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Environmental Efficiency of Agriculture in Visegrád Group Countries vs. the EU and the World

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Abstract: The production of foodstuffs for an ever-increasing population is the basic, irreducible and unalienable function of agriculture. It involves environmental impacts, including greenhouse gas emissions. This is what makes it so important to examine the levels of environmental efficiency of agriculture. As countries differ in their emission levels, it is reasonable to look for what determines them. Hence, the purpose of this study was to identify the changes in the environmental efficiency of agriculture in Visegrád Group countries and worldwide in 1961–2020. These countries share a similar economic history and demonstrate comparable environmental and geographic conditions, making it possible to pinpoint the factors responsible for how the parameters covered by the study change over time. The research used data from the FAOSTAT database. Environmental efficiency of agriculture was defined as the relationship between production volumes in kilocalories and emissions. Initially, this parameter deteriorated in the Visegrád countries, but since the late 1970s it has improved, first linked to the crisis of the socialist economy and its collapse (including a drastic decline in livestock production) and then to the implementation of CAP instruments.

Keywords: environmental efficiency; agricultural production; sustainable development; greenhouse gas emissions; environmental costs of agricultural production

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1. Introduction

The relationship between humans and the natural environment is a complex one. The Earth, together with all animated and inanimate objects, its lithosphere, hydrosphere and atmosphere, is the place where humans live, and provides essential resources for their survival [1], but also bears the consequences of externalities generated by human economic activity. These include solid, liquid and gaseous pollutant emissions which contribute to environmental degradation [2,3]. Anthropogenic environmental impacts [4] became particularly severe after the industrial revolution, which intensified the production of goods [5]. Today's major problems include climate change driven by anthropogenic greenhouse gas emissions [6,7]. Increasingly common extreme weather events [8,9] raise concerns because of how frequent and widespread they have become around the globe and because they adversely affect the wellbeing of societies and ecosystems [10,11]. Moreover, the risk of climate change has a negative impact on the global economic system [12–14].

In the mutual relationship between the environment and the economy, the economy depends on the environment and its resources while it knocks the environment out of balance due to human economic activity [15–18]. However, as the main goal of economic development is to improve the quality of human life [19], it is reasonable to believe that continuous human development and activity are essential and indispensable parts of social life. Nevertheless, note that today the quality of life is also viewed as the ability to live in a clean and safe environment. Therefore, measures taken to reduce anthropogenic environmental impacts while maintaining the levels of production efficiency currently represent the biggest challenge faced by today's world, by the economy and by economics as a science. This is especially true for agriculture. As a sector, it produces essential goods intended for non-postponable consumption, and its production volume strongly depends on the quality and sustainability of environmental parameters [20–22].

Agricultural greenhouse gas emissions have been a topic of interest to a number of researchers for some time [23–27]. Agriculture, as well as the whole agri-food sector (due to the nature of its production), greatly contributes to greenhouse gas emissions [28,29]. According to estimations, agriculture is accountable for more than 80% of anthropogenic N_2O emissions and 70% of anthropogenic NH3 emissions (mostly generated by animal excrements and the use of non-organic fertilizers) as well as ca. 40% of anthropogenic CH4 emissions (mostly caused by enteric fermentation) [30]. The total share of agriculture in greenhouse gas emissions is ca. 22% [31]. However, the estimates may differ slightly due to the method of calculating the agricultural share. For example, differences can be influenced by the inclusion of energy consumption in the estimates or the addition of food production steps, such as food processing, transportation and packaging.

Environmental degradation driven by agriculture is mostly due to the intensification of agricultural production, which leads to an environmental disequilibrium [32,33]. However, currently, agricultural development driven by technological advancements has an effect on improvements to both the productivity [34,35] and environmental efficiency of agricultural production [36]. Greenhouse gas emissions from agriculture cause climate change, which, in turn, is of major importance to agricultural productivity [37].

Hence, it is important that farms take measures intended to contribute to environmental enhancement [28–40]. However, combating climate change cannot pose a barrier to increasing food production volumes [41]. As noted by Staniszewski and Matuszczak [42], that trend could be referred to as 'sustainable agricultural intensification' [43], which means making more efficient use of resources while reducing human impacts on the environment. Therefore, the solution is to improve environmental efficiency, i.e., to produce a greater quantity of goods (in this case, food) while having an increasingly smaller environmental footprint [44,45]. Thus, the environmental efficiency of production may be defined as the ratio between the output (production) and the input (environmental cost). In this paper, production volume (output) means the amount of kilocalories produced by the agricultural sector, whereas the input corresponds to the amount of greenhouse gases generated by it.

Agricultural emissions can be reduced by the market mechanism or through informed political decisions. Farmers, just like all other economic operators, seek the maximization of economic effects (mainly incomes), and do so using methods that minimize the cost-intensity of production [46]. The reduction in harmful emissions, including greenhouse gases, is somehow a secondary effect of a successive reduction in the material and energy intensity of production. This is where the general social and private interests go hand in hand. Nevertheless, giving regard to the importance of the threats, it is necessary to take political measures, too. In the European Union, these measures include either offering financial support or imposing limitations and restrictions. For instance, the assumptions behind the MacSharry reform of the 1993–2000 Common Agricultural Policy alone included agricultural extensification and a reduced use of chemical fertilizers [47]. Today, it is clear that these plans were too general and needed further clarification. The EU's most recent strategy, the European Green Deal, emphasizes the need for reducing environmental pollution caused by agricultural production [48,49].

The agricultural problems discussed above are also witnessed in countries of the Visegrád Group (V4) composed of the Czech Republic, Hungary, Poland and Slovakia. In the context of the topics addressed in this paper, they characteristically share a common economic history, which includes the real socialism period in 1944–1990, the post-1990 political transformation and joining the EU in 2004. All of these groundbreaking events had at least a potential impact on the technical and environmental parameters of agricultural production. They strongly differed from EU-15 countries in development levels and agricultural production performance (including incomes, labor productivity and other productivity ratios) [50,51]. Also, V4 countries were undergoing a political transformation that significantly affected their development. Technically, the V4 group has existed since 1991 [52]. Following the of dissolution of Czechoslovakia into two independent states, the Czech Republic and Slovakia, in 1993, it has been functioning as a union of four countries [53]. Its creation was a clear sign of its members starting to rebuild their relationships with Western countries [54] and of their commitment to socioeconomic growth and development.

The importance of agriculture and its evolution in Visegrád Group countries is discussed by scientists such as Bozduman [55]; Czyżewski and Michałowska [56]; Firlej and Kubala [57]; and Svatoš and Smutka [58]. In the context of the ongoing climate change, it is also important to examine the relationship between environmental efficiency and agricultural production.

2. Materials and Methods

The study was carried out for Visegrád Group countries. The results were compared to EU-15 members, all EU countries and the world as a whole (147 countries with a population of more than 1 million, subject to data availability).

EU-15 refers to all Union members until 2004. Comparing them against the Visegrád Group is all the more important since they have a longer track record in EU structures and demonstrate high levels of economic development. In turn, the European Union as a whole is a Europe-wide benchmark for changes in specific parameters in the Visegrád Group countries covered by this study. Similarly, taking account of worldwide trends was a way to indicate the particularities of these countries in terms of variables relating to agricultural production and its environmental impacts.

In the case of relative indicators, the following algorithm was used:

$$\mathrm{Cb} = \frac{\sum_{t=1}^{n}\sum_{i=1}^{n} CZ1}{\sum_{t=1}^{n}\sum_{i=1}^{n} CZ2} \tag{1}$$

where

Cb: feature covered by the analysis;

i: countries;

t: decades from 1961 to 2020;

*CZ*1: first factor which defines the feature under consideration (e.g., agricultural energy production volume, emission of agricultural gases);

*CZ*2: second factor that defines the feature under consideration (e.g., agricultural land area, population).

The study relied on FAOSTAT data for the years 1961–2020. The study adopted a long-term approach and covered all years where data were available because changes in the economy itself and in its environmental impacts take place over relatively long periods. Moreover, during the study period, Visegrád countries witnessed two key events which at least potentially had a determining effect on the phenomena considered. The first one was the downfall of real socialism, and the second was them joining the European Union.

The study was conducted in two stages. The first included determining the environmental efficiency of agriculture in Visegrád Group countries vs. the country groups identified above.

Since this paper aimed to identify the environmental efficiency of agriculture, two basic measures were used in the study:

- the amount of agricultural GHG emissions;
- agricultural production volume in terms of energy.

This paper defines efficiency in a classical way as the relationship between outputs and inputs; outputs mean the amounts of energy produced, whereas inputs are the quantities of greenhouse gas emissions.

The first abovementioned metric, which determines the climate and environmental costs of agricultural production, was retrieved directly from the FAOSTAT database.

The production volume was presented as the number of kilocalories produced by agriculture. This approach was motivated by the fact that its basic, necessary and irreducible function is to provide human bodies with energy. Furthermore, energy is measured in an objective way, and its actual value is invariant over time, unlike financial figures. Thus, it is possible to convert the entire agricultural (crop and livestock) production into a single universal unit [36,59–61]. However, as these figures are not published in public statistical databases, they were estimated using the following original method:

$$\sum \text{Ew} = \sum_{i=1}^{n} Es_i \times P \times W_i \quad (2)$$

where

Ew: amount of energy derived from agricultural production (kcal per year);

Esi: average energy consumption of agricultural product i (kcal per capita per year);

P: population;

Wi: food self-sufficiency ratio for product *i.*

$$\text{Wi} = \frac{P_i}{Z_i} \quad (3)$$

where

Pi: production volumes of product *i* (tons per year);

Zi: domestic consumption of product *i* (tons per year).

Food balance data were calculated for each product group listed below in accordance with FAO's methodology as per the following formulas. Next, it was used in estimating the metrics referred to above (items used in estimating the amount of energy produced are marked in bold).

domestic supply quantity =
production +
imports +
stock variation –
exports

The daily kilocalorie intake for plant and animal products was retrieved from the following databases: Food supply–crops primary equivalent and Food supply–livestock and fish primary equivalent.

The list of products used in this study covers all aggregates of agricultural produce included in the FAOSTAT database, making it possible to determine the volume of agricultural production measured in kilocalories.

The second stage of this study included indicating the amounts of agricultural greenhouse gas emissions relative to the population and to the area of agricultural land. Additionally, the study determined the consumption volume of mineral fertilizers as, on the one hand, the metric of production intensity, and, on the other, a proxy of how it impacts the environment (next to agricultural greenhouse gas emissions). Similarly, livestock stocking rates were also considered as a predictor of structural change in V4 agriculture and an important factor influencing emissions.

The results are presented in a graphical form as linear graphs spanning over a nearly 60-year period. This is due to the need to pinpoint the changes in the relevant phenomena and to show the Visegrád Group countries in relative terms against other groups which were used as benchmarks.

3. Results and Discussion

Due to a number of national and international regulations which require countries to reduce human impacts on the environment in all aspects of production activities, negative environmental costs of human activity can be reasonably expected to go down [62]. In particular, the regulations are related to greenhouse gas emissions because their effects are of a transboundary nature and lead to climate change, which determines a series of complex and intensive transformations. These, in turn, entail multi-factor combinations of stress [63], such as extreme weather events, the decline in biodiversity or hydrological imbalance [64–67]. The global goals for environmental changes were set out by the Kyoto Protocol, the Paris Agreement and the 2030 Agenda adopted in 2015, without limitation [68–71]. In Europe, an important strategic document is the European Green Deal (EGD) [72,73]. The environmental goals for the agricultural sector—a major source of GHG emissions—are set out in a number of documents, including the Common Agricultural Policy (CAP), which has been received more than one-fourth of the budget for combating climate change since 2013 [74], and the EGD, which lays out the reduction objectives and specifies the measures to be taken to reduce human environmental impacts of agriculture, e.g., through projects such as Farm to Fork or Sustainable Value Chains [72].

Irrespective of informed political decisions, enhancements in environmental efficiency are also fueled by the market mechanism [75], which forces competitors to improve the ratio between production costs and volumes [76]. Obviously, the objective of businesses and farms is to increase economic effects and become more competitive. However, the use of increasingly more material and energy-efficient productive inputs also contributes to improvements in environmental efficiency [77,78], which are somehow a secondary effect. It is clear that the ability to use efficient technologies is made possible by consistent scientific and technological progress spanning a number of agricultural aspects.

As expected, both globally and in all the considered groups, there has been a decline in GHG emissions per 1000 kcal (Figure 1), which means that the environmental costs of agricultural energy production are following a downward trend and that environmental efficiency is on the rise. At the beginning of the study period, the highest and the lowest environmental costs of agricultural energy production were recorded in EU-15 countries and in the Visegrád Group, respectively. A downward trend was witnessed in the following years. Only the Visegrád Group saw an increase in GHG emissions per 1000 kcal in the late 1970s/early 1980s. It could have been caused by the development of conventional agriculture and by the so-called green revolution [79], which involved agricultural mechanization and the consumption of large amounts of resources, fossil fuels, fertilizers and pesticides [80]. In Eastern Bloc countries, this was due to socialist assumptions, among other factors, and was the result of large-scale state-owned farms growing in importance. In the V4 countries, gradual improvements in environmental efficiency have been noticeable since the late 1970s, more than 10 years before the collapse of real socialism. Since then, environmental cost-intensity has been falling systematically and more quickly than in other groups of countries. The decade of the 1980s was the beginning of the crisis of the socialist economy, including influences in the agricultural sector. Since then, there has been a slight decrease in livestock density and stagnation of agricultural energy production. More significant decreases were recorded in the decade of the 1990s, i.e., after the collapse of the socialist economy, for both livestock density and fertilizer consumption. Initially, the reduction in environmental cost-intensity was associated with a simultaneous decline in the production results of the V4 countries. Nevertheless, since the beginning of the 21st century (and especially after the accession period), an increase in production volumes has been seen, despite the fact that livestock densities have consistently remained low, even below the world average. At the same time, the process of improving environmental performance was continuing.

Finally, Visegrád Group countries reported the smallest environmental costs in the last period covered by the study, with only ca. 0.5 kg CO_2 eq. of emissions per 1000 kcal of energy produced (vs. nearly 0.8 kg CO_2 eq. in EU-15 countries and more than 0.7 kg CO_2 eq. globally). The study suggests that the environmental costs of producing agricultural energy differ between the country groups that were considered. Moreover, as noted by Poor and Nemecek [81], the environmental costs of producing the same commodities are largely volatile and may differ 50 times between manufacturers of the same product. This explains the variation in environmental efficiency between groups of countries dealing with such different economic and environmental conditions and coming from different political pasts.

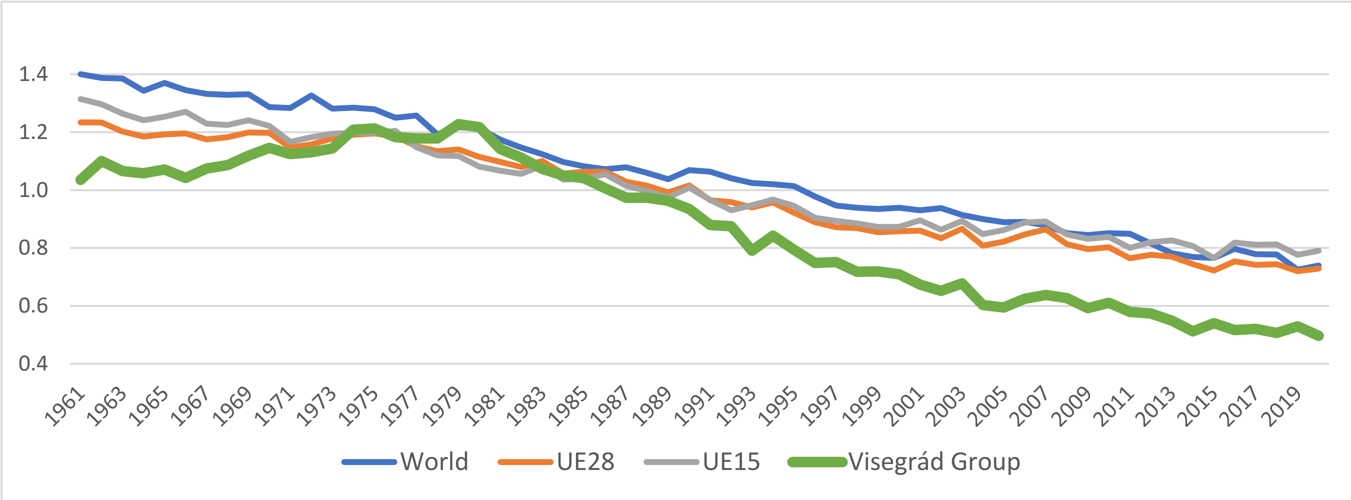

Figure 1. Environmental costs of agricultural energy production (kg CO_2 eq./1000 kcal). Source: own calculation based on www.faostat.fao.org (accessed on 5 February 2024).

At the global level, the growing demographic pressure was among the driving forces behind the steadily growing amount of greenhouse gases per hectare (Figure 2). Due to the abovementioned agricultural industrialization, it was also the case for European countries until the early 1990s. However, the later part of the study period saw a slight decline in agricultural GHG emissions per hectare of utilized agricultural area (UAA). It was particularly noticeable in V4 countries, which can be explained by a turbulent economic transformation following the downfall of communism, or even a little earlier. The privatization of farms resulted in attracting greater attention to a reduction in production costs. Furthermore, the political transformation took place in the context of an economic crisis, which naturally forced the post-socialist countries (including V4 members) to extensity production. In EU-15 countries, the situation was slightly different. After 1990, they recorded a relatively small decline (but had the greatest emissions volume per hectare of all groups anyway). However, in these countries, growth in emissions was stopped because of political measures rather than economic factors. Indeed, that period saw the adoption of environmental regulations provided for in the MacSharry Reform of the Common Agricultural Policy (including a reduction in the use of chemical fertilizers) [47], which considerably contributed to preventing further growth in emissions. After 2000, European countries saw only modest changes in the levels of greenhouse gas emissions. Note, however, that the lowest emissions per hectare were recorded in the Visegrád Group countries. Their volumes were much smaller than those in other groups of European countries covered by this study, despite being similar in the 1970s [82].

Plant protection products and fertilizers used in agriculture are one of the major sources of agricultural GHG emissions. However, their usage strongly differs between countries and crop types. The consumption of fertilizers and pesticides varies from 1 kg of nitrogen per hectare in Uganda to 300 kg of nitrogen per hectare in China [81]. Hence, the necessary condition for making agricultural production sustainable is to find the optimal balance between using plant protection products and fertilizers and keeping a satisfactory level of productivity that is sufficient to feed more than 8 billion people around the world [83]. This is all the more urgent since the global population is forecasted to exceed 10 billion by 2050. Thus, is it necessary to adapt to the growing population in the context of climate change [84], which may become less and less beneficial to productivity. The intersecting challenges [85] related to environmental protection, adapting to climate change, the growing population and the need to ensure food security must be tackled by different branches of science, including economics, agriculture, ecology and law [73]. Research carried out so far suggests that all groups of European countries experienced growth in NPK consumption starting in the early 1960s (Figure 3). After 1990, there was a clear reduction in NPK volumes in V4 countries. This was due to the abovementioned crisis that accompanied the political transformation, including changes in ownership within agriculture itself. EU-15 members also witnessed a decline, yet at a slower rate. It could be explained by the new structure of the CAP following the MacSharry reform and by successive scientific and technological enhancements. Over the following years, the Union saw a fluctuation in NPK consumption levels, and the trend differed between country groups. After 2000, there was a slight reduction in NPK consumption in EU-15 countries, especially in 2009, for reasons which included the global crisis and fluctuations in fossil fuel prices. Ultimately, NPK consumption in the last period was similar to that recorded in the initial period. After a decline in the late 1980s/early 1990s, Visegrád Group countries saw a gradual increase in NPK levels; as a consequence, NPK consumption in the last period was more than double the amount they reported in the early 1990s. This was due to the stabilization in ownership and production conditions following the political transformation and to the opportunities brought by European Union membership. In this context, an important role was played by their eligibility for support under the first and the second pillars of the CAP and by their participation in the single EU market. According to Sadowski and Antczak [86], Polish farms allocate most of the funds they derive from direct payments to financing the purchase of productive inputs, including mineral fertilizers. Globally, there is a continuous growth trend resulting from the intensification of agricultural production that is fueled by demographic pressure.

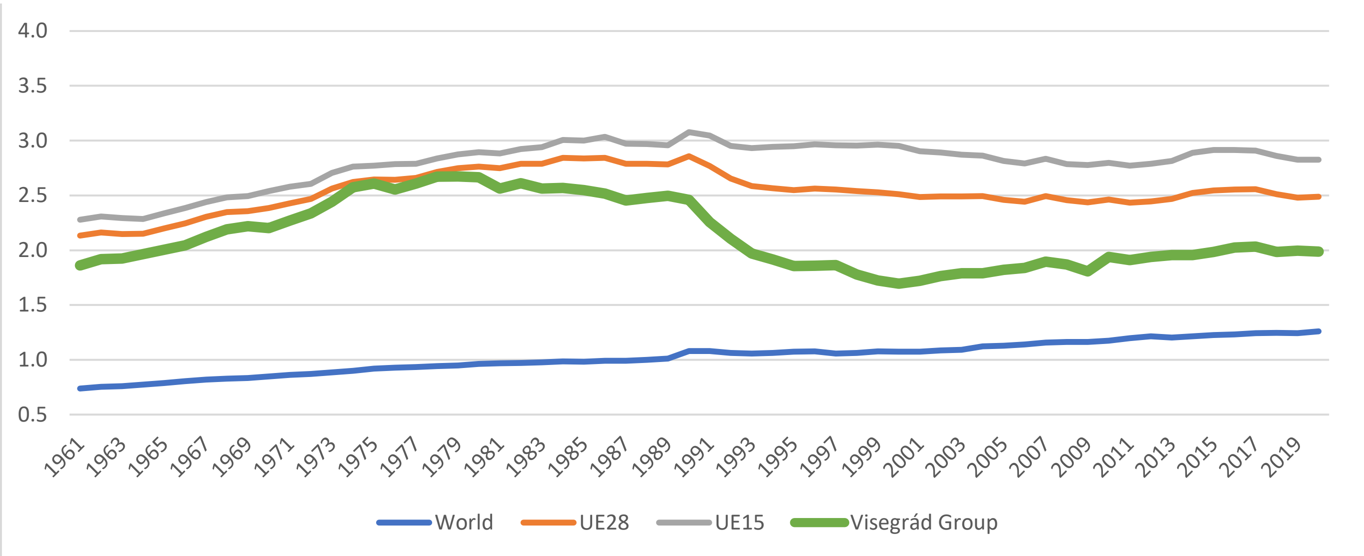

Figure 2. Agricultural emissions (t CO_2 eq./ha UAA). Source: own calculation based on www.faostat.fao.org (accessed on 5 February 2024).

In the initial period, the animal density in the V4 countries was at a level similar to that of other European countries (EU-28 and EU-15) and much higher than the world average (Figure 4). The crisis of the socialist economy, especially its collapse in the late 1980s, led to a dramatic decline below world level. Initially, the cause was the collapse of state and cooperative farms where animal production was concentrated. However, unlike in the case of fertilizer consumption, after accession there was no increase, but rather stagnation at a low level. This situation was caused in part by the increase in the capital intensity of production as a result of the introduction of EU standards. Animal production therefore moved to countries with surpluses of capital in relation to land

and labor resources. The economic essence of animal production is to add value to crop production. The reduction in livestock density had a negative impact on the situation of the entire agricultural sector of the V4 countries. At the same time, however, a reduction in the environmental cost of agricultural production was recorded. The temporal coincidence of the decline in animal stocking, expressed as livestock units (LUs), (Figure 4) and the improvement of environmental efficiency (Figure 1) should be noted. If the importance of animal production for greenhouse gas emissions is taken into account, it can be assumed that there is a cause-and-effect relationship between both phenomena.

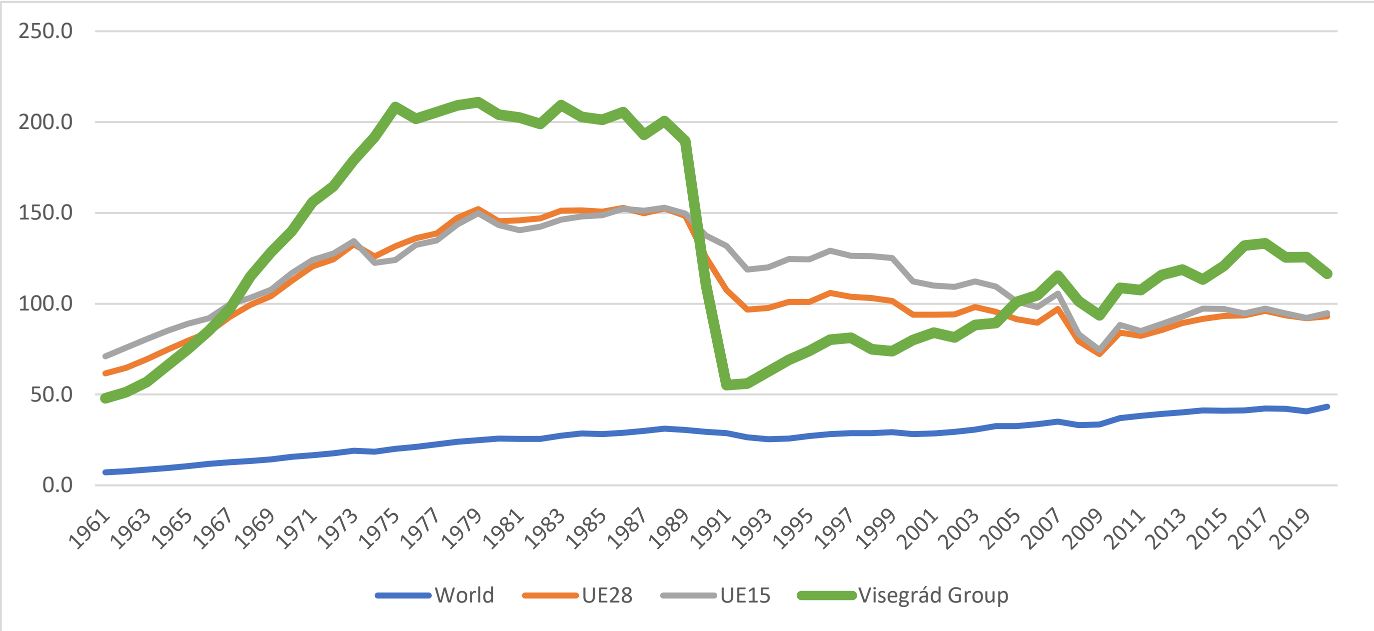

Figure 3. NPK consumption (kg/ha of agricultural land). Source: own calculation based on www.faostat.fao.org (accessed on 11 February 2024).

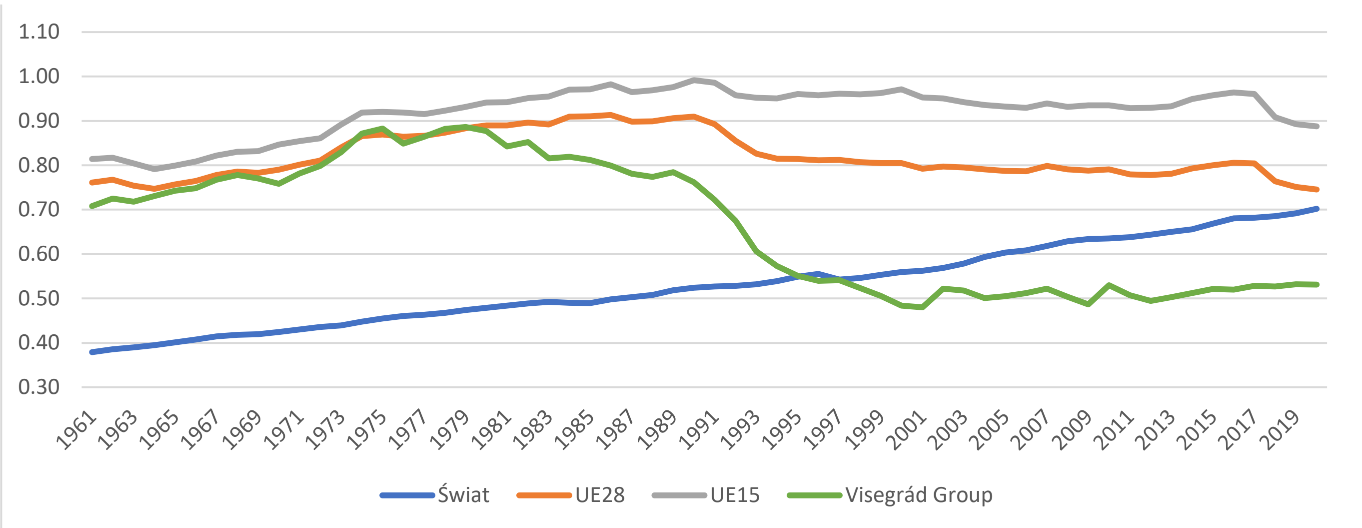

Figure 4. Livestock density (LU/ha of agricultural land). Source: own calculation based on www.faostat.fao.org (accessed on 11 February 2024).

Interestingly, despite the reduction in GHG emissions, all groups under consideration saw an increase in production (measured in thousand kcal per hectare of agricultural land) over the study period (Figure 5). A slight temporary decline in productivity was experienced in European countries after 1991, and was particularly pronounced in Visegrád Group countries. It was caused by the downfall of communism, accompanied by a general economic downturn (stagnation is already apparent in the 1980s). Production growth restarted after 2000; the stabilization that followed in the 2010s was mostly due to the accession of Visegrád Group countries to the EU. Integration with global markets increased the trade volume, which also had a boosting effect on productivity [87]. At the global level, productivity followed a slight upward trend throughout the study period.

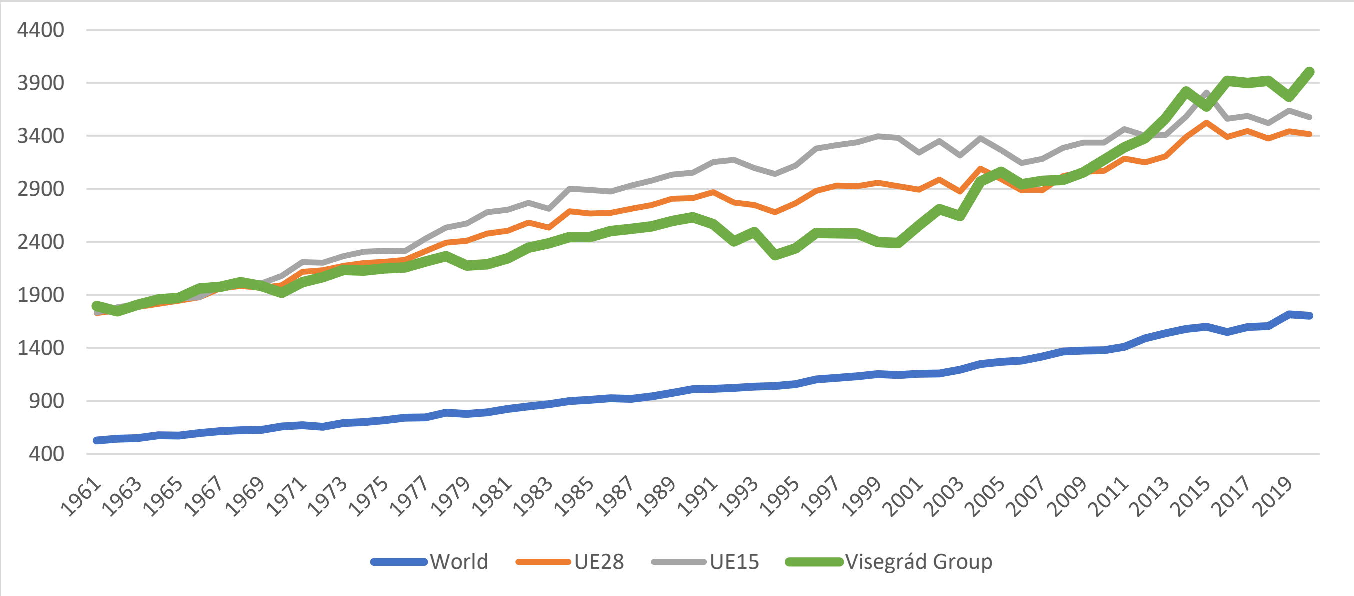

Figure 5. Agricultural energy production (thousand kcal/ha UAA). Source: own calculation based on www.faostat.fao.org (accessed on 16 February 2024).

4. Conclusions

Today's agriculture faces two challenges that contradict each other. The first one is to provide enough food for the ever-growing population, whereas the second regards reducing environmental and climate pressures. Furthermore, the sector is sensitive to both positive and negative political impulses. The countries of the Visegrád Group presented in this paper are located in Europe, which, in addition to having good natural and geographic conditions, also enjoys high levels of economic development. For about half of the study period, the specificity of the Visegrád Group countries resulted from them being dominated by the socialist system, in which the agricultural sector was mostly composed of (usually large) state-owned and cooperative farms, with the sole exception of Poland. The need to address the demand for food is what focused country-level agricultural policies on production growth fueled by industrial productive inputs, including fertilizers. Therefore, between the 1960s and the 1970s, the environmental efficiency of production (calculated as the relation between greenhouse gas emissions and production expressed in kcal) in that group deteriorated against other country groups, both in Europe and globally. Indeed, although Visegrád Group countries had the best parameters at the beginning of the study period, the levels they recorded in the 1980s were similar to those found in other aggregates. The downfall of real socialism was a breakthrough event which took place in the context of an economic crisis and changes in agricultural ownership, causing a considerable decline in the use of fertilizers and a stagnation of agricultural energy production (calculated in kcal). Some symptoms of this phenomenon were even noticeable as early as the 1980s, i.e., at a time when the socialist economy was breaking down. That moment marks the beginning of improvements in environmental efficiency in these countries. Initially triggered by historically driven agricultural extensification, that trend later became the consequence of implementing the assumptions behind the Common Agricultural Policy. However, these improvements are not only specific to V4 countries, as similar phenomena took place in all country groups used as benchmarks. Nevertheless, the accession to the EU marks another milestone for Visegrád Group countries. In 2020, a number of factors—including support for agricultural modernization and being part of the single market—resulted in V4 countries demonstrating the best environmental efficiency (compared to other groups covered by this study), just like in the early 1960s, despite the growth in production volumes and the increased use of fertilizers.

Changes in the environmental cost-intensity of the V4 countries lead to one more conclusion. Improvement has been taking place since the beginning of the 1980s, but the reasons were different in subsequent historical periods. Initially, it was a side effect of the crisis, production stagnation and reduced animal livestock density. This was contrary not only to the economic interests of the countries themselves, but also to the need to produce food for the growing population. The later period, before and especially after accession to the EU, is the time of participation in the CAP. Support instruments and legal regulations allowed for a simultaneous increase in production and further reduction in environmental costs. This state of affairs may be an indication for future agricultural policy, which should simultaneously pursue nutritional and climate–environmental goals. Above all, solutions should be found in more innovative production, taking into account not only economic but also environmental effects. In addition, there is a need to develop effective support instruments that encourage farmers to take environmental considerations into account in their decisions. The study was based on data relating to estimated agricultural energy production and its environmental costs. Although these were large aggregates determined at the level of countries over a long period of time, they allowed for the correct identification of the state and dynamics of the analyzed phenomena.

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References

1. Nwankwoala, H. Causes of Climate and Environmental Changes: The Need for Environmental-Friendly Education Policy in Nigeria. *J. Educ. Pract.* **2015**, *6*, 224–234.
2. Maurya, P.K.; Ali, S.A.; Ahmad, A.; Zhou, Q.; da Silva Castro, J.; Khane, E.; Ali, A. An Introduction to Environmental Degradation: Causes, Consequence and Mitigation. *Environ. Degrad. Causes Remediat. Strateg.* **2020**, *1*, 1–20. [CrossRef]
3. Akbulut, A. Environmental Degradation as a Security Threat: The Challenge for Developing Countries. *Int. J. Hum. Sci./Uluslararası İnsan Bilim. Derg.* **2014**, *11*, 1227–1237. [CrossRef]

4. Seneviratne, S.; Nicholls, N.; Easterling, D.; Goodess, C.; Kanae, S.; Kossin, J.; Luo, Y.; Marengo, J.; McInnes, K.; Rahimi, M.; et al. Changes in climate extremes and their impacts on the natural physical environment. In *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*; Field, C.B., Barros, V., Stocker, T.F., Qin, D., Dokken, D.J., Ebi, K.L., Mastrandrea, M.D., Mach, K.J., Plattner, G.-K., Allen, S.K., et al., Eds.; A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC); Cambridge University Press: Cambridge, UK; New York, NY, USA, 2012; pp. 109–230.
5. Panayotou, T. Economic Growth and the Environment. In *The Environment in Anthropology*, 2nd ed.; New York University Press: New York, NY, USA, 2020; Volume 14, pp. 140–148. [CrossRef]
6. Stern, N. *The Economics of Climate Change*; Cambridge University Press: Cambridge, UK, 2007. [CrossRef]
7. Mohsin, M.; Rasheed, A.K.; Sun, H.; Zhang, J.; Iram, R.; Iqbal, N.; Abbas, Q. Developing Low Carbon Economies: An Aggregated Composite Index Based on Carbon Emissions. *Sustain. Energy Technol. Assess.* **2019**, *35*, 365–374. [CrossRef]
8. Pradhan, P.; Seydewitz, T.; Zhou, B.; Lüdeke, M.K.B.; Kropp, J.P. Climate Extremes Are Becoming More Frequent, Co-Occurring, and Persistent in Europe. *Anthr. Sci.* **2022**, *1*, 264–277. [CrossRef]
9. Mika, J. Weather and Climate Extremes in Light of the IPCC SREX (2011) and beyond. In *Aerul şi Apa: Componente ale Mediului (Air and Water: Environmental Components), Proceedings of the International Conference, Cluj-Napoca, Romania, 23–24 March 2012*; Pandi, G., Moldovan, F., Eds.; Presa Universitară Clujeană: Cluj-Napoca, Romania, 2012; pp. 25–32.
10. Zhou, S.; Yu, B.; Zhang, Y. Global Concurrent Climate Extremes Exacerbated by Anthropogenic Climate Change. *Sci. Adv.* **2023**, *9*, eabo1638. [CrossRef]
11. Weiskopf, S.R. Climate Change Effects on Biodiversity, Ecosystems, Ecosystem Services, and Natural Resource Management in the United States. *Sci. Total Environ.* **2020**, *733*, 137782. [CrossRef] [PubMed]
12. Wade, K.; Jennings, M. The Impact of Climate Change on the Global Economy. *Schroders Talking Point*. 2016. Available online: https://mybrand.schroders.com/m/01053abe732aa4a1/original/The-impact-of-climate-change.pdf (accessed on 8 November 2024).
13. Batten, S. *Climate Change and the Macro-Economy: A Critical Review*; Working Paper 706; Bank of England: London, UK, 2018. [CrossRef]
14. Gavazzi, P.; Dobrucka, R.; Haubold, S.; Przekop, R. The impact of climate change on selected areas of the world economy. *Res. Enterp. Mod. Econ. Theory Pract.* **2023**, *1*, 4–16. [CrossRef]
15. Costantini, V.; Monni, S. Environment, Human Development and Economic Growth. *Ecol. Econ.* **2008**, *64*, 867–880. [CrossRef]
16. Meinshausen, M.; Meinshausen, N.; Hare, W.; Raper, S.C.B.; Frieler, K.; Knutti, R.; Frame, D.J.; Allen, M.R. Greenhouse-Gas Emission Targets for Limiting Global Warming to 2 °C. *Nature* **2009**, *458*, 1158–1162. [CrossRef]
17. Iqbal, W.; Yumei, H.; Abbas, Q.; Hafeez, M.; Mohsin, M.; Fatima, A.; Jamali, M.; Jamali, M.; Siyal, A.; Sohail, N. Assessment of Wind Energy Potential for the Production of Renewable Hydrogen in Sindh Province of Pakistan. *Processes* **2019**, *7*, 196. [CrossRef]
18. Acheampong, A.O.; Opoku, E.E.O. Environmental Degradation and Economic Growth: Investigating Linkages and Potential Pathways. *Energy Econ.* **2023**, *123*, 106734. [CrossRef]
19. Van den Berg, H. *Economic Growth and Development*; World Scientific Publishing Company: Singapore, 2016; pp. 28–30.
20. Lynch, J.; Cain, M.; Frame, D.; Pierrehumbert, R. Agriculture's Contribution to Climate Change and Role in Mitigation Is Distinct from Predominantly Fossil CO_2-Emitting Sectors. *Front. Sustain. Food Syst.* **2021**, *4*, 518039. [CrossRef] [PubMed]
21. Keutgen, A.J. Climate change: Challenges and limitations in agriculture. *IOP Conf. Ser. Earth Environ. Sci.* **2023**, *1183*, 012069. [CrossRef]
22. Pawlak, J. Rolnictwo a środowisko naturalne [Agriculture vs. the natural environment]. *Probl. Inżynierii Rol. [Probl. Agric. Eng.]* **2015**, *23*, 17–28.
23. Hu, Y.; Su, M.; Jiao, L. Peak and Fall of China's Agricultural GHG Emissions. *J. Clean. Prod.* **2023**, *389*, 136035. [CrossRef]
24. Tongwane, M.I.; Moeletsi, M.E. A Review of Greenhouse Gas Emissions from the Agriculture Sector in Africa. *Agric. Syst.* **2018**, *166*, 124–134. [CrossRef]
25. Tubiello, F.N.; Salvatore, M.; Rossi, S.; Ferrara, A.; Fitton, N.; Smith, P. The FAOSTAT Database of Greenhouse Gas Emissions from Agriculture. *Environ. Res. Lett.* **2013**, *8*, 015009. [CrossRef]
26. Pathak, H.; Bhatia, A.; Jain, N.; Aggarwal, P.K. Greenhouse gas emission and mitigation in Indian agriculture–A review. *ING Bull. Reg. Assess. React. Nitrogen Bull.* **2010**, *19*, 1–34.
27. Singh, S.N. *Climate Change and Crops*; Springer: Berlin/Heidelberg, Germany, 2009. [CrossRef]
28. Chataut, G.; Bhatta, B.; Joshi, D.; Subedi, K.; Kafle, K. Greenhouse Gases Emission from Agricultural Soil: A Review. *J. Agric. Food Res.* **2023**, *11*, 100533. [CrossRef]
29. Pierrehumbert, R.T. Climate change: A catastrophe in slow motion. *Chi. J. Int. L.* **2005**, *6*, 573. Available online: https://chicagounbound.uchicago.edu/cjil/vol6/iss2/6 (accessed on 29 March 2024).
30. Birch, E.L. A Review of "Climate Change 2014: Impacts, Adaptation, and Vulnerability" and "Climate Change 2014: Mitigation of Climate Change". *J. Am. Plan. Assoc.* **2014**, *80*, 184–185. Available online: http://ipcc-wg2.gov/AR5/report/final-drafts/ (accessed on 12 April 2024). [CrossRef]
31. IPCC. Mitigation of Climate Change Climate Change 2022 Working Group III Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. 2022. Available online: https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_FullReport.pdf (accessed on 15 May 2024).

32. Gołaś, M.; Sulewski, P.; Wąs, A.; Kłoczko-Gajewska, A.; Pogodzińska, K. On the Way to Sustainable Agriculture—Eco-Efficiency of Polish Commercial Farms. *Agriculture* **2020**, *10*, 438. [CrossRef]
33. Chowdhury, S.; Khan, S.; Sarker, M.F.H.; Islam, M.K.; Tamal, M.A.; Khan, N.A. Does Agricultural Ecology Cause Environmental Degradation? Empirical Evidence from Bangladesh. *Heliyon* **2022**, *8*, e09750. [CrossRef] [PubMed]
34. Fayomi, O.S.I.; Adelakun, J.O.; Babaremu, K.O. The Impact of Technological Innovation on Production. *J. Phys. Conf. Ser.* **2019**, *1378*, 022014. [CrossRef]
35. Sharma, R. *Transformation of Rural Areas Through the Use of Technology: Opportunities for Women and Youth*; MPRA 2012 Paper 115336; University Library of Munich: Munich, Germany, 2012.
36. Sadowski, A. *Wyżywieniowe i Środowiskowe Funkcje Światowego Rolnictwa—Analiza Ostatniego Półwiecza (Nutritional and Environmental Functions of Global Agriculture: An Analysis of the Last Five Decades)*; Publishing House of the Poznań University of Life Sciences: Poznan, Poland, 2017.
37. Genstwa, N.; Zmyślona, J. Greenhouse Gas Emissions Efficiency in Polish Agriculture. *Agriculture* **2023**, *14*, 56. [CrossRef]
38. Zhang, Y.; Collins, A.L.; Jones, J.I.; Johnes, P.J.; Inman, A.; Freer, J.E. The Potential Benefits of On-Farm Mitigation Scenarios for Reducing Multiple Pollutant Loadings in Prioritised Agri-Environment Areas across England. *Environ. Sci. Policy* **2017**, *73*, 100–114. [CrossRef]
39. Atari, D.O.A.; Yiridoe, E.K.; Smale, S.; Duinker, P.N. What Motivates Farmers to Participate in the Nova Scotia Environmental Farm Plan Program? Evidence and Environmental Policy Implications. *J. Environ. Manag.* **2009**, *90*, 1269–1279. [CrossRef]
40. Bachev, H. *Environmental Management in Agriculture–Case of Bulgaria*; MPRA, Paper 59054; University Library of Munich: Munich, Germany, 2014.
41. Hasegawa, T.; Fujimori, S.; Shin, Y.; Tanaka, A.; Takahashi, K.; Masui, T. Consequence of Climate Mitigation on the Risk of Hunger. *Environ. Sci. Technol.* **2015**, *49*, 7245–7253. [CrossRef]
42. Staniszewski, J.; Matuszczak, A. Environmentally Adjusted Analysis of Agricultural Efficiency: A Systematic Literature Review of Frontier Approaches. *Zagadnienia Ekon. Rolnej* **2023**, *374*, 20–41. [CrossRef]
43. Lampkin, N.H.; Pearce, B.D.; Leake, A.R.; Creissen, H.; Gerrard, C.L.; Girling, R.; Lloyd, S.; Padel, S.; Smith, J.; Smith, L.G.; et al. The Role of Agroecology in Sustainable Intensification. Report for the Land Use Policy Group; Organic Research Centre, Elm Farm and Game & Wildlife Conservation Trust. 2015. Available online: http://www.snh.gov.uk/docs/A1652615.pdf (accessed on 14 April 2024).
44. Tittonell, P. Ecological Intensification of Agriculture—Sustainable by Nature. *Curr. Opin. Environ. Sustain.* **2014**, *8*, 53–61. [CrossRef]
45. Iram, R.; Zhang, J.; Erdogan, S.; Abbas, Q.; Mohsin, M. Economics of Energy and Environmental Efficiency: Evidence from OECD Countries. *Environ. Sci. Pollut. Res.* **2019**, *27*, 3858–3870. [CrossRef]
46. Zmyślona, J.; Sadowski, A.; Genstwa, N. Plant Protection and Fertilizer Use Efficiency in Farms in a Context of Overinvestment: A Case Study from Poland. *Agriculture* **2023**, *13*, 1567. [CrossRef]
47. Williams, A.J. The Common Agricultural Policy and the General Environmental Policies Concerned with Agriculture in the European Community and Their Implications for Fertilizer Consumption. *Mar. Pollut. Bull.* **1994**, *29*, 500–507. [CrossRef]
48. European Commission. *Farm to Fork Strategy for Sustainable Food*; Food Safety: Brussels, Belgium, 2020. Available online: https://ec.europa.eu/food/farm2fork_en (accessed on 6 April 2024).
49. Heuser, I. Special Issue on Soil Governance of the Journal of Soil Security: Soil Governance in the Current European Union Law and in the European Green Deal. *Soil Secur.* **2022**, *6*, 100053. [CrossRef]
50. Luboslav, S.; Miroslav, G.; Michal, Z. Agricultural Performance in the v4 Countries and Its Position in the European Union. *Agric. Econ. (Zemědělská Ekon.)* **2018**, *64*, 337–346. [CrossRef]
51. Bajan, B.; Łukasiewicz, J.; Mrówczyńska-Kamińska, A. Energy Consumption and Its Structures in Food Production Systems of the Visegrad Group Countries Compared with EU-15 Countries. *Energies* **2021**, *14*, 3945. [CrossRef]
52. Latawski, P. On Converging Paths? The Visegrad Group and the Atlantic Alliance. *Paradigms* **1993**, *7*, 78–93. [CrossRef]
53. Schmidt, A. Friends Forever? The Role of the Visegrad Group and European Integration. *Politics Cent. Eur.* **2016**, *12*, 113–140. [CrossRef]
54. Cottey, A. The Visegrad Group and Beyond: Security Cooperation in Central Europe. *Palgrave Macmillan UK Ebooks* **1999**, 69–89. [CrossRef]
55. Bozduman, E.T. The Concentration of the Agriculture and Livestock Sector in the Visegrad Group After Membership to the European Union. *Ekon. Poljopr.* **2023**, *70*, 867–879. [CrossRef]
56. Czyżewski, A.; Michałowska, M. The Impact of Agriculture on Greenhouse Gas Emissions in the Visegrad Group Countries after the World Economic Crisis of 2008. Comparative Study of the Researched Countries. *Energies* **2022**, *15*, 2268. [CrossRef]
57. Firlej, K.; Kubala, S. The Assessment of Export Potential of Agricultural and Food Products in the Visegrad Group Countries in the Years 2005–2017. *Econ. Sci. Agribus. Rural. Econ.* **2018**, *2*, 167–173. [CrossRef]
58. Svatoš, M.; Smutka, L. Development of Agricultural Trade and Competitiveness of the Commodity Structures of Individual Countries of the Visegrad Group. *Agric. Econ. (Zemědělská Ekon.)* **2012**, *58*, 222–238. [CrossRef]

59. Sadowski, A.; Baer-Nawrocka, A. Food and Environmental Function in World Agriculture—Interdependence or Competition? *Land Use Policy* **2018**, *71*, 578–583. [CrossRef]
60. Baer-Nawrocka, A.; Sadowski, A. Food Security and Food Self-Sufficiency around the World: A Typology of Countries. *PLoS ONE* **2019**, *14*, e0213448. [CrossRef]
61. Sadowski, A.; Wojcieszak-Zbierska, M.M.; Zmyślona, J. Agricultural Production in the Least Developed Countries and Its Impact on Emission of Greenhouse Gases—An Energy Approach. *Land Use Policy* **2024**, *136*, 106968. [CrossRef]
62. Baratta, A.; Cimino, A.; Longo, F.; Solina, V.; Verteramo, S. The Impact of ESG Practices in Industry with a Focus on Carbon Emissions: Insights and Future Perspectives. *Sustainability* **2023**, *15*, 6685. [CrossRef]
63. Zandalinas, S.I.; Fritschi, F.B.; Mittler, R. Global Warming, Climate Change, and Environmental Pollution: Recipe for a Multifactorial Stress Combination Disaster. *Trends Plant Sci.* **2021**, *26*, 588–599. [CrossRef]
64. Sala, O.E. Global Biodiversity Scenarios for the Year 2100. *Science* **2000**, *287*, 1770–1774. [CrossRef] [PubMed]
65. Olesen, J.E.; Bindi, M. Consequences of Climate Change for European Agricultural Productivity, Land Use and Policy. *Eur. J. Agron.* **2002**, *16*, 239–262. [CrossRef]
66. Gray, S.B.; Dermody, O.; Klein, S.P.; Locke, A.M.; McGrath, J.M.; Paul, R.E.; Rosenthal, D.M.; Ruiz-Vera, U.M.; Siebers, M.H.; Strellner, R.; et al. Intensifying Drought Eliminates the Expected Benefits of Elevated Carbon Dioxide for Soybean. *Nature Plants* **2016**, *2*, 16132. [CrossRef] [PubMed]
67. Anderson, J.T.; Song, B.H. Plant adaptation to climate change—Where are we? *J. Syst. Evol.* **2020**, *58*, 533–545. [CrossRef]
68. Iwata, H.; Okada, K. Greenhouse Gas Emissions and the Role of the Kyoto Protocol. *Environ. Econ. Policy Stud.* **2012**, *16*, 325–342. [CrossRef]
69. Robiou du Pont, Y.; Jeffery, M.L.; Gütschow, J.; Rogelj, J.; Christoff, P.; Meinshausen, M. Equitable Mitigation to Achieve the Paris Agreement Goals. *Nat. Clim. Change* **2016**, *7*, 38–43. [CrossRef]
70. Stanujkic, D.; Popovic, G.; Zavadskas, E.K.; Karabasevic, D.; Binkyte-Veliene, A. Assessment of Progress towards Achieving Sustainable Development Goals of the "Agenda 2030" by Using the CoCoSo and the Shannon Entropy Methods: The Case of the EU Countries. *Sustainability* **2020**, *12*, 5717. [CrossRef]
71. Schleussner, C.-F.; Ganti, G.; Rogelj, J.; Gidden, M.J. An Emission Pathway Classification Reflecting the Paris Agreement Climate Objectives. *Commun. Earth Environ.* **2022**, *3*, 1–11. [CrossRef]
72. Fetting, C. The European Green Deal. *ESDN Rep.* **2020**, 53. Available online: https://www.esdn.eu/fileadmin/ESDN_Reports/ESDN_Report_2_2020.pdf (accessed on 29 April 2024).
73. Ejdys, J.; Szpilko, D. European Green Deal—Research Directions. A Systematic Literature Review. *Ekon. I Sr.—Econ. Environ.* **2022**, *81*, 8–38. [CrossRef]
74. ECA. *Common Agricultural Policy and Climate: Half of EU Climate Spending But Farm Emissions Are Not Decreasing*; European Court of Auditors: Luxembourg, 2021.
75. Iwata, H.; Okada, K. How Does Environmental Performance Affect Financial Performance? Evidence from Japanese Manufacturing Firms. *Ecol. Econ.* **2011**, *70*, 1691–1700. [CrossRef]
76. Gupta, M.; Pevzner, M.; Seethamraju, C. The Implications of Absorption Cost Accounting and Production Decisions for Future Firm Performance and Valuation. *Contemp. Account. Res.* **2010**, *27*, 889–922. [CrossRef]
77. Nishitani, K.; Kokubu, K. Can Firms Enhance Economic Performance by Contributing to Sustainable Consumption and Production? Analyzing the Patterns of Influence of Environmental Performance in Japanese Manufacturing Firms. *Sustain. Prod. Consum.* **2020**, *21*, 156–169. [CrossRef]
78. Haleem, A.; Javaid, M.; Singh, R.P.; Suman, R.; Qadri, M.A. A Pervasive Study on Green Manufacturing towards Attaining Sustainability. *Green Technol. Sustain.* **2023**, *1*, 100018. [CrossRef]
79. Duncan, C. The Centrality of Agriculture: History, Ecology and Feasible Socialism. In *Necessary and Unnecessary Utopias: Socialist Register*; Panitch, L., Leys, C., Eds.; The Merlin Press: Suffolk, UK, 2000.
80. Horrigan, L.; Lawrence, R.S.; Walker, P. How Sustainable Agriculture Can Address the Environmental and Human Health Harms of Industrial Agriculture. *Environ. Health Perspect.* **2002**, *110*, 445–456. [CrossRef]
81. Poore, J.; Nemecek, T. Reducing Food's Environmental Impacts through Producers and Consumers. *Science* **2018**, *360*, 987–992. [CrossRef]
82. Carlson, K.M.; Gerber, J.S.; Mueller, N.D.; Herrero, M.; MacDonald, G.K.; Brauman, K.A.; Havlik, P.; O'Connell, C.S.; Johnson, J.A.; Saatchi, S.; et al. Greenhouse Gas Emissions Intensity of Global Croplands. *Nat. Clim. Change* **2016**, *7*, 63–68. [CrossRef]
83. Godfray, H.C.J.; Beddington, J.R.; Crute, I.R.; Haddad, L.; Lawrence, D.; Muir, J.F.; Pretty, J.; Robinson, S.; Thomas, S.M.; Toulmin, C. Food Security: The Challenge of Feeding 9 Billion People. *Science* **2018**, *327*, 812–818. [CrossRef]
84. Schmidhuber, J.; Tubiello, F.N. Global Food Security under Climate Change. *Proc. Natl. Acad. Sci. USA* **2007**, *104*, 19703–19708. [CrossRef]
85. Evans, A. The Feeding of the Nine Billion. Global Food Security for the 21st Century. Chatham House Report. 2009. Available online: http://chathamhouse.org/uk/files/13179_r0109 (accessed on 10 April 2024).

86. Sadowski, A.; Antczak, W. Directions of Using Direct Payments by the Individual Farms Located in Chosen Regions. *J. Agribus. Rural Dev.* **2012**, *26*, 103–113.
87. Grešlová, P.; Přemysl, Š.; Salata, T.; Józef, H.; Knizkova, I.; Bičík, I.; Leoš, J.; Prus, B.; Tomasz, N. Agroecosystem Energy Metabolism in Czechia and Poland in the Two Decades after the Fall of Communism: From a Centrally Planned System to Market Oriented Mode of Production. *Land Use Policy* **2019**, *82*, 807–820. [CrossRef]