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Policy Gaps Related to Sustainability in Hungarian Agribusiness Development

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Abstract: The world's agriculture faces many challenges nowadays, such as tackling the effects of climate change, conserving agrobiodiversity, or feeding the Earth's growing population. These issues often induce conflicting development directions, such as digitalization and ecologization, as the case of the European Union's Common Agricultural Policy (CAP) shows. In the last decades, policymakers have focused mainly on greening agricultural production and the food industry, and now the CAP is part of the European Green Deal. In our research, we assessed the sustainability problems affecting the agribusiness sector and food consumption in Hungary using descriptive statistical analysis. On the other hand, we examined the latest sectoral development documents (Digital Agricultural Strategy, Digital Food Industry Strategy) in order to find out to what extent they answer the identified issues. Our results revealed that the Hungarian agribusiness sector is struggling with several sustainability challenges, which do not receive adequate attention from policymakers. The newest development strategies are characterized by forced digitalization efforts, while their applicability and effectiveness are uncertain. Because of similar development trajectories, we believe most of our results are relevant to other Central Eastern European Member states. Hence, further CAP and national policy reforms are needed to make Europe's agribusiness sector more sustainable.

Keywords: sustainability; digitalization; ecologization; agribusiness development; Hungary

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1. Introduction

Nobel Prize-winning chemist Richard Smalley identified the world's ten most important issues for the next 50 years. In his opinion, energy comes first, water second, food third, environment fourth, and poverty fifth [1]. The agribusiness sector is closely linked to these five key challenges and thus plays a crucial role in achieving global and local sustainability. The agribusiness sector is closely linked to these five challenges. Therefore, the transformation of the agri-food industry is necessary, in which two fundamentally different directions are decisive: digitalization and ecologization [2–4].

The digitization of the agri-food industry means applying digital solutions from the field to food production and is often compared to the development of Industry 4.0 [3,5]. Thus, digitalization appears as an essential tool for achieving environmental, economic, and social sustainability goals due to increasing production efficiency, reducing costs, and improving coordination [6].

The agribusiness sector's ecologization means using practices and technologies which not only minimize the environmental impact of food production and consumption but also consider restoring ecosystem services [2,7]. Thus, concerning the environment, its goals are more extensive and complex than the digitalization approach.

In Europe, the environmental issues and agri-environmental measures already play an increasingly important role in the EU Common Agricultural Policy (CAP). However, the results of the greening process are questionable [8], and the EU Member States' agri-food industries have struggled to find their way to sustainable development in the last decades. Thus, the CAP is now subordinated to the European Green Deal (EGD) to strengthen its environmental goals.

The Central and Eastern European countries (CEE), such as Hungary, are in a unique situation. They have been facing a third significant challenge regarding food production and rural development in the past 30 years. The first dramatic transformation came from dismantling the socialist system, and the second was the accession to the EU in 2004 [9]. As a third challenge, they now have to readjust their production-oriented agri-food and rural development policies due to environmental sustainability and compliance with the new CAP and EGD.

Our research, therefore, aims to identify the sustainability issues of the Hungarian agricultural sector, from field production to food consumption. We also aim to evaluate the primary goals of the new sectoral development strategies and how well they relate to the new CAP and EGD directions and address the identified problems.

Therefore, after this introduction, we review the literature about the sustainability dilemmas regarding the CAP. Then, we present the development of Hungarian agriculture and the food industry after 1990. The fourth section describes the materials and methods used in our analysis. In the results section, we assess the changes in sustainability-related indicators, and then scrutinize the government's development strategies from the viewpoint of sustainability and the common European goals. Next, we discuss the key issues which hinder the agribusiness sector's environmental, economic and social sustainability. Finally, we draw conclusions and make some proposals to address the identified policy gaps.

2. Sustainability Dilemmas about the CAP

Agriculture is dominant in European land use, as it utilizes 39% of the total area [10]. Thus, the intensification of agriculture is one of the leading causes of biodiversity loss in Europe [11,12]. In addition, agriculture makes a significant contribution to climate change through GHG emissions (10% of the total emission) [13] and land abandonment [14]. Furthermore, using fertilizers and pesticides severely impacts the environment and, in many cases, endangers consumers' health [15].

In its original form, the agricultural development policy focused on productivity and competitiveness, which changed in the reform process launched in 1992. Significant interventions were made every 5–8 years (1999, 2003, 2008, 2013, 2021) to tackle various environmental problems [16]. As a result, productivity (industrial agriculture) was replaced by sustainability (multifunctional agriculture) [17,18], while competitiveness as a goal remained. Thus, the CAP had two objectives that were difficult to reconcile. Therefore, it is no coincidence that the agri-environment and rural development measures introduced in the support system have achieved only modest results to date [19,20].

Based on the results of De Schutter and colleagues [21], the EU's governance structures are ill-adapted to the challenges of food systems (e.g., climate change, biodiversity loss, food poverty) and to formulate conflicting goals during the continuous reform process. Furthermore, other research warns that the EU and the Member States do not spend agricultural subsidies efficiently [22]. The reason for the poor efficiency is that the effects of the measures are scattered, making them costly [23,24]. The most glaring example is greening, an essential financial income source for farmers today. These payments have not been effective in changing agricultural production practices to a level that could justify the input costs [25]. This is supported by the fact that the number of farmland birds has fallen sharply in Europe in recent decades due to intensive farming [26]. This trend could not be stopped or effectively addressed by environmental payments [27].

Examining the issue of climate change, the CAP contains adaptation and carbon footprint reduction goals, but the results of Brady and colleagues [28] show that direct agricultural support payments increase the GHG emissions of production.

Therefore, the current situation leaves no room for confidence in direct agricultural subsidies in terms of helping move toward sustainability. Some authors have also raised the question of whether the EU CAP genuinely aims at greening or is just greenwashing [29].

An additional problem is that the food industry and other related sectors are not an integral part of the CAP. Therefore, the goals and developments are not coordinated. Recanati and colleagues [30] propose expanding the CAP and creating an integrated Common Agri-food Policy to solve this issue. This approach would also be needed because the CAP does not address all of the sustainable development goals (SDGs) linked to the agri-food system. Scown and colleagues [31] highlighted that health, gender equality, oceans, and institutions as development areas would not be monitored during the CAP implementation. Concerning health, particular attention should be paid to healthy eating and diet-related diseases (e.g., obesity). Gender equality may play a significant role in the generational renewal of the farming community (e.g., increased involvement of women in agricultural production) [30].

The CAP and the associated Farm to Fork Strategy and the Biodiversity Strategy (until 2030) will lie at the heart of the European Commission's sustainable development goals (SDGs) for the next budgetary period [32]. The CAP reform adopted in 2021 (which will begin to apply in 2023) has added social elements (a fairer CAP) to the long-standing environmental and competitiveness goals. However, environmental and nature protection measures have strengthened, and competitiveness goals have narrowed; the preference for digitalization in the EGD may override these reforms. This approach can cause problems. On the one hand, European agriculture's farm structure is ill-suited to applying these technologies [33]. On the other hand, these measures may launch new technological competition (in farm machinery), overshadowing other environmental and social goals [34].

This threat is particularly prevalent in the CEE countries, where decades of technological backwardness in many farms have not yet been eliminated. Even though governments have placed agricultural development at the forefront of their national strategic plans in the past decades. We hypothesize that the attitudes of the Hungarian government and other CEE countries' governments will be similar in the next budgetary period. Therefore, the competitiveness-enhancing aspects of digitalization will be preferred, thus pushing environmental concerns (ecologization) and social justice (fairness) into the background.

3. Study Area

3.1. Environmental Conditions of Agriculture

Hungary's natural endowments favor agricultural production regarding soils, topography, and climate. Thanks to these environmental conditions, from the 1960s, the country could be essentially self-sufficient in primary agricultural and food products. Moreover, according to the National Chamber of Agriculture assessment, Hungarian agriculture could supply 18–20 million people, while the country's current population is 9.75 million [35].

However, these favorable environmental conditions are changing, and complex land degradation processes [36] and climate change [37] significantly affect production. Gaál and colleagues' [38] results show that climatic changes may even be positive for certain crops until 2050, but for the period between 2071 to 2100, they predict adverse outcomes for the whole crop production sector.

3.2. Hungarian Agri-Food Policy after 1990

After 1989, the socio-economic environment and legislative framework of agricultural production in Hungary changed fundamentally. The new political elite emphasized compensation for the confiscated private properties such as agricultural land. As a result, 1.5 million new landowners received land; by 1995, 48.2% of the arable land was already in the hands of smallholders [39].

In 1994, Hungary submitted a membership application to the EU and was granted candidate status by the European Council in 1997. Because of this, the Hungarian government made significant efforts to prepare for the accession successfully. Law No. CXIV of

1997 laid down the reform of agricultural development, which focused on increasing the competitiveness of agricultural production. Novel concepts (at least for Hungary) were also introduced, such as harmonizing agricultural activities with environmental needs and local traditions and facilitating agro-innovations.

Until the accession, the funded activities (118 payment titles at most) were published yearly by the Ministry of Agriculture. The support regulations mostly adopted the payment titles of the European Union to help the transition to the CAP system (e.g., area payment schemes, support for young farmers). Additionally, some titles aimed to increase the farmers' competitiveness, while others helped capacity building and to boost production (subsidies for new vineyards and orchard plantations) before joining the Common Market. The introduction of the family farms in 2001 was an essential part of these efforts because they received an additional area payment and investment support.

Another critical issue was the protection and environmentally friendly use of rural landscapes. Law No. LIII of 1996 about natural protection contained recommendations that farmers are entitled to compensation for their lost profit because of the natural protection regulations. As a result, the National Agro-environmental Program started in 2002, and one year later, the Program's landscape and ecofarming support scheme already involved more than 5000 farmers with around 230,000 hectares of subsidized land [40].

Fulfilling the Copenhagen Criteria, Hungary entered the European Union on 1st May 2004. The agribusiness sector's general environment changed again, and the Common Agricultural Policy and the Common Market provided new frameworks. However, the preferences of agricultural governance did not change, and even after the EU accession, the focus remained on developing and boosting agricultural production. A study by the State Audit Office of Hungary [41] reveals that around 10 billion Euros were paid as direct subsidies between 2007 and 2014. On the contrary, the New Hungary Rural Development Program made up only around 5.5 billion Euros during the same period. Even from that value, the first (improving the competitiveness of agriculture) and the second (agro-environmental farming) axes took 77%, leaving only a little more than 1 billion Euros for rural development.

In the Rural Strategic Program of 2012, the Hungarian government focused on developing livestock breeding (especially pig farming) and modernizing animal holdings. Other goals of the program (protection of rare breeds, horse breeding program) were also connected to the main focus [42].

The payment of subsidies is in line with the EU CAP's regulations. In 2018, 170 thousand applications were received by the Hungarian Treasury for 5 million hectares of agricultural land [43]. The paid amount in agricultural subsidies was 2.012.681.868 EUR in 2021. A total of 53% of this amount (1.070.799.726 EUR) was direct payment to farmers; only 31% went for rural development and fisheries, 2.42% for markets and other subsidies, and 13.3% were paid as national support [44].

However, while the subsidies positively impacted the competitiveness and mechanization of the agricultural sector, they also started unfavorable processes. We consider such a negative change to be the increasing concentration of farm sizes since 2004 and the rapid rise in land prices and rents [45]. Furthermore, we agree with the results of Kovách [46] that some area-based subsidies are not used in rural areas but are "exported" to cities, so they do not serve the interests of the agricultural sector or rural society.

3.3. Economic Background

After 1990, Hungarian agricultural output dropped significantly, mainly due to the loss of export markets. Consequently, it implied a decline in employment in agriculture (decreased by 412,000 workers) and the food industry (decreased by 74,000 employees). The result was a deep social crisis in rural areas from the beginning of the 1990s. Finally, after nearly 30 years, both sectors were able to increase the number of employees marginally. The sectors' share in GDP followed a similar declining trend. Agriculture share declined by 10% after 1990, stabilizing to this day at around 4–4.4%. In the food industry, its share declined by only 3% percent from GDP in the same period. Despite this decline, agriculture is still an important economic sector because it has constantly improved its trade balance. For example, its positive balance increased more than eightfold between 1993 and 2016 (Table 1).

Table 1. Performance indicators of Hungarian agriculture and food industry from the transition until 2016.

Agriculture and Food Industry	1989/1990	1997	2004	2016	Change 1990–2016
Production and investment					
Agriculture share in GDP (%)	13.7	5.9	3.9	4.4	−9.3
Food-industry share in GDP (%)	5.2	3.7	2.8	2.2	/−3
Utilized agricultural area (1000 ha)	6473.1	6194.6	5863.8	5349	−1124.1
Trade					
Share in export %	22.4 *	15	6.9	8.6	−13.8
Share in import %	6.4 *	5.1	4.1	5.49	−0.91
Balance (million HUF)	109.362 *	332.343	275.815	816.000	706.638
Employment					
Employed in agriculture, forestry and fishery (1000 person)	693	288	205	217	−476
Employment in food industry (1000 person)	234	160	141	143.8	−90.2
Share of total employment (%)	19	12.29	8.87	8.29	−10.71
Production of cereals (1000 t)					
Wheat	6161.4	5257.6	6006.8	5603.1	−558.3
Maize	4257.7	6827.7	8332.4	8729.9	4472.2
Barley	1357.6	1330.2	1413.3	1594.2	236.6
Production of main industrial crops (1000 t)					
Sunflower seeds	677.3	540.2	1186.1	1875.4	1198.1
Rape seeds	104.4	144.8	290.5	924.9	820.5
Sugar beet	4740.9	3690.9	3515.8	1121.2	−3619.7
Production of potato, grapes, vegetables, and fruits (1000 t)					
Potato	745.5	1139.5	783.6	429.4	−316.1
Vineyard	862.9	649.5	788.6	476.4	−386.5
Tomatoes	403.8	219.7	269.2	173	−230.8
Apple	945.4	499.9	700.3	497.1	−448.3
Number of livestock Units (1000 heads)					
Cattle	1571	871	723	852	−719
Pigs	8000	4931	4059	2907	−5093
Sheep	1865	858	1397	1141	−724
Poultry	50,011	35.665	41.329	40.185	−9826

* 1993 data.

In the development of the Hungarian food industry, the privatization process and the EU accession had a significant impact. During the privatization, the new foreign owners of Hungarian food companies closed them down after a few years because they only wanted to buy market share. The EU accession influenced the sector due to the reduction in sugar beet production and closure of sugar factories, and also with mandatory adoption of EU food regulations. Currently, processing capabilities lag behind agricultural output, so Hungary often exports raw products while importing processed ones.

The output of crop production reached the pre-1990 levels around 2000, while the crisis of animal husbandry lasts even today (Table 1). Crop production has become greener after the transition because of the market problems; it was simply not worth using fertilizers and pesticides [47]. After the EU accession in 2004, the subsidies have shifted crop production mainly towards cereals and industrial crops, and the intensification of production is still increasing [48]. In contrast, the output of the capital- and labor-intensive vine-fruit and horticulture sectors are declining due to complex reasons. The development of animal husbandry has been a constant priority over the past years. However, its results are barely perceptible, and the spread of avian influenza and African swine fever is currently a severe concern whose emergence in Hungary is a consequence of climate change [49,50].

4. Materials and Methods

4.1. Materials

We identified the sustainability challenges affecting Hungarian agriculture, food industry, and food consumption using data from the Hungarian Central Statistical Office (HCSO) and Eurostat. We primarily used the long time-series agricultural data and the Hungarian Agricultural Census of 2020 by the HCSO and Eurostat's Agri-environmental Indicators (AEIs) database. Concerning the indicator selection, we primarily chose those that also played a role in the CAP monitoring process, but we also considered those that were Hungarian-specific.

For the document analysis, we selected the most recent sectoral strategic documents and reports to identify the trends in the Hungarian agri-food industry and determine the main policy focus areas and bottlenecks regarding sustainability. Moreover, we assessed not only Hungarian-related documents but also European ones. The set of analyzed documents was as follows:

1. Agrifood Concept of Hungary: made by the Ministry of Agriculture, it determines the need to increase the efficiency and competitiveness of domestic food production. In addition, it expresses the intention of Hungarian agricultural policy to make more intensive use of digital technologies to increase the efficiency of human resource management. Another frequently occurring ambition in the strategy is adapting the Industry 4.0 management approach and tools. The document builds on using CAP and EU funds (12.39 billion euros during the 2014–2020 programming period).
2. EU Agricultural Outlook for markets, income, and environment: is a technical report of the European Commission, summarizing the main trends between 2021–2031, considering agricultural production and markets, land use, environmental aspects, and future scenarios.
3. Digital Agricultural Strategy (DAS): is the fundamental document of our study and the current Hungarian Agricultural policy discourse. It was created within the national cross-sectoral digitalization program, the Digital Welfare Program. Resources are provided by the CAP and the National Rural Development Program. It aims to integrate digitalization achievements into agriculture and introduce Agriculture 4.0 in Hungary.
4. Agricultural Labor Market Barometer Survey: was conducted by the Institute of Agricultural Economics Nonprofit LLC. (AKI), which sheds light on labor demand in the agricultural sector, exploring labor market trends in the Hungarian food economy.
5. Digital Food Industry Strategy Summary (DFS): is closely linked to DAS, but it is not yet adopted, and currently, only a summary is available. In parallel with the DAS, the objectives of the DFS include a concrete action plan for the intensive use of digital, automatic, and robotic technologies. The two main pillars of the DFS are production technology development and education.
6. European Green Deal (EGD): the European Commissions' Green Deal is one of the primary policy instruments of the EU. From 2019 until 2050, it uses one-third of the funds available in the Multiannual Financial Framework of the EU (MFF) and the Next Generation EU program. In the frame of the EGD, Europe would become the first climate-neutral continent by 2050, resulting in a cleaner environment, more affordable energy, smarter transport, new jobs, and overall better quality of life.

7. Farm to Fork Strategy (F2F): contributes to the EGD by shifting the EU food system to a more sustainable way. The leading indicators to be achieved are cutting pesticide use by 50%, reaching the objective of at least 25% of EU agricultural land under organic farming by 2030, and a significant increase in organic aquaculture. F2F relies on cohesion funds and the European Agricultural Fund for Rural Development (EAFRD).
8. Regenerative agriculture in Europe: a critical analysis of contributions to the European Union F2F and Biodiversity Strategies. Localization and shortening the production and consumption chains based on local conditions and resources are the fundamental notions in this report. Localization means producing a diversity of products locally, in low-input systems, according to the local socio-economic context. Thus, the Scientific Advisory Board of the European Academies pointed out that the CAP and the European Structural and Investment Funds should be reallocated using best-fit farming practices at different scales.

4.2. Methods

Various methods are available for analyzing policy and development documents, among which we applied the framework analysis [51]. We chose it because it is well suited to research with specific questions, a limited time frame, and a priori issues. The framework analysis consists of five steps to identify critical issues and policy gaps: familiarization, identifying a thematic framework, indexing, charting, and interpretation [51].

During the analysis of the documents, we used the MAXQDA software. With a two-step keyword-based indexing of the documents, we identified the important sections and contents highly relevant to our research. In this process, we focused on easily identifiable (manifest) and latent, non-primary information on development objectives and specific interventions. Additionally, we generated a word cloud from the most used terms in the DAS to visualize the main goals of Hungarian agricultural policy. This tool gives a quick, comprehensive view of the Strategy. In order to minimize irrelevant terms in the word cloud, we added articles, adverbs, and conjunctions to a so-called 'Stop-list', which excludes these terms [52].

Finally, we evaluated the previously selected sustainability indicators using descriptive statistical methods and charted some of them in Microsoft Excel.

5. Results

5.1. Sustainability Challenges in Hungarian Agribusiness

5.1.1. Environmental Problems in Agricultural Production

There is a worldwide trend to intensify agricultural production, accompanied by an increase in the input side (use of water, pesticides, fertilizers). The impact of agriculture on the environment can be monitored with many indicators such as pesticides and fertilizer usage, GHG emissions, or farmland bird population index. In Hungary, after the regime change, the economic collapse led to a significant decline in the use of fertilizers, pesticides, and other materials. However, between 2000 and 2021, the amount of fertilizer used per hectare doubled from 61 kg/ha to 133 kg/ha (Figure 1). The use of pesticides showed a similar trend after the EU accession, thanks to the stabilization of the producers' financial situations. Despite high pesticide and fertilizer use, crop losses were high because of frequent inclement weather events such as late frosts, hails, and droughts.

Droughts are an increasing challenge for farmers. Between 1901 and 2019, the number of rainy days in Hungary decreased by about 24%, and the average annual temperature increased by 26%. Another problem is that extremism within the country is growing year by year. The water consumption of agriculture has increased in the last twenty years from 110.7 to 140.56 million m^3. Most farmers are engaged in farming practices that do not meet the present challenges due to a lack of skills on the one hand and a lack of capital on the other. These farmers, who are usually low-yielding, are even more exposed to the water scarcity problems caused by climate change. As a result, water management in agriculture is not efficient enough.

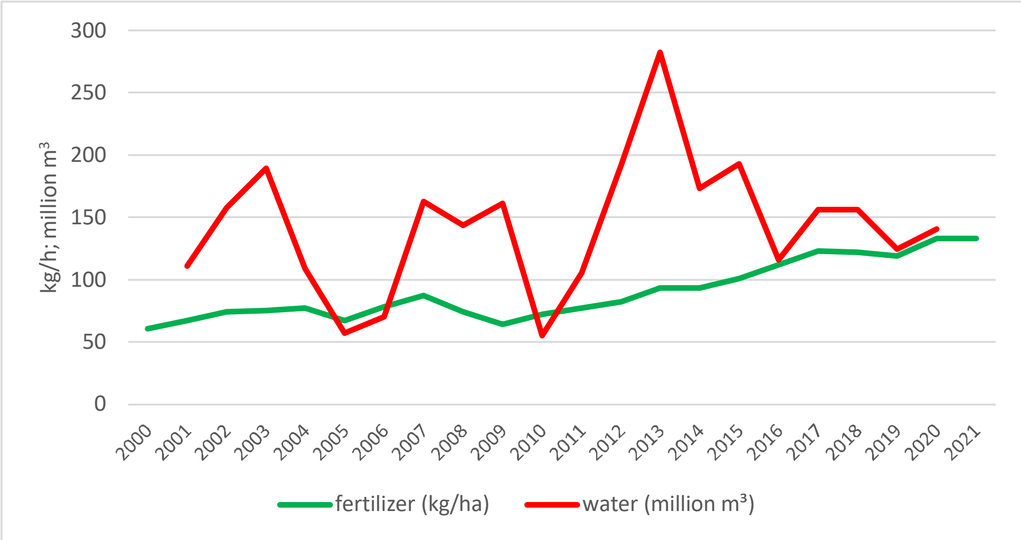

Figure 1. Trends in fertilizer and irrigation water use of agriculture between 2000 and 2021 in Hungary (Source of data: Hungarian Central Statistical Office).

Sustainability is also threatened by increased energy consumption and the parallel increase in GHG emissions. Eurostat data show the previous favorable trend of declining energy expenditure reversed in 2010. From 2010, both energy consumption (up by 32% to 2016) and energy costs increased (from 284.106 EUR to 447.507 EUR between 2011 and 2020).

The European Commission's Country Report also highlights the poor energy efficiency. It states that "domestic energy resources are scarce and economic policy is focused on engaging resource-intensive production tasks in global value chains, while regulated energy prices do not encourage the efficient use of imported fossil fuels." [53]. An additional problem in agriculture is the low utilization of by-products. A typical example is the non-utilization of biowaste from grapevine cultivation for energy purposes.

GHG emissions in Hungary have also increased due to increasing energy consumption. Its extent has exceeded the European average over the past decade, with emissions now above the EU average (Figure 2).

Land use has undergone significant transformations in recent decades. According to the HCSO long-time series data, 57% of the country's territory was agricultural land in 2019. However, in 1990 this proportion was 69.6% (6.47 million hectares), but mainly due to urban sprawl and infrastructure modernization, the utilized agricultural area decreased by 1.17 million hectares in the past 30 years.

The development of organic farming in Hungary is quite controversial. Farmers initially welcomed the agri-environmental programs and opportunities, but due to the difficulties of the bureaucratic system, the total area cultivated with agri-environmental measures decreased somewhat. In the case of organic farming, unlike in the EU, we did not see a significant increase in the utilized area until 2010. Its rate has long been stagnant at around 2% of the agricultural land. Since 2015, similar to the EU trends, the area of organic production has expanded by 3–3.5%, but its share is still far behind the EU data (Figure 3).

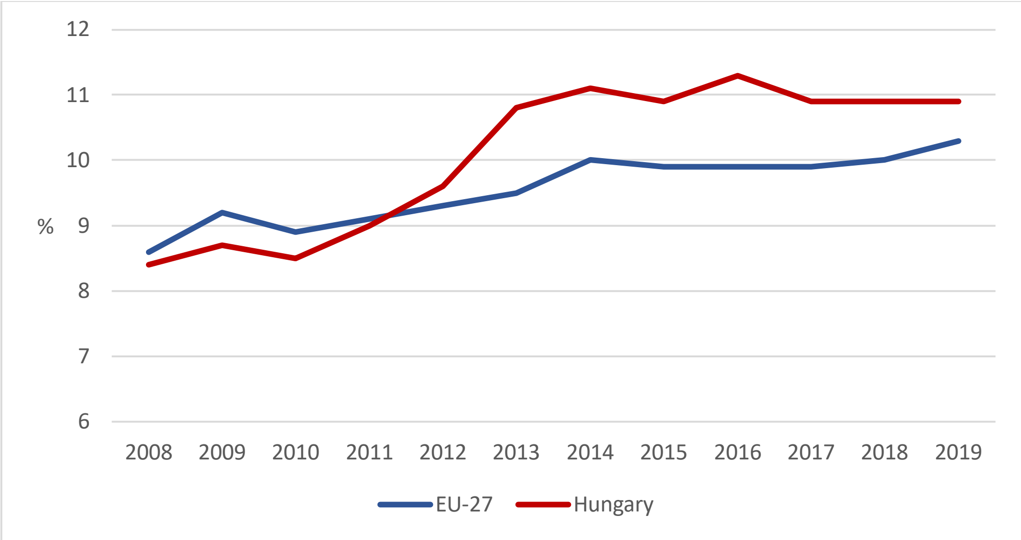

Figure 2. Greenhouse gas emissions of agriculture in Hungary and within the EU between 2008 and 2019. (Source of data: EUROSTAT).

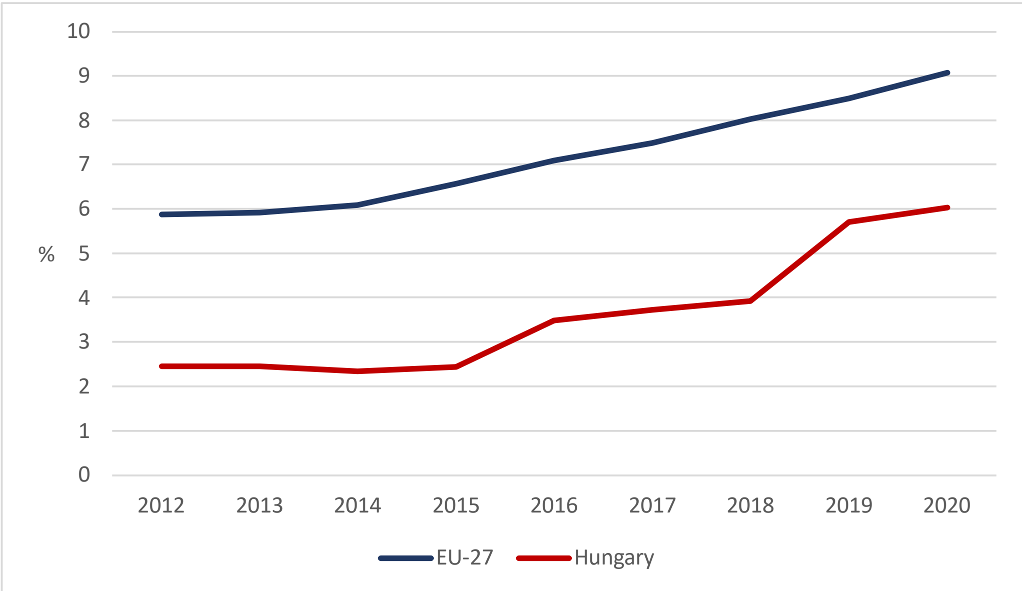

Figure 3. Area under organic farming (Source: EUROSTAT).

Finally, we investigated the Farmland Bird Index, widely used to measure the environmental impact of agriculture. The EUROSTAT agri-environmental database recorded a 30-point index decrease between 1999 and 2019 in the case of Hungary (Figure 4).

The decline in the farm bird population was primarily due to the shrinkage of habitats. Monoculture cultivation reduces habitat diversity, adversely affecting plant and animal communities that feed on birds and nesting sites [54,55]. The situation in Hungary is similar to the other EU Member States, and the bird index fell sharply from 1999. Between 2005 and 2012, it was even below the EU average.

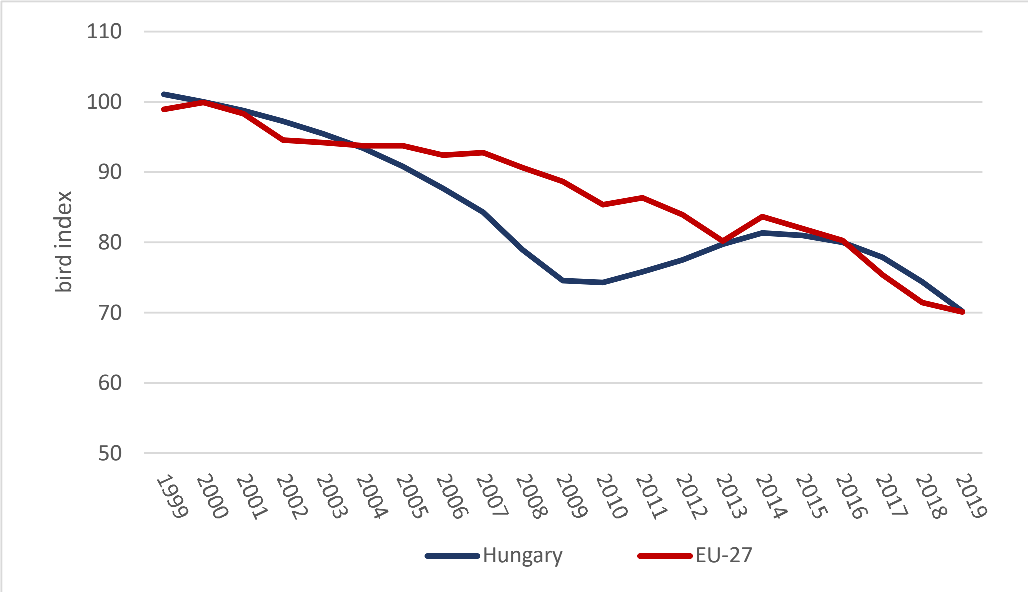

Figure 4. Changes in the common farmland bird index, 1999–2019, (2000 = 100%) (Source: EUROSTAT).

5.1.2. Problems Related to the Economic and Social Conditions of Production

Regarding the socio-economic aspects of production, three fundamental problems can be identified based on the analysis of the Agricultural Census data: increasingly aging farmer population, lack of qualification, and fragmented farm size structure.

In 2020, the average age of farm managers was higher than ten years earlier, and only 10 percent among them were under 40 years of age. The mean age was 57.9 years; therefore, generational change is becoming an increasingly pressing issue. The reasons behind farmers' aging are complex: working in agriculture is not particularly attractive to young people today, and the regulatory environment has also strongly hampered the generational shift. It is bureaucratic and complicated for new farmers to enter production and for the aging generation to retire.

Qualification and age are closely linked, whereas the census results show that the share of people with tertiary education decreases with age. The highest proportion of people with tertiary education is in the 25–44 age group. The older the farmer, the more likely he/she is to have only experiential knowledge, while most younger farmers have some agricultural education. In 2010, the share of farmers aged 65 and over with agricultural education was only 12%, which increased to 28% in 2020. The favorable change is presumably due to the high number of farmers entering this age group in the past ten years.

In addition to generational change, the census data shows that the standard production output value strongly correlates with the educational level and age. Furthermore, these three social characteristics determine tendering activity. This connection is important because of the farmers who received rural development support plans to continue farming in the long run, 36% of them intended to produce in the next ten years. However, without external financial resources, farm modernization is challenging these days.

Regarding farm sizes, there has been a significant increase in the last ten years. As a result, the land area per farm increased in all types of farming, while the number of farms has fallen. This trend suggests that the concentration of land has not yet reached its peak, especially in crop production, where it is profitable to acquire large-scale precision technologies. However, farms are also very diverse depending on their conditions, and the problem is that the support system has so far favored larger producers, while smallholder family farms have found it very difficult to survive.

5.1.3. Societal Challenges in the Food Economy

Among the many functions of agriculture, food production has a prominent place. Food security is a matter of quantity and quality, which also strongly impacts the financing and sustainability of agriculture at the European level. Malnutrition is not limited to third-world countries; the phenomenon is also present in Europe, but on a smaller scale. Between 2014 and 2019, the proportion of the underweight population decreased on average in the EU and Hungary as well. In the latter case, to a greater extent, the Hungarian value is lower today than the EU average. However, this positive trend does not apply to the ratio of the normal to the obese population. The proportion of people with a normal body mass index decreased, while the proportion of overweight people increased in Hungary to a greater degree than in the European Union (Figure 5.).

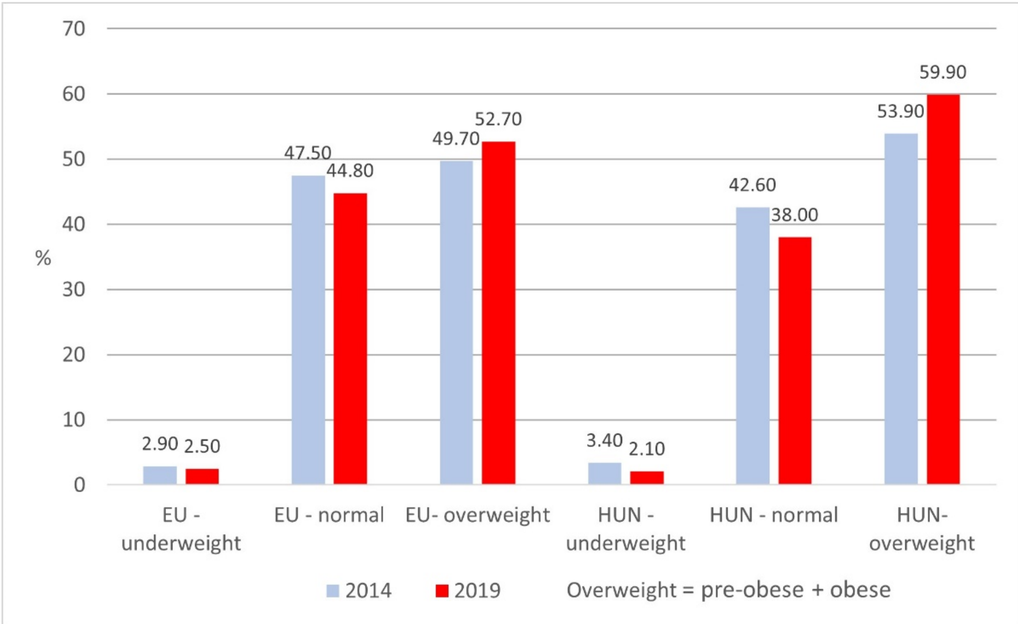

Figure 5. Body Mass Index in Hungary and the EU (2014; 2019) (Source: EUROSTAT).

The unfavorable development of the body mass index draws attention to the changes in eating habits and the problems related to the quantity and quality of food. In Europe and Hungary, overproduction and overconsumption are becoming increasingly significant problems. On the other hand, the abundance of available food should also be mentioned in the background of malnutrition due to financial conditions, especially in Hungary.

The transformation of food consumption habits in Hungary can be well traced on the consumption data of each food category (Figure 6.).

The consumption of fats, particularly meat, has gradually increased over the past decade. It presents a decline in healthy, quality nutrition. This fact is also indicated by the decline in fruit consumption and the stagnation of vegetable consumption, in which potato consumption accounts for the largest share.

In addition to the quantitative and qualitative problems associated with nutrition, food waste raises additional questions. The FAO estimates that one-third of food produced for human consumption is wasted every year. This means 1.3 billion tons of food waste per year worldwide. Hungary produces approx. 1.8 million tons of food waste; 20% of food losses come from households. This amount means 40–46 kg of food waste per person/year, which means 10% of all food purchased. However, this amount is half of the EU average, which is around 20% per year [56]. This phenomenon also contributes to the increase in GHG emissions, as this amount of food waste leads to 170 million tons of CO_2 emissions per year [57].

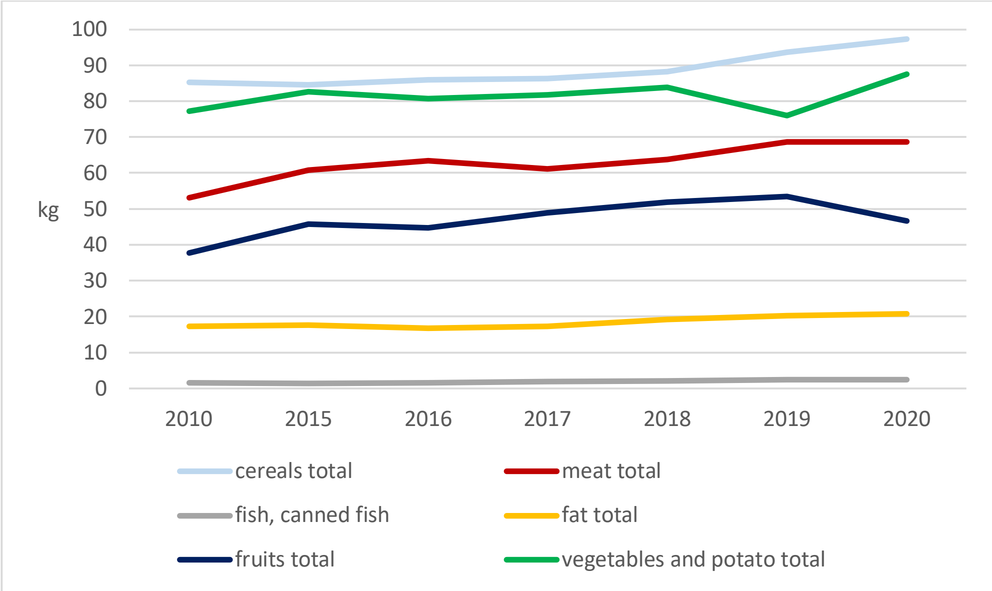

Figure 6. Food consumption in Hungary 2010–2020 (Source: EUROSTAT).

One of the components of food waste is the dependence on production and consumption systems, which connect to agricultural production and trade. This problem is another challenge to the sustainability of agriculture. It must also be part of environmentally friendly farming to keep as little of the food produced as possible to waste. Producers and consumers have a crucial role in this, and the importance of shaping attitudes must be emphasized.

5.2. Policy Goals and Measures of Hungarian Agribusiness Development

Hungary's Digital Agricultural Strategy was accepted in 2019, while a designated workgroup created working material for the upcoming Digital Food Industry Strategy. These documents primarily promote the expansion of precision agriculture in Hungary, which is expected to improve agricultural productivity and meet environmental objectives. As stated in the DAS (2021:5), "Hungary can be not only a successful adopter of new technologies but also a winner in the process as a participant in their development, rejoining the world's agro-technological vanguard. In order to achieve the goals of Hungary's Digital Agricultural Strategy, precision farming needs to be applied as widely as possible: in crop farming, animal husbandry, horticulture, viticulture, fisheries, and forestry. The profitability of precision farming is ensured by the data generated during production".

From an ecological standpoint, one of the DAS's primary measures is the development of agrometeorology. The aim is to set up an information system providing free access to meteorological data and examining the return on investment in meteorology. This measure would help farmers' day-to-day operations and support agriculture in studying and mitigating the effects of climate change. Perhaps the biggest challenge today is preparing for climate change and adapting to the harmful consequences in which such a free service could be essential.

Another positive aspect of the DAS is that it addresses human resource issues related to proliferating smart/precision agricultural technologies. In describing the level of education, they rely on the Agricultural Labor Market Barometer 2016 survey of the Institute of Agricultural Economics. The report shows that the lack of digital competencies is a problem not only at the level of agricultural employees but also at the level of company managers. According to the DAS, there is a current shortage of 3000 professionals in the sector who are familiar with IT and agricultural processes. This statement underlines the importance of agricultural higher education and the inevitability of its development.

The Strategy identifies the creation of model farms as an essential tool for spreading digital solutions. Concerning educational developments, the DAS aims to introduce the possibilities of digital technologies to farmers on a user level within the Digital Agricultural Academy web portal. However, since almost 170,000 registered companies and farmers need support with digital solutions, the earlier mentioned 3000 professionals with IT knowledge is only enough to launch basic digital applications in the agribusiness sector. In terms of sustainability, maybe the most contradictory plan is the radical increase in irrigated areas, which have strong support from the government and the Hungarian Irrigation Association, among others. In addition, they also plan to set up irrigation communities, although neither the various production nor sales cooperatives have had significant success among farmers in the past. Furthermore, we must be aware that the water available for irrigation will likely decrease due to climate change, and water retention does not receive enough attention, so this concept is not in line with Hungarian reality for the future

Similar orientations emerge in the Digital Food Industry Strategy (DFS). Its two main pillars are production technology and the development of education. The primary forms of training are also named, from secondary education through higher digital professional training to doctoral programs. The priority actions include launching a university degree in food digitalization engineering.

The main slogan of the DFS is efficiency. Decision-makers see the use of Industry 4.0 automated, robotic technologies as the key to consistent quality and quantity in food production. Therefore, the question remains: what is the role of small-scale, "craft" food production farms in the future of Hungarian agriculture? For example, the "Development of human resources with digitalization competencies" measure addresses the organization and implementation of training courses for managers of SMEs and large enterprises, leaving out small ones such as traditional artisan producers.

Among the expected results, the DFS also deals with waste and losses during food production, with a 9% reduction goal by 2025. This objective has significant environmental protection implications, which policymakers want to achieve through technological modernization and the formation of management attitudes towards digitalization. Additionally, automation also appears in the document, primarily among the objectives of laboratory development.

The most critical finding of our analysis may be that the DAS and DFS interpret the problems and weaknesses of the agricultural and food sector primarily in terms of competitiveness (Figure 7).

Figure 7. Word cloud of Digital Agricultural Development Strategy. Source: made by the authors.

Hence, the second problem is that sustainability issues are only treated as of secondary importance in the two strategies. This is a clear position on the part of the policymakers between digitalization and ecologization efforts. As a result, the goals are not in line with the new directions of the CAP, in which the development of organic farming and the fairness of the agricultural support system are priorities.

Finally, the third most critical characteristic of the two strategies is the significant discrepancy between the stated aspirations and reality. The DAS builds on missing foundations, such as the ability of the farmers to use digital applications and programs, the barely available financial resources for technological investments, or even the essentially non-existent irrigation water resources.

6. Discussion

The analysis of the DAS and DFS strategies confirmed our hypothesis that developing the agri-food sector's competitiveness is the most crucial goal of the Hungarian government for the next EU planning cycle. Despite that, the EGD and the 2021 agreement on the CAP outline a more balanced approach between digitalization, ecologization, and social goals.

Furthermore, our results show that the CAP and its greening have not had any meaningful impact on the sustainability of the Hungarian agribusiness sector. On the contrary, the examined statistical indicators show a deteriorating situation in every field. Thus, based on the statistical outcomes and the analysis of documents, we identified five policy gaps affecting sustainability: (1) a lack of an ecological approach, (2) climate change is not getting enough attention, (3) complex landscape management does not appear in the documents, (4) measures that increase inequalities between farmers, (5) the DFS does not deal with healthy food consumption and food waste issues.

Concerning the first policy gap, we do not question that the digitalization of agriculture has many benefits, such as reduced inputs and increasing outputs, which means higher production efficiency and lower environmental impact [58]. However, only the systematic application of digital technologies can bring the results expected by policymakers [59]. This presupposes that a significant part of Hungarian farms will use these innovations, for which most are unprepared, as our analysis shows in Section 5.1.2. Overall, forced technological modernization means increasing the performance of traditional large-scale agriculture, which is primarily in the interests of technology manufacturing companies [34,60].

On the other hand, one of the most complex forms of the agro-ecological approach is so-called regenerative agriculture [61,62]. This type of cultivation offers a way out of soil erosion and degradation by replenishing vital nutrients and restoring soil organic matter, microorganisms, and fauna [63]. Thus, this approach eliminates the burden on the most critical environmental resources related to production and improves or restores their quality [64]. Therefore, this production method contributes more to sustainability compared to conventional or precision farming without the need to purchase new farm machinery.

In addition to the adverse environmental effects of farming, another major challenge today is climate change (second policy gap). It fundamentally affects crop yields, and thus food security [65,66]. Agriculture's role is complex in this process because it is also a GHG emitter and carbon sequester. For the former role, several studies show that precision and organic farming reduce GHG emissions [67–70]. In addition, organic farming stores CO_2 in the soil [71]. A long-term experiment (Rodale Farming Systems Trial, Kutztown, Pennsylvania, USA) comparing organic and conventional farming systems found that organic systems reduced fossil fuel consumption, thus emitting 30% less GHGs [72,73].

Regarding crop yields and food security, production experience shows that soils treated with conventional deep-plowed cultivation have a higher biomass production potential than soil-friendly farming [74]. In addition, organically produced cereals in Europe lag behind by 30–40% in per-hectare crop yields achieved by traditional cultivation methods [75]. Several researchers [75,76] have concluded that expanding organic farming is hampering the population's food needs due to poorer crop yields. However, the research of Seufert and colleagues [76] also showed that under unfavorable dry-weather conditions, the crop yield of soil-friendly cultivation is more stable. Therefore, there are benefits in both directions (digital and ecological) when climate change and food security are the issues.

Moreover, it must be acknowledged that smart/precision farming approaches are becoming more environmentally friendly and thus more climate-friendly by improving production efficiency [77]. However, this approach does not offer long-term and sustainable solutions to the impacts of climate change, such as droughts, extreme weather events, water scarcity, cropland degradation, and the emergence of new pests. In contrast, every 1% increase in soil's organic matter content by regenerative agriculture practices helps the soil retain 20,000 L more water per hectare [78]. Increased water holding capacity means that plants are more resistant to drought or heavy rainfall, and the need for irrigation decreases. Several studies suggest that regenerative agriculture provides a favorable opportunity to adapt to climate change [61,62]. Others point out that the more varieties of regenerative management practices that are used in either crop production or grazing systems, the more carbon is stored in the soil [79,80].

The third identified policy gap is the missing complex landscape management approach. In addition to agricultural production, rural areas also have other ecological, economic, and social functions [81–83]. Although agriculture is the largest land use sector, its role is not exclusive. It must cooperate with other sectors, such as nature conservation, forestry, tourism, and hunting, to preserve the rural environment and support sustainable economic activities. Complex landscape management brings these rural land-using sectors together, as it is nothing more than a regional manifestation of environmental and natural resource management [84]. It creates an opportunity to maintain and improve ecosystem services (e.g., pollination, pest control, biochemicals from an agricultural point of view) and biodiversity, thus providing better conditions for agriculture. In addition, it facilitates cross-sectoral policy coordination and cooperation, which in Hungary is particularly conflict-prone between nature conservation and agriculture [85]. Therefore, introducing this type of resource management framework would bring mutual benefits to all stakeholders, including precision and organic agriculture. Furthermore, the digital data that arise during the digitalization process is valuable for complex landscape management; thus, the lack of this approach from the DAS is a lost opportunity to facilitate cross-sectoral cooperation.

As the fourth policy gap, digitalization deepens the already significant inequalities between farmers. Smallholders are in a challenging position when digitalization emerges as a primary development direction. They are disadvantaged in technology implementation and climate adaptation due to insufficient resources and knowledge. Most smallholders have long been left out of farm development programs and grants. Moreover, they are mainly affected by aging and the lack of qualified youth who can take their places. The planned measures are primarily attractive to those who already operate larger, more efficient farms, which is confirmed by the results of Balogh and colleagues [86]. The fairness of the new CAP is missing from the Hungarian documents. Thus, forced digitalization increases the inequalities among farmers, which is confirmed by other Hungarian and international research too [86–88]. At the same time, our results verify that the significant expansion of precision agriculture cannot be considered the right direction in Europe [33]. Smart farming technologies are suitable for countries where production (large field sizes), economic (farm size allows economic investment of smart solutions), and social factors (farmers trained in digital applications) are favorable, such as in the United States, Australia, and the eastern part of Germany [89].

The fifth policy gap focuses on the shortcomings of the DFS strategy. It does not address food consumption's health and environmental issues, or more precisely, how the food industry could prevent and help solve nutrition-based health problems and food waste. Based on consumption and health data, the public health product tax ("chips tax") on food and beverages containing too much salt or sugar was unsuccessful in Hungary [90]. From the governmental side, more complex regulation is needed that moves food companies towards producing healthier food. At the same time, the food industry should be involved in shaping consumer attitudes, reducing overconsumption, and promoting quality food.

7. Conclusions

The agri-food sector faces severe challenges, and its ongoing transformation has two fundamental trends: digitalization and ecologization. These are also the main directions of the EGD and new CAP for the period after 2023.

However, there is a danger that post-socialist countries such as Hungary, with solid roots in mechanization and industrial agriculture, will continue a technology-only agrarian development trajectory. The scrutinized Hungarian sectoral development strategies confirmed this hypothesis because the primary goal of these documents is improving sectoral competitiveness through forced digitalization efforts. On the other hand, this means that the policymakers treat sustainability as a secondary issue, which is underlined by the fact that the EU's proposals are often referred to as the "dark green" narrative in public debates in Hungary.

From a sustainability perspective, we identified five policy gaps in the Hungarian strategies: (1) a lack of an ecological approach, (2) climate change is not getting enough attention, (3) complex landscape management does not appear in the documents, (4) measures that increase inequalities between farmers, (5) the DFS does not deal with healthy food consumption and food waste issues.

At the European level, we agree with the proposals of previous research, such as transforming the CAP into a new integrated agri-food policy and putting more emphasis and support on climate change mitigation and the restoration of ecosystem services [8,30]. In addition, it would be necessary to reduce bureaucracy, clear up inconsistencies in the agricultural payment schemes, and strengthen the CAP's monitoring systems to persuade the Member States to move toward the EU's common goals.

At the national level, the Hungarian agribusiness sector and policymakers should outline a more balanced development approach with a comprehensive focus on environmental issues. The benefits of digitalization and ecologization complement each other while strengthening the inclusivity of the development policy. Furthermore, cross-policy coordination and cooperation with nature conservation, tourism, and other rural economic sectors should be improved. Regarding the food industry, supporting healthy food production must be indicated as a goal in the DFS. Companies should be encouraged to provide consumer attitude formation activities to promote healthy food consumption and reduce food waste.

On a practical level, we recommend applying agricultural practices that respond to climate change, help reduce GHG emissions, improve carbon sequestration, reduce land degradation, protect soil moisture content, and restore ecosystem services. In order to help farmers, further training of consultants is needed to recommend methods and development possibilities adapted to the farms' characteristics. In order to achieve all these, the generational renewal of farmers is necessary because neither organic nor precision agriculture can function without them.

Our future research plans focus on farm-level comparisons of precision and organic farming in a drought-affected landscape between the Danube and Tisza rivers. We plan to quantify and assess the advantages and disadvantages of the two cultivation methods because, in the future, production will occur under similar conditions in several Hungarian regions.

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