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ARTICLE

Analysis of the Agricultural Sector Impact on the Territory Sustainable Development in Kyrgyzstan through the Integral Indicators Calculation

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ABSTRACT

The main objective of this study is to rank the territories of Kyrgyzstan by calculating integral indicators consisting of certain parameters of the agricultural sector that affect their sustainable development. The paper presents an approach to selecting territorial indicators considering the reflection of social, economic, and environmental aspects of development, namely: employment in the agricultural sector and poverty level; gross agricultural output per capita and its growth rate; reforestation and pesticides used in agriculture. In accordance with the methodology for calculating integral indicators, composite indices were determined reflecting the influence of the agricultural

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sector on the regions of the country for the following years with a five-year step: 2013, 2018, and 2023. The average composite indices of the influence of the agricultural sector on all regions by year were 2.81 (2013), 3.30 (2018), and 2.99 (2023). According to the results of ranking individual territories, the Chui and Issyk-Kul regions have consistently high results of the influence of the agricultural sector on their development. Batken region had the lowest rating for all observed periods, and Talas did the same during 2018–2023. In general, this methodological approach allows for similar calculations of the influence of any industry/sector on the development of the territory of a country or group of countries.

Keywords: Sustainable Development; Agricultural Sector; Methane Emissions; Territories; Peasant Farms; Personal Subsidiary Farms; Integrated Impact Indicator

1. Introduction

The development of the modern economy is accompanied by an increasing flow of capital into the development of innovative and digital technologies, the relocation of corporate production capacities from countries with cheap labor back to their countries of origin, rapid changes in global logistics chains, and massive, uncontrolled migration flows of people.

All this does not reduce people's needs for food produced by both innovative and traditional methods. The agricultural sector of the Kyrgyz Republic (KR) is represented, for the most part, by traditional production. It has important socio-economic significance, guaranteeing food security, saturating domestic and export markets with agricultural products, and providing the population with sources of income and employment [1,2]. At the same time, the development of this sector in individual regions of the country is not uniform, which affects the stability of these regions.

Therefore, our research needs to determine the influence of the agricultural sector on the development of the country's regions and their subsequent ranking.

To determine the impact of the agricultural sector on the territory of the country, it is necessary to justify the choice of influencing factors and determine their contribution to the total impact of this sector on the development of the territory. The agricultural sector of Kyrgyzstan consists of agriculture, forestry, hunting, and fishing. Currently (2023), this sector provides 9.5% of the country's GDP [3], employs 17.1% of all workers [4], and is developing in all regions of the country, determining their social, economic, and environmental parameters.

The definition of indicators that can directly measure the impact of the agricultural sector of the economy on the above-mentioned parameters of the country's development, and especially its regions, is a pressing task and is distinguished by its novelty.

The main methodology of our analysis is to determine quantitative indicators of changes in the agricultural sector, which together reflect the main aspects of the impact of this sector on the development of individual territories and, if necessary, can form the basis for calculating the integral index of this process. It should be noted that the agricultural sector of the country, according to the methodological approach of the National Statistical Committee of the Kyrgyz Republic (NSC KR), consists of agriculture, forestry, and fisheries, while the gross output of agricultural products directly constitutes the prevailing part of the GDP of the entire agricultural sector [3].

Each region of Kyrgyzstan has specific development of the real economy, population, and state of the environment, therefore, determining the level of impact of the agricultural sector on individual regions of the country by calculating the integral indicator will allow them to rank, as well as identify directions and opportunities for alignment in the growth of these regions from the point of view of their sustainable development.

Ranking by integrated indicators selected to obtain quantitative assessments is a necessary tool for government agencies responsible for the regional growth of economic sectors when developing regulatory measures for managing sustainable development processes in territories.

Thus, the importance of the agricultural sector of

Kyrgyzstan is constantly growing due not only to the obvious global crisis of rising food prices, but also due to its impact on the development of the country's territories.

2. Brief Description of the Sector

The distinctive feature of the agricultural sector of Kyrgyzstan is the almost equal development of crop production (47.9%) and livestock farming (47.5%) with an extremely insignificant level of others (production of sectoral services, forestry together with hunting and fishing) in total not exceeding 5% of the gross output of the agricultural sector of the country. The main producers in the agricultural sector of the country are peasant (farm) households (PFH) and personal subsidiary plots (PSP) of the population, which together produce 95.6% of the gross output of the sector (**Figure 1**).

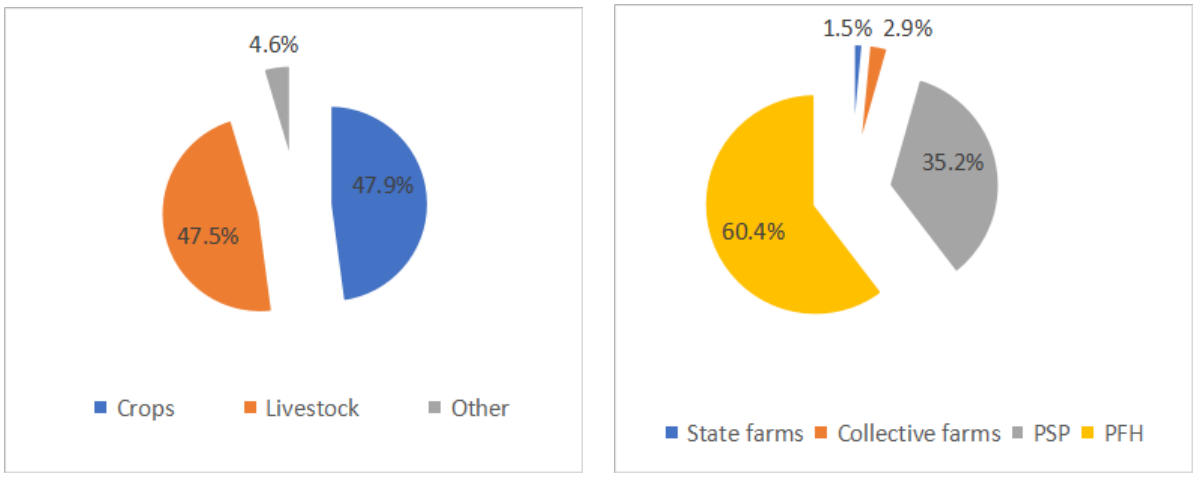

Figure 1. Structure of production and categories of producers in the sector, 2023.

Hence, it is extremely important to monitor the production priorities of the main categories of producers in the Kyrgyz Republic[5]. In the production of crops and livestock products, various organizational forms give preference to those types of production whose volumes and, accordingly, related incomes they can best provide, given the available crop areas, climatic conditions, and, most importantly, market demand for their products.

In **Table 1**, the highest priority or first place is given to those types of products that have the most significant production value. As can be seen, when comparing regional data for 2013 and 2023, the priorities of peasant and private subsidiary farms may coincide, or they may be opposite. For example, in the Talas region in 2013, the cultivation of grain and leguminous crops in private household farms was in fourth place, and in 2023 it shifted to last place, which illustrates, in a certain way, the concentration of leguminous crop production in this region. In the country, over the past decade, the highest priority for both peasant farms and private household farms has remained for growing livestock and poultry. Also, the production of raw milk is the second most important priority for private household farms, and the third most important priority for peasant farms, which illustrates the livestock specialization of the main categories of producers in Kyrgyzstan.

The predominance of agricultural producers in the form of peasant farms (PF) and private subsidiary farms (PSF) in the agricultural sector of the Kyrgyz Republic allows them to provide themselves with the necessary agricultural products, fill local markets with them, preventing a significant increase in prices for food products, supply raw materials to enterprises processing agricultural products, and ensure the export of products[6]. These are the distinctive features of agricultural production in the Kyrgyz Republic.

Table 1. Changes in priorities by region, product type and farm category for 2013/2023.

Region \ Products	Grains and Legumes	Potatoes	Vegetables	Fruit	Growing Livestock and Poultry	Raw Milk
Kyrgyzstan, total						
PFH	2/2	4/5	5/4	6/6	1/1	3/3
PSF	6/6	4/5	3/3	5/4	1/1	2/2
Batken region						
PFH	1/3	6/6	5/5	4/3	2/1	4/2
PSF	6/6	5/5	4/4	3/3	1/1	2/2
Jalal-Abad region						
PFH	3/4	5/5	4/3	6/6	1/1	2/2
PSF	6/6	5/4	3/2	4/5	2/1	1/3
Issyk-Kul region						
PFH	3/3	1/1	6/6	5/4	2/2	4/4
PSF	6/6	4/5	5/4	3/3	1/1	2/2
Naryn region						
PFH	3/3	4/4	5/5	6/6	1/1	2/2
PSF	5/6	2/2	4/4	6/5	1/1	3/3
Osh region						
PFH	1/1	3/4	4/3	6/6	2/2	5/5
PSF	6/6	3/4	4/3	5/5	1/1	2/2
Talas region						
PFH	1/1	2/3	5/5	6/6	3/2	4/4
PSF	4/6	3/3	2/1	6/4	1/2	5/5
Chui region						
PFH	2/3	5/5	3/2	6/6	1/1	4/4
PSF	5/6	4/4	3/3	6/5	1/1	2/2

3. Related Works

We would like to begin our review of related work with the three-pronged concept of sustainable development—the fundamental classical approach that was formulated in the work of the Brundtland Commission [7]. The triune concept stipulates the coverage of social, economic, and environmental characteristics of all measured processes.

The scientific publications we have reviewed resonate with the triune concept and examine the aspects of sustainable development we have indicated with a certain emphasis on the economy of the agricultural sector [8–10], the need to use agricultural science and innovation [11–13], the importance of sectoral social development [14–16], as well as the impact of sectoral production on the environment and climate [17–19].

Smit and Smithers [8] emphasize that agriculture provides for the economic needs of people. According to Brenda [9], sustainable agriculture involves new technologies and innovations that provide higher productivity and profits without harming the environment. In the work of Marambea and Silva [10], it is noted that the economic success of agricultural production has become possible due to the introduction of high-yielding varieties of crops and the use of modern resources such as chemical fertilizers and pesticides.

Wu et al. [11] identified a non-linear relationship between the allocation of agricultural science and innovation resources and rural revitalization. In their previous work, Wu [12] ranked individual areas in Anhong Province, China, according to the efficiency of the scale of allocation of agricultural science and technology innovation resources. In the paper, Yao et al. [13] explored the relationship between agricultural science and technology innovation and the influencing factors in the integration of the agricultural industry.

In the work of Prayitno et al. [14], strengthening social capital in agricultural communities is vital to ensure food security and long-term economic sustainability. Armanto et al. [15] investigated farmers' perception of quality of life, classifying the identified dimensions of this quality, affecting human capital, financial, physical, natural, and social. Sustainable agricultural development is linked to social values by Omar et al. [16].

In an article on the relationship between economic growth and CO_2 emissions, Wahyudi et al. [17] recommend promoting sustainable agricultural development, adopting green technologies, and conducting regular assessments to ensure environmental and economic sustainability to reduce carbon emissions. According to

Nguyen Van et al.[18], green credit should be used to impact the environment and its conservation, which plays a crucial role in promoting sustainable development against the threat of the "brown economy", and with it, climate change. Khan et al.[19] found a growing impact of climate on household food security in disadvantaged areas of Pakistan, including socio-psychological stress and stigma.

In connection with the above, we consider it necessary to note that by measuring the development of the agricultural sector from various sides, namely: society, economy, ecology, we determine the impact of the agricultural sector on the sustainable development of regions. That is, any indicators characterizing the agricultural sector reflect its impact on the development of the territory.

4. Materials and Methods

It should be noted that agriculture has multiple impacts on society[20]. When speaking about the need to define an integral indicator, we must necessarily group social, economic, and environmental indicators for this[21].

The article by Gulaliyev et al.[22] analyzes the essence of agricultural sustainability issues, their economic, social, and environmental aspects, as well as some methods for measuring the level of sustainability. According to the authors, increasing the economic aspect of sustainability can reduce the environmental aspect of sustainability. In our opinion, any selected indicators affect sustainability in a complex manner, and not all economic development reduces the environmental aspect of sustainability. We believe that for an objective assessment of the development of a region, it is necessary to calculate an integrated indicator reflecting three aspects of sustainability: society, economy, and ecology. This indicator will show the complex impact of the agricultural sector on the development of the territory. The triune concept or approach based on the coverage of changes in social and economic indicators is discussed in the works of Abubakar[23] and Mukambaeva[24].

For a comparative assessment of the impact of the agricultural sector on regional development in Kyrgyzstan, it is important to develop a methodological framework to substantiate criteria and indicators reflecting the impact of this sector on social, economic, and environmental parameters in the regional dimension.

First, it is necessary to select indicators that do not require additional research, due to their availability in national statistical materials. The selected indicators can be used to calculate the index of the impact of the object of study by territories (in our case, regions) for their ranking and comparative analysis.

Many indicators reflect social aspects of development. Researchers often suggest using the employment level as a social indicator[2].

The poverty level is justifiably used as an indicator reflecting the social aspect of development. Poverty reduction is a commitment of Kyrgyzstan within the framework of the Millennium Development Goals program to ensure its social development potential.

An important indicator for development, covering primarily economic, but also social and environmental aspects, is the gross output of agricultural products (million soms), which determines its sale on the domestic and foreign markets. To calculate the integral impact index, we take the GDP indicator of the agricultural sector, calculated per capita in the region. This indicator indirectly, and sometimes directly, reflects the provision or saturation of the domestic market of the corresponding territory with agricultural products.

To calculate the integral impact index, the indicators reflecting the environmental aspects of the functioning of the agricultural sector of the Kyrgyz Republic should include the indicator of reforestation, i.e., the area of forest growth, and data on the pesticides used. It is necessary to explain that we will take the restoration indicator as a share of the increase in forest area in each territory, that is, as a ratio of the area of forest restoration to the total area of the state forest fund in each territory. The significance of the forest restoration indicator is due to the leading role of the forest as a protective, environment-forming, and formation system. That is why the reforestation indicator is so important for calculating the integral impact index of the agricultural sector of the economy on the development of the territories of the Kyrgyz Republic.

The use of pesticides is required by the commercial interests of industrial agricultural production [25]. Since insect pest control and plant disease control products are used on both agricultural and non-agricultural lands, we calculated the rate of pesticide use (herbicides and insecticides) per 1000 sq. km of the region's territory.

Thus, to calculate the above index, we selected the following indicators reflecting our conceptual approach to the impact of the agricultural sector on regional development (i) of society: employment rate (%) in the agricultural sector by region of the Kyrgyz Republic [4] and poverty rate (%) [26]; (ii) of the economy: agricultural output per capita in the region (million soms) [3,27] and growth rate of gross agricultural output (%) [3]; (iii) of the environment: the share of reforestation by region of the Kyrgyz Republic (%) [28] and the use of pesticides (herbicides and insecticides), unit of measurement: tons per 1000 sq. km of the region's territory [28].

The six specified indicators are publicly available in the publications of the NSC KR and have both national and regional dimensions. That is, the total and integral indices of the impact of the agricultural sector on the socio-economic development of territories calculated by regions allow for additional regional ranking.

The series of indicators we selected has various distribution patterns and units of measurement. In this regard, an important approach to analyzing various indicators is their preliminary normalization or non-dimensionalization [29].

Normalization is an action on the values of indicators that allows the values of all features to be in a certain predetermined scale (usually from 0 to 1), the standard Equation (1) of which is:

$$K_i = (X_i - X_{min}) / (X_{max} - X_{min}) \quad (1)$$

where: K_i, X_i are the normalized and initial values of the i-th indicator, respectively, Xmax and Xmin are the barrier values of the indicators, which may be some critical values of the indicators, for example, the maximum and minimum.

In our study, the indicators that directly (positively) influence the development of the territories under consideration (employment in the agricultural sector, gross agricultural output per capita, growth in agricultural output, and the share of reforestation) will be standardized according to Equation (1). In this case, to simplify the calculations, $X_{min} = 0$.

Indicators that have a negative impact on the development of the territories under consideration (poverty level and the use of pesticides) are standardized according to Equation (2):

$$K_i = 1 - \frac{X_i}{X_{max}}. \quad (2)$$

In this case, the highest value for any area is taken as the maximum value for each positive indicator. As a result, in this area, the index of this indicator is equal to one.

The maximum value of the negative indicator is equal to zero, which means that there is no positive contribution of this indicator to the total index of the influence of the agricultural sector. For example, the poverty level is a negative indicator. Its highest value is designated as zero, and the highest value of the index reflects the lowest poverty level.

5. Results

To track the dynamics of change, we calculated the proposed index of the influence of the agricultural sector on the territory of the Kyrgyz Republic in the interval 2013–2023 with a breakdown of 2013, 2018, and 2023. The unevenness of the breakdown is not of fundamental importance for the conclusions of the conducted studies. For the control points according to the annual breakdowns, the corresponding years 2013 (**Table 2**), 2018 (**Table 3**), and 2023 (**Table 4**) were constructed.

As a result of calculations for 2013, we obtained the largest impact index for the Chui region, consisting of:

$\kappa_1 = 0.43$; $\kappa_2 = 0.56$; $\kappa_3 = 0.7$, $\kappa_4 = 1$; $\kappa_5 = 1$; $\kappa_6 = 0.00$.

The integral impact indicator, as the arithmetic mean of the obtained indicators (indices), will be equal to:

$$I_{imp} = \frac{\sum i}{6} = 3.66/6 = 0.61,$$

where I_{imp} is the integral indicator of the impact of the agricultural sector on the development of the Chui re-

dex per 1000 sq. km of territory, which characterizes the highest level of application of the specified chemicals, gion. The zero indicator of the pesticide application indid not make any contribution to the total indicator of the impact of the agricultural sector on the development of the Chui region.

Table 2. Agricultural sector impact index for the territory of the KR, 2013.

Indicators / Region	Batken	Jalal-Abad	Issyk-Kul	Naryn	Osh	Talas	Chui
1. Employment index in the agricultural sector	0.40	0.61	0.71	0.74	0.86	1.00	0.43
2. Poverty index	0.00	0.14	0.10	0.19	0.19	0.57	0.56
3. Gross agricultural output per capita index	0.45	0.42	0.68	0.61	0.33	1.00	0.67
4. Agricultural output growth index	0.23	0.12	0.62	0.17	0.00	0.30	1.00
5. Reforestation index	0.21	0.62	0.28	0.32	0.51	0.07	1.00
6. Pesticide application index	0.68	0.26	0.87	0.98	0.44	0.33	0.00
Total impact index	1.97	2.17	3.26	3.01	2.33	3.27	3.66

Table 3. Agricultural sector impact index for the territory of the KR, 2018.

Indicators / Region	Batken	Jalal-Abad	Issyk-Kul	Naryn	Osh	Talas	Chui
1. Employment index in the agricultural sector	0.41	0.59	0.63	0.75	0.79	1.00	0.39
2. Poverty index	0.00	0.05	0.30	0.09	0.56	0.35	0.54
3. Gross agricultural output per capita index	0.51	0.56	0.85	0.70	0.43	1.00	0.87
4. Agricultural output growth index	1.00	0.44	0.96	0.40	0.44	0.31	0.71
5. Reforestation index	0.25	0.65	0.30	0.34	0.50	0.09	1.00
6. Pesticide application index	0.78	0.74	0.91	0.96	0.68	0.00	0.32
Total impact index	2.95	3.03	3.95	3.24	3.40	2.75	3.83

Table 4. Agricultural sector impact index for the territory of the KR, 2023.

Indicators / Region	Batken	Jalal-Abad	Issyk-Kul	Naryn	Osh	Talas	Chui
1. Employment index in the agricultural sector	0.16	0.58	0.58	0.76	0.71	1.00	0.35
2. Poverty index	0.00	0.25	0.19	0.81	0.58	0.52	0.45
3. Gross agricultural output per capita index	0.50	0.59	1.00	0.28	0.43	0.62	0.89
4. Agricultural output growth index	0.48	0.40	1.00	0.32	0.33	0.25	0.44
5. Reforestation index	0.29	0.52	0.45	0.21	0.54	0.47	1.00
6. Pesticide application index	0.83	0.72	0.87	0.96	0.39	0.00	0.20
Total impact index	2.26	3.06	3.09	3.34	2.98	2.86	3.33

The indicators for other areas are calculated similarly. By its nature, the impact indicator is in the range $0 \leq I_{imp} \leq 1$. It is possible to talk about the absolute impact of the agricultural sector only if $I_{imp} = 1$, and about its absence if $I_{imp} = 0$.

The lowest total impact index in 2013 was observed in the Batken region. This is due to the highest poverty level (zero indicator in **Table 2**), the lowest employment index, and below-average reforestation indicator, which in general showed a very low impact of the agricultural sector on the development of the region.

For 2018, for the Issyk-Kul region, we have: $k_1 = 0.63$; $k_2 = 0.30$; $k_3 = 0.857$; $k_4 = 0.96$; $k_5 = 0.30$; $k_6 = 0.91$, for which the integral index of impact (or I_{imp}) is equal to 0.66.

The lowest level of impact of the agricultural sector on the development of the territory relative to other territories in 2018 is observed in the Thalassa region ($I_{imp} = 0.46$). Here in the year under review, the highest index of pesticide use (zero contribution), the zero index of reforestation, as well as the lowest index of GDP growth of the agricultural sector are noted.

It is noteworthy that in 2018, compared to 2013, the most significant decrease (almost 20.0%) in the total index of the impact of the agricultural sector relative to other territories was observed in the Talas region.

For 2023 in the Naryn region (the best result), we have: $k_1 = 0.76$; $k_2 = 0.81$; $k_3 = 0.28$; $k_4 = 0.32$; $k_5 = 0.21$; $k_6 = 0.96$; for which the integral impact index (or I_{imp}) is equal to 0.56.

The lowest level of impact of the agricultural sector relative to other territories in 2023 is again observed in the Batken region (I_{imp} = 0.37).

6. Discussion

Let us consider the behavior of indices by regions of the Kyrgyz Republic. In 2013, high employment in the agricultural sector was noted in the regions of Talas, Osh, and Naryn (the top three). In 2018, the Talas, Osh, and Naryn regions were again in the lead in this indicator. In 2023, the composition of the top three has not changed; only the regions of Naryn and Osh have changed places. The lowest, and sometimes one of the lowest, employment in the agricultural sector in the Batken region indicates that in this region, compared with other regions for all the periods under consideration, the share of agricultural firms, collective farms, cooperatives, and similar organizations in the structure of the main forms of producers in the agricultural sector is very low, employment in which is reflected in the statistics. In other words, an increase in the number of large and medium-sized producers could improve the employment index in the Batken region.

We also conducted a dispersion analysis of the data using the Excel package "Data Analysis" at a given significance level of 0.05. The analysis allowed us to identify trends in the behavior of our indicators in the period under review, 2013–2023.

When calculating the average employment: 0.73 (2013), 0.69 (2018), 0.66 (2023), there is a decrease in the indicator for the selected period. That is, employment in the agricultural sector is falling in all regions of the country. The dispersion increases from 0.04 (2013) to 0.05 (2023), which indicates an increase in regional employment disparities.

Regarding the poverty level, in 2013, the lowest value of this indicator was observed in the Talas region, and also with a minimal lag in the Chui region. In 2018, the lowest poverty level was observed in the Osh region and then in the Chui region. In 2023, the lowest poverty level was found in Naryn and Osh region. As we can see, over the 10 years, low poverty levels have been consistently maintained in Talas, Chui, Osh, and Naryn regions. The highest poverty level for all three observation periods was observed in the Batken region. In addition to the tense labor market in this region, indicating a shortage of jobs, it is also worth noting a significant share of the region's population who not only do not have the means to rent a plot of land to grow crops, but also do not have their farmstead to keep livestock and poultry.

The values of average poverty indicators show an increase in their values from 2013 to 2023 (0.29, 0.31, 0.36), which indicates an increase in the poverty level in the country with its uniform distribution across regions, as indicated by a drop in dispersion from 0.46 to 0.28.

Further, in **Figures 2**, **3**, and **4**, we showed changes by regions and years of average indices, grouped according to their belonging to social, economic, and environmental indicators.

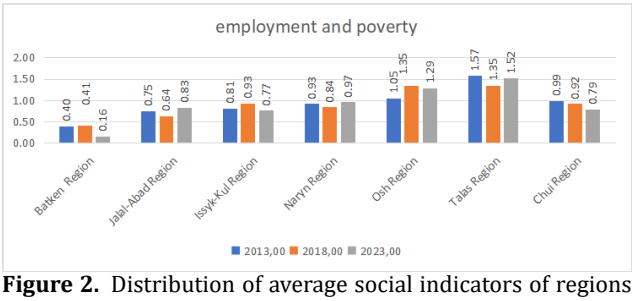

Figure 2. Distribution of average social indicators of regions by years.

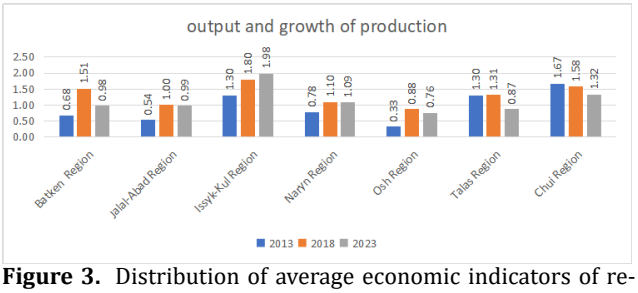

Figure 3. Distribution of average economic indicators of regions by years.

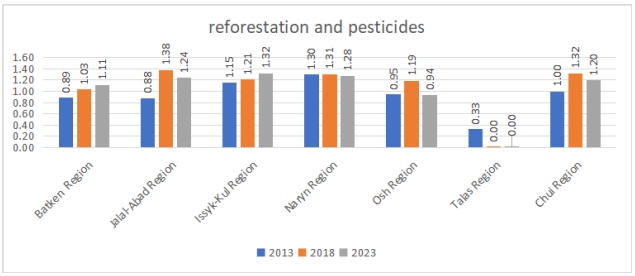

Figure 4. Distribution of average environmental indicators of regions by years.

GDP of the agricultural sector per capita of the region. Talas, Issyk-Kul, and Chui regions demonstrated the best indicators for 2013. Subsequently, these regions distinguished themselves again —Talas, Chui, and Issyk-Kul in 2018; Issyk-Kul, Chui, and Talas in 2023. The worst-performing regions in terms of sector GDP per capita were: Osh in 2013, Osh in 2018, and Naryn in 2023.

A comparison of sector averages for GDP per capita shows an increase from 0.62 in 2013 to 0.73 in 2018, followed by a slight decrease in 2023 (0.71). Overall, however, we can talk about an upward trend. However, the gradual decrease in dispersion from 0.06 in 2013 to 0.04 in 2023 indicates a decrease in data dispersion over time. This means that data in later years have become more grouped around their mean. A decrease in the dispersion of gross output per capita means that the differences between the country's regions in this indicator are decreasing. In other words, agricultural production per capita is becoming more uniform across the country.

The highest index of output growth was noted in the Chui region in 2013, the Batken region in 2018, and the Issyk-Kul region in 2023. Analysis of agricultural output growth also showed an increase in its average value from 0.35 in 2013 to 0.61 in 2018, and then a decrease in 2023 to 0.45, remaining higher than in 2013. In general, we can talk about an increase in this indicator. A decrease in dispersion from 0.12 to 0.06 shows a decrease in scatter around the average value, that is, a decrease in differences between regions.

As can be seen from **Tables 1**, **2**, and **3**, the reforestation index is the highest in the Chui region and the lowest in the Talas region for all observation periods. Analysis of average reforestation, as in the case of economic components, showed an increase in average values over the observation period from 0.45 (2013) to 0.47 (2023). A decrease in the dispersion of reforestation from 0.11 (2013) to 0.10 (2023) indicates a decrease in differences in the volumes of reforestation by region. In other words, the share of forest restoration by region is becoming increasingly close in volume.

The use of pesticides in our approach is a negative indicator. In 2013 and 2018, the lowest use of pesticides was noted in Naryn, Issyk-Kul, and Batken regions. In 2018 and 2023, again, Naryn, Issyk-Kul, and Batken showed the lowest use of pesticides. The lowest use of these chemicals for all the periods under review is noted in the Naryn region. This region does not have a large area of arable land—only 9.6% of the arable land area in the country. Due to the severity of the climate, a small number of crops are cultivated here; the region specializes in livestock farming.

A comparison of average pesticide use shows an increase from 0.48 in 2013 to 0.52 in 2023, indicating an increase in its use. At the same time, the dispersion increases slightly in our time interval, from 0.14 to 0.15, that is, differences in the volumes of pesticide use between regions remain. Let us note the negative impact of average environmental indicators on the development of the Talas region (**Figure 4**). This is due to low indicators of forest restoration in the period under review, as well as the worst indicators of pesticide use in this region in 2018 and 2023.

An important environmental direction of development, recently, is the concept of a "green economy". One of the directions of the transition to a "green economy" is the UN initiative, reflected in the Millennium Development Goals for each country, aimed at reducing or completely stopping greenhouse gas emissions. First, this requires reducing methane emissions, since global warming is caused by methane emissions by one-third. This also concerns the agricultural sector, since some experts associate livestock farming with 30% of methane emissions, and crop production with 15% [30].

Regarding Kyrgyzstan, the most effective and gentle for the main forms of producers will be the policy of forestry development, which should be presented as one of the alternative measures to combat greenhouse gases. Therefore, it is very important not only to monitor the behavior of the forest restoration index across the country. A study to determine the necessary scale of increasing the area of forest plantations as an alternative to offsetting methane emissions associated with livestock farming has prospects for future research.

Currently, a significant reduction in methane emissions in livestock farming can be achieved by significantly reducing the number of cattle. For the agricultural sector of Kyrgyzstan, this is a painful issue, given the fact

that the main producers in the agricultural sector of the Kyrgyz Republic are peasant farms and private households, and their most preferred types of production are cattle and poultry farming, as well as milk production, as we have emphasized above. On the one hand, the main source of income for households and the population of Kyrgyzstan is livestock maintenance; on the other hand, the state does not have sufficient financial resources to compensate for the reduction in cattle numbers to reduce methane emissions.

Alternative approaches to reducing methane levels without reducing cattle numbers include special cattle feeding programs that reduce methane production by the animal's body [31] or research that alters the genetics of animals to prevent methane production by editing the animal's genes through cattle vaccination [32]. However, the most effective way to reduce greenhouse gases currently, in our opinion, is technology for directly extracting carbon dioxide or greenhouse gases from the atmosphere and converting them into something useful [33].

According to the EAEU Concept for the implementation of green economy principles, each state must ensure an optimal balance between protecting the environment and climate, on the one hand, and achieving national goals of socio-economic development, on the other [34].

Average total indices of the impact of the agricultural sector in all regions by year: 2.81 (2013), 3.30 (2018), 2.99 (2023). As we can see, the specified index in 2023 became lower than the 2018 index. Nevertheless, in general, we can talk about the growth trend of the average total index in the period under review.

Figure 5 shows the results of ranking our regions by a set of selected indicators. Here, the Chui and Issyk-Kul regions consistently show the best results, the Batken region has been consistently among the outsiders for all three years of observation, and the Talas region has been among the last two years of observation. The remaining regions have average ranks. The obtained results of the study can form the basis for recommendations on improving state policy for the development of the country's regions and their alignment, if necessary. In addition, the situation with the use of pesticides and insufficient forest growth in the Talas region indicates the need to develop a state policy for the development of regions, including measures aimed at improving the safety of the environment, including the soil.

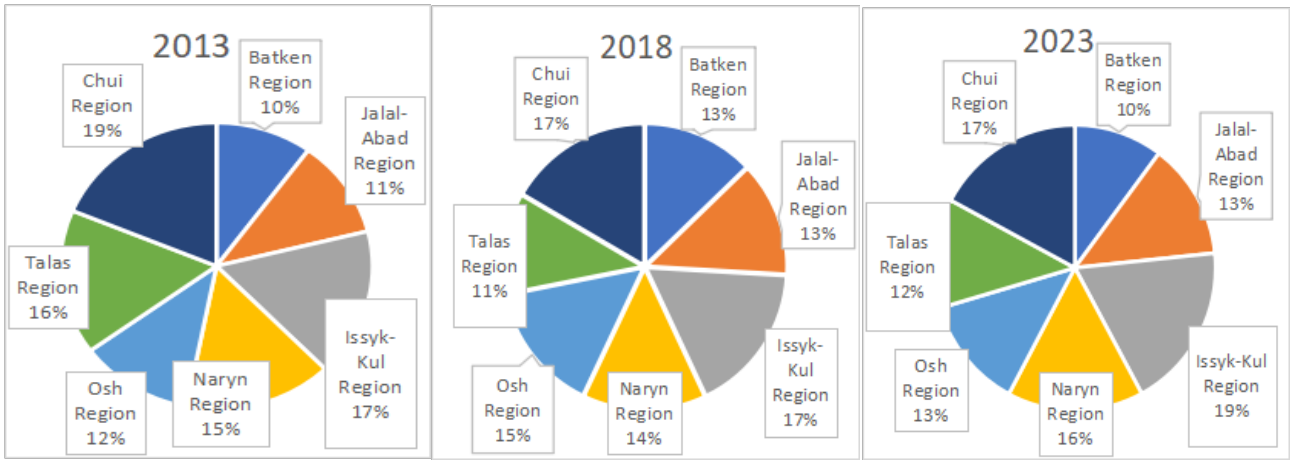

Figure 5. Ranking of regions by years of observation.

Thus, the analysis of the agricultural sector's impact on the territory development of Kyrgyzstan through the calculation of integral indices allows us to track their trends and conduct rankings.

7. Conclusion

The importance of the agricultural sector in Kyrgyzstan is that the sector's producers provide themselves with the necessary agricultural products, fill local markets with them, preventing a significant increase

in prices for food products, supply raw materials to processing plants, and also ensure the export of fresh and processed products from the sector.

For a comparative assessment of the impact of the agricultural sector on regional development across the territory, it is important to develop a methodological approach to substantiate criteria and indicators reflecting the impact of this sector on social, economic, and environmental parameters in the regional dimension.

Our methodological approach is based on the triune concept of sustainable development, which was formulated by the Brundtland Commission. The triune concept stipulates the coverage of social, economic, and environmental characteristics of all measured processes.

First of all, we selected indicators that do not require additional research, due to their availability in national statistical materials.

For an objective assessment of the region's development, it is necessary to calculate an integral indicator reflecting three aspects of sustainability: society, economy, and ecology. This indicator will show the comprehensive impact of the agricultural sector on the sustainable development of the territory.

To calculate the above index, we selected the following indicators reflecting our conceptual approach to the impact of the agricultural sector on regional development: (i) society: the level of employment in the agricultural sector by region and the poverty level; (ii) economy: the output of agricultural products per capita in the region and the growth rate of gross output of agricultural products; (iii) ecology: the share of reforestation by region and the use of pesticides (herbicides and insecticides) per 1000 sq. km of the region's territory.

In this paper, we considered the indicators assuming that their significance (weight) is the same. We believe that it is promising for future research to develop a methodology for determining the significance or weights for the indicators included in the integral indices of impact on the sustainable development of territories.

A dispersion analysis of the indicators included in the integral index showed both growth trends for some of them, which indicates an increase in differences by region, and a decrease trend, which indicates a decrease in differences by region.

In this paper, we considered all the selected indicators with the same weights; we believe that it is promising for future research to calculate the indicators included in the integral indices of impact with the corresponding weights.

The UN global initiative, reflected in the MDGs for each country, is aimed at reducing or completely stopping greenhouse gas emissions. First of all, this requires reducing methane emissions. This also applies to the agricultural sector, since some experts associate livestock farming with 30% of methane emissions, and crop production with 15%.

The problems of reducing methane emissions in Kyrgyzstan are related, on the one hand, to the fact that the main source of income for farms and the population of the country is cattle breeding, on the other hand, the state does not have sufficient financial resources to compensate, for example, for the reduction of cattle population in order to reduce methane emissions.

As alternative approaches to reducing methane levels without reducing cattle population, we recall that there are special cattle feeding programs that reduce methane production by the animal's body. Some studies change the genetics of animals to prevent methane production by the animal's body through genetic editing, such as through cattle vaccination. However, the most effective way to reduce greenhouse gases at the moment, in our opinion, is the technology of direct extraction of carbon dioxide or greenhouse gases from the atmosphere and converting them into something useful.

In order to develop measures aimed at compensating for methane emissions associated with agricultural production, a study to determine the scale of the increase in forest plantation area required for this purpose is promising. In addition, the authors believe that it is possible analyze the reduction of interregional inequality through sigma convergence in the future.

The results of this study can form the basis for recommendations on improving state policy for the development of the country's regions and their alignment, if necessary. Thus, to reduce methane emissions from livestock and crop production in Kyrgyzstan, a state-level program should be developed to introduce technologies for extracting and processing methane from the atmo-

sphere. In addition, an option for offsetting methane emissions from the development of agricultural production in the country will be the intensive development of forestry.

Ranking by integrated indicators selected to obtain quantitative assessments is a necessary tool for government agencies responsible for the regional growth of economic sectors when developing regulatory measures for managing sustainable development processes in territories.

Based on our observations, we can conclude that the solution to issues of integrated development of agriculture is possible only based on an analysis of the economic specifics of its producers, regional development characteristics, social indicators, and taking into account the environmental requirements of modern program frameworks.

Thus, the methodical approach to determining integrated indicators reflecting the complex impact of the agricultural sector on social, economic, and environmental aspects allows for similar calculations of the impact of any sector/industry on the sustainable development of individual territories of any country or group of countries.

Author Contributions

Conceptualization, I.B.M., N.J.M., and N.I.A.; methodology, D.N.K. and L.P.; formal analysis, G.K.E.; investigation, P.L. and G.K.E.; resources, N.I.A. and D.N.K.; data curation, N.J.M., P.L., and G.K.E.; writing—original draft preparation, I.B.M., N.J.M., and D.N.K.; writing—review and editing, I.B.M. and N.I.A. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

The indicators we have considered are publicly available in the publications of the NSC KR and have both a national and regional dimension.

Conflicts of Interest

The authors declare no conflict of interest.

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