was accompanied by a 136% increase in crops and a 145% increase in emissions in Slovakia, coupled with a 158% increase in crops.

During the period under review, the values of the countries showed almost the same fluctuations. In the case of this product, it can therefore be concluded that the cereal production potential of the countries has increased, but the implementation of the related cultivation and management tasks has become greener.

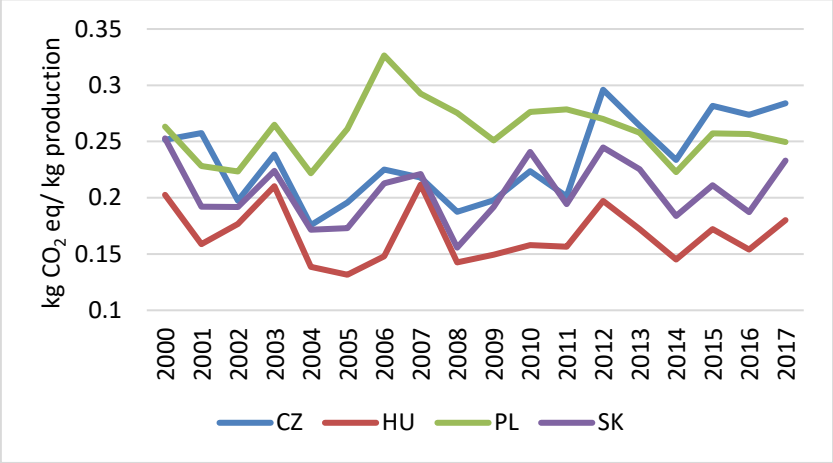

Figure 2 The intensity of GHG emission associated with cereal production without rice, kg CO_2 eq/ kg production. Source: (FAOSTAT. DATA, 2019)

We find a larger difference in the intensity of the GHG result per kilo of eggs, the Czech Republic lags far behind the trend of other member states. It produced lower values than the other member states and showed a steady decline with a minimum of 0.7073 kg CO_2 equivalent/kg of eggs in 2010. In contrast, for Slovakia, the highest emission intensity was measured at a maximum value of 1,465 kg CO_2 eq/kg of eggsin 2002. In terms of averages, Poland also has the highest value for this product at 1.1176 kg of CO_2 eq/ kg of eggs. Hungary average emissions intensity for egg production was 1.1062 kg CO_2 eq /kg of eggs, for Slovakia this value was 1.0955 kg CO_2 eq /kg of eggs, while for the Czech Republic only 0.7592 kg CO_2 eq/ kg of eggs.

The lowest variability is in Hungary with a CV of 5.33%, and the Czech Republic the second lowest with 5.73%. For Poland and Slovakia, we received higher CV results of 9.07% and 10.17%. In addition to variability, we observed a decrease from 2000 to 2017 in all countries except Hungary (+0.93%). Hungary's low growth was achieved while output decreased by -23.9% from 2000 to 2017 and product production by -23.96%. The Czech Republic reduced CO_2 eq emissions per kilo of eggs by -15.3%, Poland by -17.60% and Slovakia by -12.94%. In

the Czech Republic, the decrease was achieved by a -55% decrease in product production and a -61.9% decrease in emissions from 2000 to 2017. In contrast, for Poland, the decrease in GHG emissions intensity was achieved with an increase in emissions of 115.6% and an increase in product production of 140%. In the case of Slovakia, we also observed a decrease with increasing output (106%) and increasing product production (122%). Overall, the values of Hungary, Poland and Slovakia developed similarly, while the Czech Republic lags significantly behind them. The extremely low value of the Czech Republic is because egg production is carried out in a very extensive way than in other Visegrad countries, and the share of imports is highest in this country.

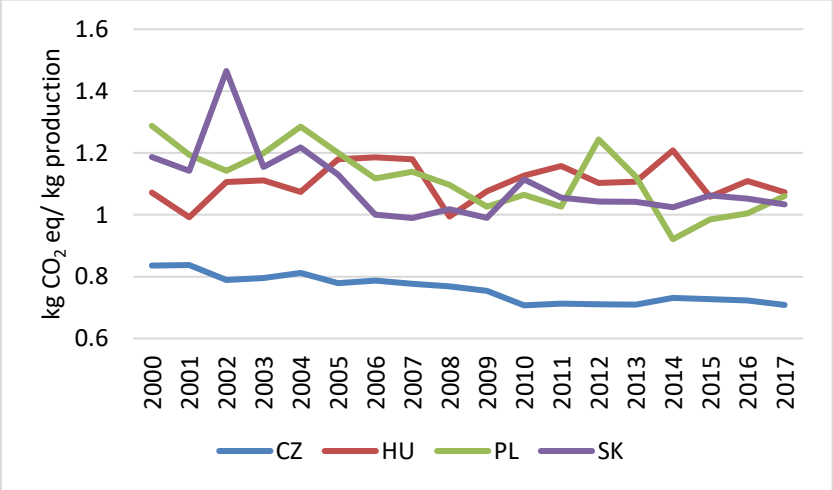

Figure 3 The intensity of GHG emissions associated with egg production, kg CO_2 eq/ kg production. Source: (FAOSTAT. DATA, 2019)

In terms of the intensity of GHG emissions per kilo of beef, the country group had similar values at the beginning of the period, followed by a significant increase in emissions per kg for Slovakia, Hungary and the Czech Republic. While in Poland we have observed a decrease. Slovakia, which grew the most, produced a maximum of 56.49 kg of CO2 eq/kg of beef by the

end of the period (2016). While the lowest value was observed for Poland with a minimum value of 12.69 kg CO2 eg / kg beef in 2017. In terms of averages, Slovakia had the highest average emissions intensity over the time period of 34.7972 kg CO2 eq/ kg of beef. The second highest value was calculated for Hungary with a value of 25,798 kg CO_2 eq/ kg of beef. For the Czech Republic, the average for this product is 22.9635 kg CO_2 eq/ kg of beef, while for Poland it is only 14.99873 kg CO_2 eq/ kg of beef. While Poland, which is on a downward trend, has added a minimum of 12.69 kg of CO_2 eq/ kg of beef for 2017 by the end of the period. In terms of their variability, Poland has the lowest CV % of 8.05%, which is significantly different from other countries.

CV of Slovakia is 16.14%, CV of Hungary is 33.77%, and CV of Czech Republic is 38.99%. 2000 to 2017 Poland reduced GHG emissions per kilogram of beef production by -20.83%, while the Czech Republic increased emissions by +57.3%, Hungary by 200.4% and Slovakia by 244.6%. Poland achieved an emission reduction of 130% and product production by 164%. The Czech Republic growth was achieved by -1.4% and product production by -37.39%. In contrast Hungary, the increase was achieved by a 126% increase in emissions and a -57% decrease in product production. Slovakia showed a decrease in product production of -78% with an emission reduction of -24.2%. The decline in the production potential of countries is greatly influenced by the shortage of domestic demand. Thus, income is driven by the evolution of the world market price.

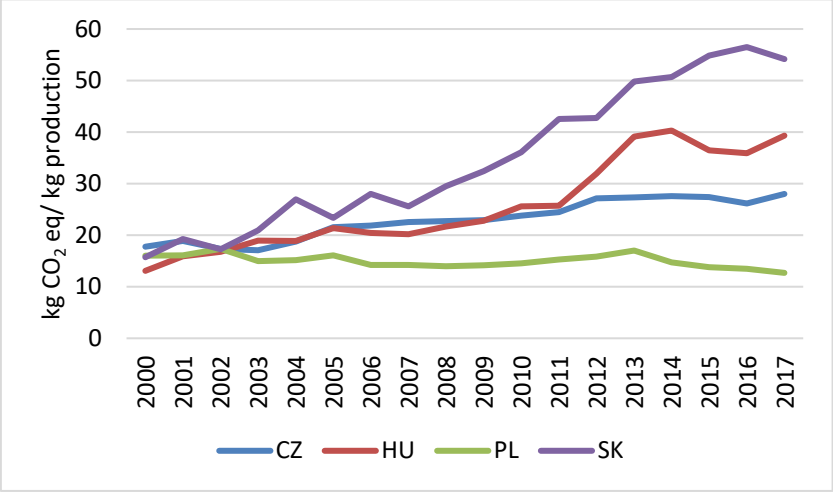

Figure 4 The intensity of GHG emissions associated with beef, kg CO_2 eq/ kg production. Source: (FAOSTAT. DATA, 2019)

As regards the production of chicken meat, Poland showed the highest emission intensity with a maximum of 0,6521 kg CO_2 eq/ kg of chicken meat in 2002. However, even the lowest value was among Poland's emission values with a minimum value of 0.033 kg CO_2 eq/kg chicken meat in 2000 . For the other member states, we have not seen such large differences. There was no significant differentiation between the averages of the countries.

The Czech Republic has an average emission intensity of 0.3848 kg CO_2 eq/ kg of chicken meat, 0.3493 kg CO_2 eq/ kg of chicken meat for Slovakia, 0.2750 kg CO_2 eq/ kg of chicken meat for Poland and 0.2679 kg CO_2 eq/ kg of chicken meat for Hungary. Observing the variability, it can be seen that Poland shows an outstanding deviation of 51.7%. While the Czech Republic was 11.54%, Hungary 18.06% and Slovakia 13.95% different from its average. Slovakia is the only country where we have observed a decrease from 2000 to 2017 by -16.65%. Slovakia's decrease was accompanied by a -5.4% decrease in GHG output and a 113.4% increase in product production. In the case of the Czech Republic (+18.8%), Hungary (+55.9%) and Poland (+594%), an increase was observed. The increase in the Czech Republic's emission

intensity was due to a -7.5% decrease in emissions and a -22.22% decrease in product production.

In the case of Hungary, the increase was accompanied by a 189.6% increase in output and a 121.5% increase in product production. In the case of Poland, with an increase in output of 2609.6%, there was an increase in product production of 375.5% from 2000 to 2017. The larger jump observed in Poland and then the decrease in the intensity of continuous emissions is caused by the switch to GMO broiler chickens production. To this day, Poland is still one of the dominant producers of chicken meat in Europe.

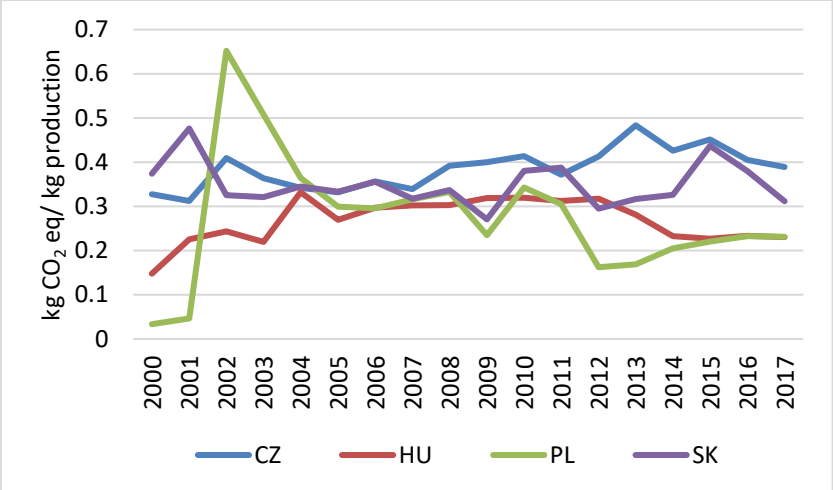

Figure 5 The intensity of GHG emissions associated with chicken meat, kg CO_2 eq/ kg production. Source: (FAOSTAT. DATA, 2019)

Concerning pork, the countries showed close values from 2000 to 2013, but from 2014 Slovakia, unlike the other countries, started to grow. The highest value for Slovakia was registered with a maximum value of 2.36 kg of CO_2 eq/ kg of pork in 2015. While the lowest value for Poland was observed at a minimum value of 1.04 kg CO_2 eq/kg of pork in 2017. In terms of averages, we did not expect large differences between countries. We calculated 1.8372

kg CO_2 eq/ kg of pork for Slovakia, 1.5499 kg CO_2 eq/ kg of pork for Hungary, 1.4816 kg CO_2 eq/ kg of pork for Poland and 1.4065 kg CO_2 eq/ kg of pork for the Czech Republic. In terms of variability, Poland has the highest difference of 17.53%, followed by Hungary the average of 12.61%. The third is the Czech Republic with a CV of 11.05% and Slovakia closes the line with a CV of 10.67%.

As already mentioned, Slovakia is the only member state where we have seen growth, from 2000 to 2017 at +5.91%. In contrast, the Czech Republic (-23.45%) Hungary (-28.85%) and Poland (-37.73%) reduced GHG emissions per kilogram of pork. Slovakia's increase in emissions intensity is due to an emission reduction of -62.4% and a decrease in product production of -64.59%. In contrast, for the Czech Republic, the decrease in emissions intensity was caused by an emission reduction of -59.5% and a decrease in product production of -47.1% Hungary's recession was accompanied by a -45.5% decrease in output and a -23.4% decrease in product production. In contrast, Poland's decrease is due to an emission reduction of -33.69% and a 106.4% increase in product production.

For all countries except Poland, the production potential of the sector has decreased due to the changed animal welfare and consumption patterns. Which also reduced the level of emissions proportionately. The constant rise in feed prices and the spread of swine fever pose additional threats to the sector in all countries. Which causes a further decrease in production and a further decrease in output in the sector.

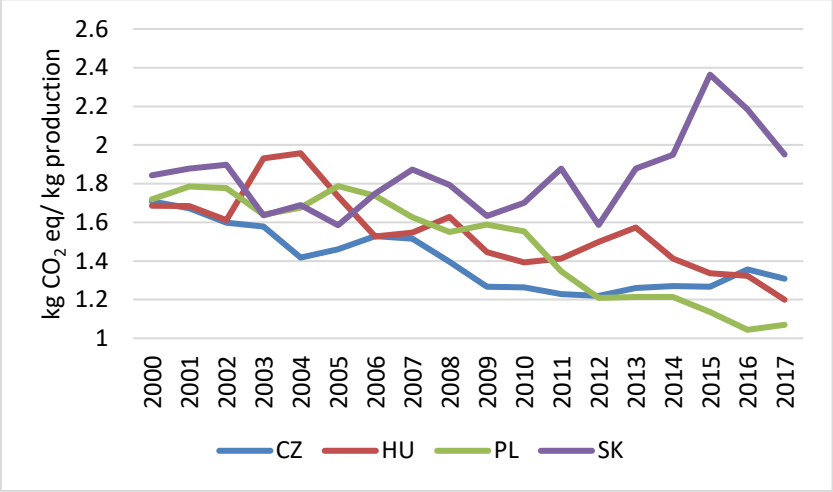

Figure 6. The intensity of GHG emissions associated with pork, kg CO_2 eq/ kg production. Source: (FAOSTAT. DATA, 2019)

In the case of the intensity of GHG emissions from lamb, we found outstanding values in Hungary. It is several times ahead of the development of emission intensities by members of the Visegrad Group of countries. The maximum value of the examined period is 537.65 kg CO_2 eq/kg lamb, which is significant in Hungary. The lowest value for the Czech Republic was 11.04 kg CO_2 eq/kg lamb. There was significant differentiation between each country. The averages were also the highest for this product.

In the case of Hungary, we calculated the highest average emission intensity with a value of 316.182 kg CO_2 eq/ kg lamb. The other member states lagged significantly behind this value, Poland averaged 68.2766 kg CO_2 eq/ kg lamb, Slovakia 48.2983 kg CO_2 eq/kg lamb, while the Czech Republic showed 17.6242 kg CO_2 eq/kg lamb. In terms of variability, Hungary CV % is the highest at 37.96%. Slovakia showed the second-highest variability with 29.03%.

The Czech Republic then deviated by 25.03% and Poland by 19.32% over the period under consideration. Hungary has significantly increased the intensity of GHG emissions per kilo of lamb production by +202.59% from 2000 to 2017. We also experienced an increase of +70%

for Slovakia. Czech Republic (-46.38%) and Poland (-38.39%) reduction was observed. Hungary increased by 132.5% due to a decrease in product production of -56.1%. In addition, for Slovakia, the increase in emissions intensity is due to an increase in emissions of 110.2% and a decrease in product production of -35.1%. The Czech Republic's decrease was caused by an increase in product production of 443.6% with an increase in emissions of 237.8%. In contrast, the recession in Poland was accompanied by a -33.65% decrease in output coupled with a 107.6% increase in product production.

The reason for the significant difference in Hungary may be the outdated livestock farming technology. Which resulted from inappropriate different genotypic mating and lack of grazing throughout the year. While in the case of Poland and the Czech Republic, the setting of successful different genotypic pairing was appropriate for pastures. In the case of Slovakia, the size of the pastures could allow the sector to develop, but the sector is struggling with a significant lack of resources, which also harms emission values.

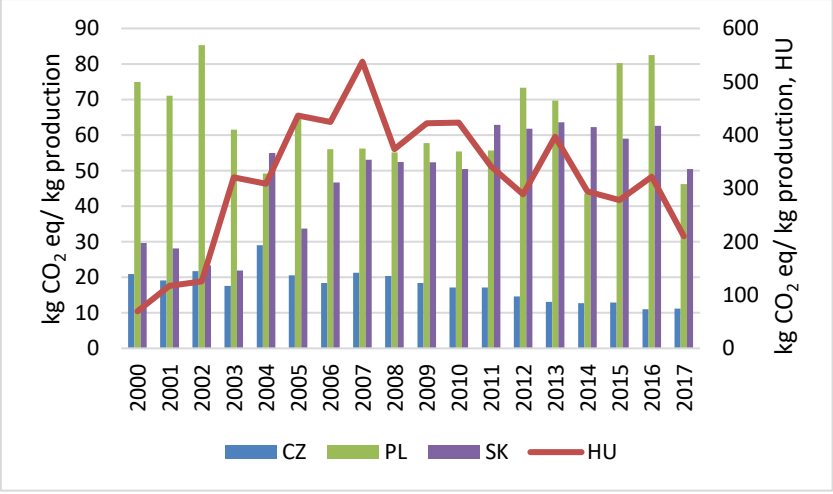

Figure 7 The intensity of GHG emissions associated with lamb, kg CO_2 eq/ kg production. Source: (FAOSTAT. DATA, 2019)

There has been a decrease in cow's milk in all countries. We have not seen any significant differences between countries. Poland showed the highest value with a maximum of 0.7497 kg of CO_2 eq/ kg cow's milk in 2000. While the lowest value was recorded for the Czech Republic with a minimum value of 0.3572 kg CO_2 eq/ kg cow's milk in 2016. Observing the bowls of countries, it can be said that there were no significant differences. The average in Poland is 0.6222 kg of CO_2 eq/ kg cow's milk, the average in Slovakia is 0.5245 kg of CO_2 eq /kg of cow's milk, Hungary average is 0.4828 kg of CO_2 eq/kg cow's milk and the Czech Republic average is 0.4300 kg of CO_2 eq/ kg cow's milk. By observing CV %, we can see that the countries have desisted from their averages by almost the same amount, with the Czech Republic by 13.40%, Hungary by 13.05%, Poland by 13.98% and Slovakia by 13.27%. From 2000 to 2017, Slovakia reduced the intensity of GHG emissions per kilogram of cow's milk by -39.59%.

Poland experienced the second-largest decrease with -37.94%. The Czech Republic followed with -33.58 and Hungary closed the line with a reduction of -27.50%. The recession in Slovakia was driven by a -47.1% decrease in output and a -12.53% decrease in product production. While in the case of Poland a -28.5% decrease in emissions, an increase of 115.18% in product production was observed. For the Czech Republic, the reduction in the intensity of emissions was achieved by a decrease of -26.4% and the production of products increased by 110.7%. Hungary's intensity of emissions showed a decrease in product production by -10.48% with an emission reduction of -35.1%. For each country, a significant decrease was observed, which is due to the development of technology

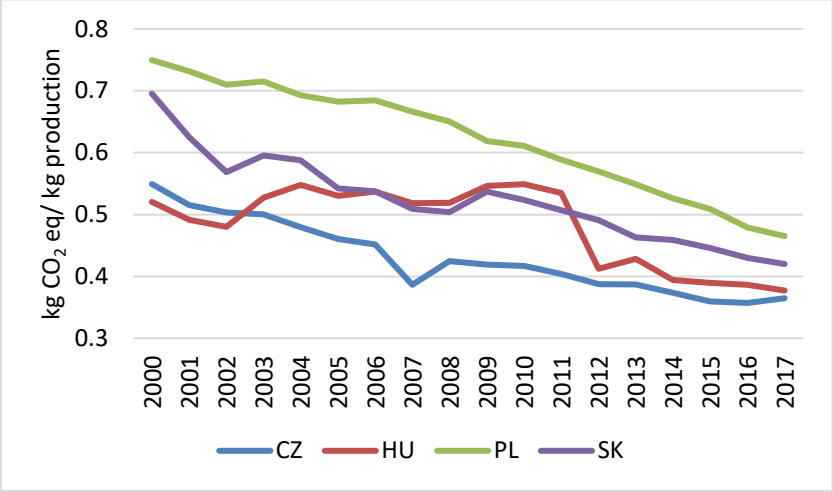

Figure 8 The intensity of GHG emissions associated with cow milk, kg CO_2 eq/ kg production. Source: (FAOSTAT. DATA, 2019)

Conclusion

Based on our studies, it can be said that prolific animal species have more favorable product production values, so intensity of the emission of GHG alterates more favorable. The highest GHG emission intensity is observed for the production of lamb. Due to the production of lamb, the high values for the annual useful production of herds, which is high in addition to the production of biomass per kilogram. Then the GHG emission intensity of beef production is also followed by a high proportion of biomass per kilogram. Pork production came in third place and egg production followed. For these products, the utility of the nutrient is more favourable and thus the intensity of GHG emissions is more favourable.

The production of cow's milk and the production of chicken meat represented similar emission intensity values. In the case of cow's milk, the low value of GHG intensity is due to the high production units, while the low value of chicken meat production is due to fertility). The lowest emission intensity was shown by the production of cereals. Furthermore, the established ranking is strongly influenced by the fact that lamb and cattle are ruminants and intestinal

fermentation, faecal formation and urination emissions make up the largest proportion of agricultural GHG emissions.

The volume of emissions by pork production came in third place because the problems of handling slurry produced by animals make a significant contribution to the totality of agricultural emissions. In the case of the production of eggs and cow's milk, there were no such high values because dairy cows' daily milk drop-off and laying eggs per day significantly exceed their emissions. The production of chicken meat does not result in significant GHG emissions due to its intensive production. The differentiation between the volume of GHG emissions of products is influenced by the specific characteristics of the products and the evolution of market conditions and is also significantly influenced by the type of farming. In the case of Poland, an increase in the production of pork, lamb and cow's milk has been observed with decreasing emissions.

As regards Slovakia, the production of chicken meat has seen an upward trend in product production, in addition to the downward trend in output. While in Hungary and the Czech Republic, it has been observed a phenomenon in terms of the production of cow's milk. In contrast, in Hungary, increased emissions in terms of beef production and lamb production and were observed in the case of the product production decreased Furthermore, for Slovakia, in the case of lamb production, we have observed a decrease in product production with increasing emissions. On this basis, it can be said that the changes in Poland were the most favourable, while in Hungary the situation proved to be rather unfavourable. Overall, there is significant potential for reducing GHG emissions in member states agriculture. The key to reducing emissions is among other things such as developing the right feed systems, supporting the transition to organic farming and encouraging farms to become more environmentally friendly.

In the next period (2021-2030), this activity incentive will be used to exploit the potential for reducing GHG emissions in agriculture.

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