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Land Productivity and Agri-Environmental Indicators: A Case Study of Western Balkans

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Abstract: Due to the environmental radicalization of European politics, which is reflected in the European Green Deal, Farm to Fork strategy, and new CAP 2023–2027, this paper aims to determine the impact of agri-environmental indicators on soil productivity based on the land productivity function model. The paper focuses on the Western Balkans countries, which are in the process of European integration and which, in the coming period, need to harmonize their agricultural policy with the CAP. First, the aggregate Cobb–Douglas production function has been used to create a land productivity function. Then, the sources of land productivity growth have been calculated, which can be particularly interesting in the context of agri-environmental indicators, such as fertilizer use and livestock density. The research results showed that land productivity is the most elastic concerning changes in the number of livestock units per hectare. Consequently, reducing livestock units had a markedly negative effect on productivity. In addition, the research results showed that using mineral fertilizers is a crucial source of growth in land productivity in these countries. These results imply that the creators of the agricultural policy must carefully assess the pace at which they will harmonize ecological and economic goals, especially if they take into account the current Ukraine crisis that can disrupt the food market.

Keywords: agri-environmental indicators; fertilizer use; European Green Deal; CAP 2023–2027

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1. Introduction

In the last few years, there has been an environmental radicalization of European politics, which is also present in the new proposal of the Common Agricultural Policy (CAP) for 2023–2027. Several important events preceded such changes. The Birds Directive (79/409/EEC) was adopted in 1979. In addition, the Green Paper (1985) is very significant, emphasizing the importance of environmental awareness of farmers and support for areas essential for preserving rural environments. Furthermore, the Nitrate Directives (91/676/EEC), whose aim is to reduce water pollution due to using nitrogen fertilizers, is particularly interesting for this paper. Indeed, the first significant turning point was Agenda 2000, which declared the new CAP goals, which include integration with environmental protection goals and sustainable agriculture promotion, and finally, the previous CAP reform in 2013 tried to respond to new concerns such as climate change, animal welfare, food safety, and the sustainable use of natural resources by including greening of payments to make agriculture more sustainable. According to [1], the new CAP will be vital to securing the future of agriculture and forestry and achieving the objectives of the European Green Deal. The first sentence in the brief overview of the new CAP suggests a strong connection with the European Green Deal. In addition, the Farm to Fork strategy (F2F) stands out as a special strategy that should provide a fair, healthy, and environmentally friendly food system [2]. One of the main goals of F2F is to create a sustainable food system that should have a neutral or positive environmental impact. As Schebesta and Candel (2020) [3] pointed out some precision targets should be achieved by 2030: a reduction of chemical and hazardous pesticides by 50% and a reduction of fertilizer use by 20%. This new state of European policies is particularly interesting for Western Balkan (WB) countries in the European integration process, which includes harmonization with EU policies and strategies. Potentially, this radicalization of EU policies, specifically CAP, could be very harmful to the agricultural sector's economic performance in countries with lower development levels.

These changes in agricultural policy and its goals are the critical motive for choosing this topic. In the context of ecology, it is exciting to analyze the use of mineral fertilizers and the intensification of livestock production due to the opposition of economic and ecological goals. In addition, it is interesting to analyze land productivity in countries with primary economic goals, such as the Western Balkans countries, which will have to harmonize their agricultural policy. Moreover, due to the specific political circumstances (the Ukraine crisis) disrupting the food supply chain, research examining the sources of productivity growth is crucial due to the need for increased food production.

So, this paper is focused on the agricultural sector of Albania, Bosnia and Herzegovina, North Macedonia, Montenegro, and Serbia. More precisely, the main focus is on land productivity and its interrelation with agri-environmental indicators: fertilizer use and livestock density. Therefore, this paper aims to determine the influence of fertilizer use intensification and livestock density on land productivity growth in WB countries. In order to quantify this influence, the land productivity function will be estimated. The application of this model to determine the impact of agri-environmental indicators on the growth of land productivity is the main contribution of this paper (in addition to the quantification of the impact itself). This research fills the gap in the literature that focuses on agricultural productivity because it looks at this phenomenon in the context of environmental goals, not just economic ones. This is particularly important for countries that have yet to adapt their agricultural policy to achieve environmental goals, such as the WB countries.

This paper is structured as follows. Section 2 provides a literature review on land productivity and agri-environmental indicators. Section 3 describes productivity and land productivity function, while the Sections 4 and 5 show results and discussion. The main conclusions are summarized in Section 6.

2. Literature Review

According to Kurduys-Kujawska et al. (2021) [4], productivity in agriculture is a measure of resource efficiency. This definition is crucial because of agriculture's global challenges, such as food security, natural resources degradation, and climate change adaptation and mitigation. Fuglie (2018) [5] points out that improving agricultural productivity is essential regarding global food security. Furthermore, the author claims that the rising agricultural productivity in developing countries increases income and encourages broader economic development. Improving the productivity of agriculture is very important due to the reduction of poverty through providing food security and higher income for farmers. Improving agricultural productivity is particularly significant in the case of countries where the agricultural sector is very important and where there is a large gap between the productivity of the agricultural sector and other sectors of the economy [6]. One of the most comprehensive studies of the partial productivity of agriculture was conducted by Yamada and Ruttan (1980) [7]. They analyzed the partial agricultural productivity of 41 states in 1970, and results showed significant differences in levels of partial productivity among these groups. Sharma, Rao, and Shepherd (1990) [8] observed partial productivity for different regions of the world in 1975 and 1980 and concluded that developed countries achieved higher levels of agricultural productivity than developing countries. In addition, they showed that the differences are more significant in the case of labor productivity than in the case of land productivity. Many authors have analyzed the agricultural sector of the WB. For example, Gajić et al. (2015) [9] compared the production performance of the countries of the Danube region. They showed that higher levels of partial productivity of agriculture are characteristic of EU countries in this region than WB. A similar conclusion is reached by Birovljev et al. (2017) [10]. They showed significant differences in the production and export performance of agriculture of the EU and the Central European Free Trade Agreement (CEFTA) countries (which are WB countries also). Therefore, they point out that it is necessary to create adequate agricultural policy instruments to improve the agricultural sector's performance in these countries before EU accession.

In order to increase productivity, especially land productivity, producers (and policymakers) usually decide to intensify chemical inputs' use, potentially endangering the environment and fostering land degradation. According to Xie et al. (2019) [11], crop production intensification in the developing world began with the Green Revolution. The Green Revolution significantly impacted the widespread use of new, input-responsive seeds and irrigation, fertilizer, and pesticides to increase cereal crop yields and improve food security [12]. With the activities of the Green Revolution, the main agricultural crop productivity more than doubled. The doubling of global food production in the previous decades was accompanied by the intensive use of inputs [13]. Although agricultural intensification led to the increasing productivity of land and volume of food supply, the negative impact on the environment, especially land, was also present. Land is a multifunctional, nonrenewable resource, and its limits are finite [14]. Moreover, besides producing food, fiber, fodder, and biofuel, the land performs many other vital functions, such as climate regulation, flood management, water quality, soil functionality, and cultural landscape and recreation. However, the land used nowadays is not sustainable and causes degradation [15,16]. Taddese (2018) [17] considers land degradation a complex phenomenon induced by natural and socio-economic factors and refers to the loss of biological and economic productivity of the land. The causes of land degradation are numerous, but in the case of agriculture, the negative impacts on land are mainly related to intensive agricultural production. According to ELD (2015) [18], 52% of agricultural land is already moderately or severely damaged by land degradation, and in the next 25 years, it is predicted that further degradation could reduce land productivity by 12% and thus lead to a 30% rise in prices of agricultural products. Agricultural intensification considers producing more per unit of input, and it is a way to increase agricultural productivity and food production [12]. According to Kopittke et al. (2019) [19] intensive agricultural production has so far significantly degraded the soil. The main forms of this degradation include the loss of organic matter, soil pollution due to excessive use of fertilizers, release of the greenhouse effect, loss of biodiversity, etc. Land degradation caused by intensive agricultural production can have a long-term negative impact on ensuring food security in the future. In order to increase agricultural production, the excessive use of agrochemical inputs had negative effects on the environment and human health [20]. Therefore, it is necessary to apply a sustainable method of agricultural production that will enable the recovery of soil, human health, and at the same time, food security.

As awareness of environmental problems caused by agricultural production grows, the number of methods for analyzing this problem is also growing. For example, the European Commission, together with all member states, defined a set of 28 agri-environmental indicators covering various areas that can be used to assess the impact of agriculture on the environment [21]. An empirical assessment of agriculture's environmental effects represents a problem that includes the inability to define and quantify all the impacts of agricultural production on the environment.

3. Materials and Methods

In the last decade, the total factor productivity (TFP) index has been mainly used to measure productivity [22]. The DEA method is the most common, based on which it is possible to obtain the Malmquist TFP index [23]. In addition, authors often decide to use the Färe–Primont Index to estimate agricultural total factor productivity growth [24,25].

However, in the second half of the 20th century, the focus of agricultural economists was mainly on the determinants of the growth of agricultural production and productivity. Very often, authors estimated aggregate agricultural Cobb–Douglas type production function [26–28], which can be presented in the following form:

$$y = A\prod_{i=1}^{n} x_i^{\beta_i} \tag{1}$$

where y—agricultural production; x_i—inputs; A, β_i—estimated parameters.

When the Cobb–Douglas production function is considered in agricultural economics, in many papers, five inputs (the most common are: labor, land, capital, fertilizers and livestock) and one output (value of agricultural production) were taken [29,30]. It can be presented as:

$$\ln Y = \alpha + \beta_1 \ln X_w + \beta_2 \ln L + \beta_3 \ln X_c + \beta_4 \ln X_f + \beta_5 \ln X_l + \gamma \tag{2}$$

where Y—output, X_w—labor; L—land; X_c—capital; X_f—fertilizers; X_l—livestock units; γ—residual.

This model is very useful for determining the causes of production growth. However, there is one more important advantage: it is possible to create a function of partial (land or labor) productivity of agriculture [31–33] simply by dividing the whole function with values for labor or land. As a main aim of this paper is the analysis of land productivity, this function can be expressed as:

$$\ln\frac{Y}{L} = \alpha + \beta_1 \ln\frac{X_w}{L} + \beta_2 \ln\frac{X_c}{L} + \beta_3 \ln\frac{X_f}{L} + \beta_4 \ln\frac{X_l}{L} + \gamma \tag{3}$$

where Y/L—land productivity, X_w/L—labor per land; X_c/L—capital per land; X_f/L—fertilizers use; X_l/L—livestock density; γ—residual.

In the context of modern times, this model can be suitable for determining the impact of agri-environmental indicators on land productivity. Based on the European Commission [21], agri-environmental indicators are the use of mineral fertilizers (*Mineral fertilizer consumption*) and livestock density (*Cropping patterns, Livestock patterns*) (among other 28 indicators presented in Table A1). Indeed, the biggest drawback of the Cobb–Douglas production function is that it shows constant returns to scale. In addition, this function is based on the unrealistic assumption of perfect competition in the factor market. However, in this paper, the model is used to approximate the impact of agri-environmental indicators on land productivity.

After estimation of the land productivity function, it is possible to determine the contribution of individual production factors to the growth of land productivity:

$$r_{Y/L} = \sum_{i=1}^{n} \beta_i r_i + \gamma \tag{4}$$

where $r_{Y/L}$—growth rate of land productivity, r_i—growth rate of use of production factors per land, β_i—coefficients, γ—residual.

This is precisely the most significant advantage of this model. It should also be noted that other models measure land productivity, but they belong more to the domain of agronomy and technology [34].

In the analysis, all data were collected from FAOSTAT [35] due to the lack of data from national statistics. Besides this, data for economic relevance for agriculture were collected from World Bank [36] and Agricultural Policy Plus (APP) [37] databases. Countries included are Albania, Bosnia and Herzegovina, North Macedonia, Montenegro, and Serbia (all of them are WB countries that are still in the process of European integration). The observed period is 2006–2018 due to missing data in the period before.

4. Results

Figure 1 shows indicators of agriculture's economic relevance in the Western Balkans and the EU countries. The lowest share of agriculture in employment is in Montenegro (8% on average), which is expected considering that some other parts of the economy, such as tourism, are far more important for the economy of this country and that the resource potentials are relatively unfavorable for agricultural production. In Serbia, Bosnia and Herzegovina, and North Macedonia, the share of employees ranges from 10 to 20%, which is four to five times higher than the EU average [38]. In Albania, the share of employment in agriculture is at a very high level (39%).

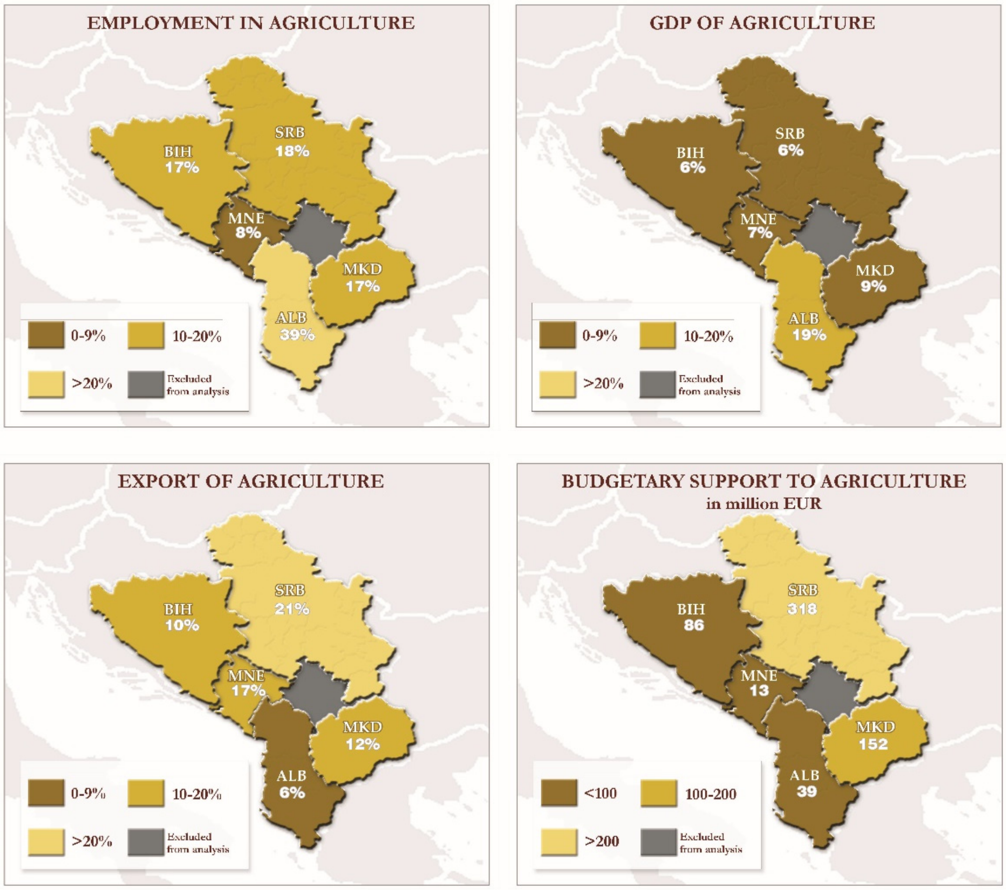

Figure 1. Economic relevance of agriculture in Western Balkans countries. Source: own research on the basis of FAOSTAT, World Bank, and APP Plus.

Note: Employment in agriculture and Export of agriculture (data from FAOSTAT) average for period 2005–2018; GDP of agriculture (data from World Bank) average for period 2005–2018; Budgetary support to agriculture (data from APP Plus) for 2019.

As expected, among the countries of the Western Balkans, the largest share of GDP in agriculture was achieved in Albania, and it is about 19% on average. In the other countries of the Western Balkans, the share of the agricultural sector is at a significantly lower level and ranges from 6 to 9%, with the present decline in the importance of the agricultural sector in the formation of GDP. The largest share of agricultural products in the total value of exports is present in Serbia, where one-fifth of the value of exports is agricultural products. Serbia has the largest comparative advantages on the international market, while only Albania has no comparative advantages in exporting these products [39]. The high share of agriculture in employment and GDP formation and the relatively low share of agricultural products in the total export of Albania (about 5%) imply that the greater part of the production is realized on the domestic market. Total budgetary support to the agricultural sector also greatly influences production performance. The largest volume of funds for agriculture is determined in Serbia, while the smallest volume of funds is in Montenegro, which is the smallest country in this sample, with relatively poor performance for agricultural production. Although all the Western Balkans countries aspire to become EU members, and to harmonize their agricultural policy with the CAP, current support from the budget is more directed towards optimal measures from the domestic (national) political economy perspective [40].

Figure 2 shows land productivity in WB countries in international US dollars per hectare and the productivity growth rate (r). Serbia has the highest level of land productivity, around USD 2000 per hectare, while the highest growth was achieved in Albania (3.01%). In Montenegro and North Macedonia, there was a decrease of 3.07% and 0.69%, respectively. Primarily, agroecological and climatic conditions determine these differences in land productivity as well as overall economic development.

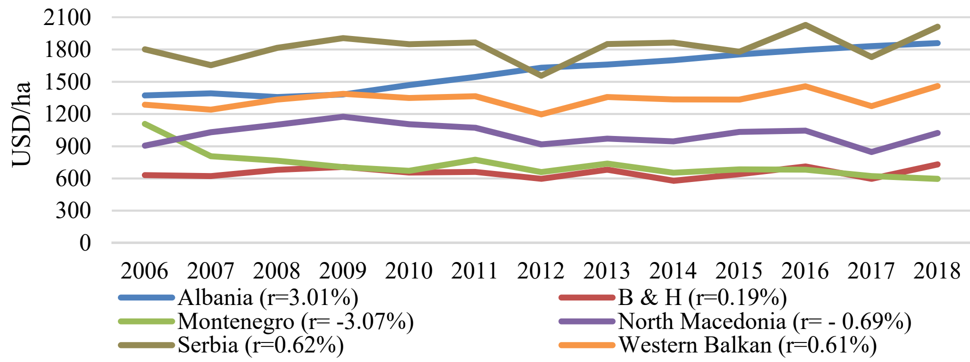

Figure 2. Land productivity in Western Balkans countries. Source: own research on basis of FAOSTAT.

Table 1 shows the regression results for the land productivity function of the WB. The coefficient of determination and the F-test show the validity of the model. All evaluated parameters are statistically significant, except the capital/land ratio. Land productivity is the most elastic in relation to changes in livestock density (0.37) and mineral fertilizer used per hectare (0.24). Both of these variables can be seen as indicators of the intensity of agricultural production.

Table 1. Estimation of land productivity function (OLS model).

Variables	Coefficients	Std. Error	t-Ratio	*p*-Value
const.	1.82	0.430308	4.234422	0.00 ***
Labor/Land	0.16	0.055803	2.804541	0.01 **
Capital/Land	0.02	0.058507	0.333235	0.74
Fertilizers/Land	0.24	0.029196	8.242370	0.00 ***
Livestock/Land	0.37	0.142243	2.602155	0.01 **
R^2			0.76	
Adjusted R^2	0.74			
F (4,73)			56.37	
p-value	0.00			

Note: ***, ** level of significance is 1% and 5%, respectively. Source: own research on basis of FAOSTAT [35].

Table 2 shows an estimation of the contribution of production factors to land productivity change. The most significant influence on land productivity has the use of mineral fertilizer per hectare, among the agricultural inputs. Such results are expected given that the average annual growth rate of mineral fertilizer use per hectare is very high (4.05%) compared to EU-27 (0.7%), which indicates an intensification of production. On the other hand, the decline in the number of employees and the reduction in the number of livestock units per hectare harmed land productivity. The estimated parameter for Labor/Land (0.16) is in line with the study conducted by Khan (1979) [41].

Table 2. Estimation of contribution of production factors to land productivity change.

Inputs	Estimated Parameters (C)	r (Growth Rate)	C x r	Contribution to Land Productivity Change (%)
Labor/Land	0.16	−1.65%	−0.26%	−43%
Capital/Land	0.02	1.81%	0.04%	6%
Fertilizers/Land	0.24	4.05%	0.97%	160%
Livestock/Land	0.37	−1.83%	−0.68%	−111%
Production factors			0.07%	12%
Residual			0.54%	88%
Land productivity growth rate		0.61%	0.61%	100%

Source: own research on basis of FAOSTAT [35].

This indicator could be very interesting from the socio-economic point of view and rural politics because results imply that workers' migration to other sectors has a negative impact on land productivity in WB. All production factors contribute to land productivity change only by 12%, primarily due to the bad influence of livestock unit reduction. Another 88% are linked to residual, which was often explained as technical progress in the past. However, there is still debate about such a conclusion [42].

5. Discussion

As it was explained, in the focus of this paper are land productivity and agri-environmental indicators, so the influence of fertilizer use and livestock density on land productivity will be discussed. The research results clearly showed that land productivity is the most elastic concerning changes in the number of livestock units per hectare, and the decrease in the number of livestock units per hectare had a negative impact on land productivity.

It indicates the extensiveness of agriculture in these countries, where crop production dominates, and livestock production has been stagnant for many years [43]. From an economic point of view, an increase in livestock production would influence the growth of production intensity and, therefore, the growth of land productivity. In all the WB countries, there was a decrease in livestock production in the analyzed period (2006–2018) at an average annual rate of −1% to −2% [35]. In addition, if the livestock density is considered, it is clear that WB countries are far behind EU-27, and a negative growth rate is present in all countries, except Montenegro (Table 3).

Table 3. Livestock unit per hectare (livestock density) in WB countries and EU-27.

	Average 2007–2010	Average 2011–2014	Average 2015–2018	Average	Growth Rate
Albania	0.62	0.62	0.64	0.63	−0.36%
B & H	0.33	0.34	0.31	0.33	−0.58%
Montenegro	0.19	0.28	0.37	0.27	7.65%
N. Macedonia	0.32	0.25	0.25	0.28	−2.76%
Serbia	0.54	0.49	0.48	0.50	−1.14%
EU-27	0.75	0.75	0.76	0.75	0.11%

Source: own research on basis of FAOSTAT [35].

A significant lag in the livestock sector is observed in comparison with the EU countries, especially regarding yields [44]. Although the countries of the WB as a whole have recently achieved some increases in crucial crop and livestock yields and labor productivity over time [38], they are still significantly lagging behind the EU [45]. For example, in Serbia, only one-third of Gross Agricultural Output comes from livestock production. At the same time, since the beginning of the 2000s, the contribution of this sector has decreased significantly, primarily due to the negative development of the meat sector, i.e., negative tendencies in the production of pig and beef meat. The main reasons are the effects of the transition period, poor competitiveness, the poor purchasing power of domestic producers, an inadequate system of incentives, and the disintegration of the value chain [46]. Similar tendencies were followed by all Central and Eastern European Countries where there was a decline in livestock production after 1990, i.e., an orientation towards more extensive sectors. As a result, the contribution of livestock production to the Gross Agricultural Output in these countries does not exceed 50% in these countries, so it is important to note that both labor and land productivity significantly increased for most of these countries after the accession to the EU [46].

In order to improve the performance of livestock production in the WB countries, it is necessary to encourage more intensive production through agricultural policy measures, which would positively affect the food industry [39]. Furthermore, it is very important in ensuring a safe supply of food and reducing import dependence [47], which can be particularly problematic in livestock production in the WB countries. Therefore, in the following period, the focus of short-term policy should be incentives to improve livestock production [48] and improve quality standards to increase competitiveness [49]. Previous research shows that it is easier and faster to start product-level agri-food competitiveness concerning country-level competitiveness [50]. Regional-level competitiveness is also important in creating export opportunities on the international market [51] Therefore, support should be directed toward products with comparative advantages, but also in research and development, which significantly influence competitiveness [52] and higher education that also significantly affect competitiveness and sustainable development [53].

However, insufficient intensification of livestock production can have a positive environmental effect. Namely, livestock contributes to releasing nitrogen, phosphorus, and potassium into the environment as much, if not more, than mineral fertilizer [54]. In addition, traces of antibiotics are noticeable in groundwater due to intensive livestock production [55]. The negative effect of livestock production can further adversely affect the food industry and the regularity in the supply chain of raw materials, which can further lead to economic and social insecurity [56].

The impact of livestock production on the environment depends not only on the livestock density index but also on the agricultural practice itself, so the increase in this index does not necessarily mean increased environmental degradation [57]. However, future policy planning based on the Common Agriculture Policy (CAP) and European Green Deal, adoption of appropriate regulations, the establishment of monitoring of financial instruments, regional cooperation, and improvement of risk management can influence the mitigation of these effects on the environment [56]. The results of previous research show that the WB countries have taken steps towards successful strategic planning of policies in the direction of the CAP, but the applied mechanisms are still not in line with the EU [58], both due to the uncertain moment of entry into the EU and the changing character of the CAP [40]. Because of that, livestock production management will play a significant role in improving environmental performance [59].

Estimates are that the relationship between livestock production and environmental protection will become particularly significant in the future, primarily due to the significant growth in demand for livestock products (mainly meat and milk). The growth of livestock production has, as a rule, in recent years generally led to negative effects on the environment [60]. In order to achieve sustainability, it will be required to strive for a double goal, the growth of livestock production, but also the reduction of negative effects on the environment, and 'sustainable intensifications' will be a solution for 'win–win' outcomes for grasslands, the environment, and smallholders [61].

The key source of agricultural growth in the WB countries was the use of mineral fertilizers in the observed period. This result was expected because the average annual growth rate of mineral fertilizer use was very high due to the intensification of the mineral fertilizer application in the transition period. Mineral fertilizers are one of the most important products in the agricultural industry that provide essential nutrients for crops and increase crop yield, agricultural productivity, and food security [62], but, at the same time, the intensive use of mineral fertilizers harms the environment and human health. The negative impacts of mineral fertilizers are mainly related to their production and application. According to Jensen et al. (2020) [63], the production and application of fertilizers have a wide range of environmental impacts, but the authors state that the most critical impacts are the consumption of valuable natural resources, eutrophication, acidification, and global warming. Namely, the authors assert that the production of mineral fertilizer has a high impact on climate change, resource depletion, and acidification, while eutrophication is a consequence of the mineral fertilizer application. There is evidence that fertilizer use has reached critical environmental limits [64], and it is necessary to consider their application in the coming period. Thus, policymakers in the Western Balkan countries must take this harmful effect into account when creating long-term development strategies.

Furthermore, bearing in mind the evolution of the CAP, it is possible to conclude that over time, due to the increasing degradation of the environment and climate changes, its focus shifted from economic to environmental goals. In addition, for the same reasons, the European Green Deal strategy is within the six priorities of the European Commission for the period 2019–2024. For the agricultural sector, the most important is F2F as a part of the Green Deal. When it comes to the use of mineral fertilizers, according to F2F, excess use of nutrients is a significant source of air, soil, and water pollution and climatic impacts. One of the aims of the Farm to Fork strategy is to reduce fertilizer use by up to 20% till 2030, and some of the objectives of the new CAP 2023–2027 should facilitate the achievement of the Farm to Fork strategy aim related to the reduction of the fertilizer application. So, because all the WB countries are aiming to become a member of the EU and that have a relatively high level of mineral fertilizer use, it is important to raise the level of knowledge about the importance of more sustainable agricultural practices, which is at the center of European policies, strategies, and values.

In addition, recent events indicate that specific problems can be expected in the coming period considering the situation in the mineral fertilizers market. Due to the pandemic and Ukraine crisis, the fertilizer price index rose by 43% from around 890 (25 February 2022) to 1270 (25 March 2022) [65]. Indeed, it is difficult to assess the final effects of this crisis, but there will most likely be some instability regarding the supply of mineral fertilizers on the global market. Certainly, this can be a significant threat to the further growth of agricultural production in WB countries.

In the end, it is important to point out that demand for agricultural products will increase due to population and income growth, and by 2050 it will be necessary to produce 60% more food than today which will create additional pressure on land and other scarce natural resources used in food production. In order to satisfy increasing demand, agricultural production will have to grow, and at the same time, it will have to minimize the environmental impact [66]. Furthermore, considering options to expand cultivated land areas are limited [67], future agricultural production will have to be more productive and sustainable at the same time. Willet et al. (2019) [68] pointed out that the current food system needs to be transformed in terms of productivity, resource use, and environmental effect.

6. Conclusions

Based on the research results, it is possible to summarize three key conclusions. First, the main booster of land productivity growth is the increased use of mineral fertilizers in the countries of the WB. However, considering the environmental consequences of the intensive use of chemical inputs, it is questionable how sustainable this growth is. Second, the decrease in livestock units has had a markedly negative impact on land productivity, implying that policymakers must pay special attention to the livestock sector in these countries. Of course, to increase competitiveness in meat and milk production, it is necessary to develop an adequate strategy that includes agricultural and other economic policies. Indeed, the development of this sector must be sustainable due to the negative environmental impact of intensive animal production. Third, as much as 88% of the increase in land productivity is due to other factors, suggesting that technical progress's influence is crucial for growth. The impact of technical progress on productivity growth will be the subject of future research. In addition, the research focus will be on EU countries. The originality of the research is the application of models that were very often used in the second half of the 20th century to observe the impact of agri-environmental indicators on land productivity which is one of the most critical questions of these days. In addition, the paper contributes to the literature concerning WB's agricultural sector and can influence policymakers' decisions in these countries. However, the paper's main limitations are the lack of a more extended time series of data due to specific regional political events (such as Yugoslavia's breakup) and the limitations of the Cobb–Douglas function itself. In the end, it is essential to emphasize that the creators of the agricultural policy must carefully assess the pace at which they will harmonize ecological and economic goals, especially if they take into account the current Ukraine crisis that can disrupt the food market, especially in the livestock sector and threaten food security in WB.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Agri-environmental indicators.

Indicator
1. Agri-environmental commitments
2. Agricultural areas under Natura 2000
3. Farmers' training level and use of environmental farm advisory services
4. Area under organic farming
5. Mineral fertilizer consumption
6. Consumption of pesticides
7. Irrigation
8. Energy use
9. Land use change
10. Cropping patterns, Livestock patterns
11. Soil cover, Tillage practices, Manure storage
12. Intensification/extensification
13. Specialization
14. Risk of land abandonment
15. Gross nitrogen balance
16. Risk of pollution by phosphorus
17. Pesticide risk
18. Ammonia emissions
19. Greenhouse gas emissions
20. Water abstraction
21. Soil erosion

Table A1. *Cont.*

Indicator
22. Genetic diversity
23. High Nature Value farmland
24. Production of renewable energy
25. Population trends of farmland birds
26. Soil quality
27. Water Quality—Nitrate pollution, Pesticide pollution
28. Landscape—state and diversity

Source: European Commision [21].

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