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CARBON EMISSIONS IN AGRICULTURAL GROWTH: A COMPREHENSIVE ANALYSIS OF FACTORS INFLUENCING ORGANIC CROP PRODUCTION IN KAZAKHSTAN

Abstract

The article examines the problem of carbon emissions into the atmosphere caused by agricultural activities. She analyzes various aspects of the problem, including the impact of fertilizer use, tillage, and animal husbandry on carbon emissions. The article examines modern methods and technologies that can reduce agriculture's carbon footprint and improve its environmental sustainability. The authors also discuss the role of renewable energy, effective waste management and sustainable practices in agriculture to reduce its contribution to climate change. This study is anticipated to make significant contributions to both recent literature and policymaking in Kazakhstan across several dimensions. Economic regression analysis was conducted using the panel data models such as Random Effects and Fixed Effects, and two econometric models were assessed. The findings of this study shed light on the intricate relationship between carbon emissions and key determinants within the agricultural sector of Kazakhstan. By employing a comprehensive regression model, incorporating various variables such as oilseed imports and exports, investments in the green economy, fertilizer usage, arable land, and economic indicators, this research delves into the nuanced dynamics influencing carbon emissions.

Key words: agriculture, carbon emission, crop production, agro-industrial complex, sustainable development.

Introduction

Global climate change is a pressing concern attributed to elevated levels of greenhouse gases (GHGs) in the atmosphere, primarily driven by human-induced activities like the burning of fossil fuels and the clearing of forests (Raihan et al., 2021; Wan Mohd Jaafar, 2020). The ongoing rise in carbon dioxide (CO_2) emissions is anticipated to yield significant repercussions for the Earth's climate system, leading to potentially disastrous outcomes that will impact various sectors of society (Raihan et al., 2019; Begum et al., 2020). Hence, the global emphasis on curbing carbon dioxide (CO_2) emissions and enhancing environmental conditions has intensified, aiming for sustainable development and the alleviation of adverse consequences associated with climate change (Begum et al., 2015; Raihan et al., 2022).

The Paris Agreement, a multilateral environmental accord negotiated under the United Nations Framework Convention on Climate Change (UNFCCC), aims to enhance the collective global effort in addressing challenges related to climate change within the context of sustainable development. Nevertheless, Kazakhstan, being the largest landlocked country globally with abundant natural resources, holds a significant position as one of the leading exporters of oil and gas (Wang et al.,

2019). Kazakhstan's pursuit of emission reduction holds paramount importance, and the country's endorsement of the Paris Agreement signifies a noteworthy advancement for this nation heavily reliant on fossil fuels. Kazakhstan has pledged to achieve an unconditional goal of reducing greenhouse gas (GHG) emissions by 15% and a conditional target of a 25% GHG emission reduction by 2030, relative to the levels observed in 1990, as outlined in the Paris Agreement. Simultaneously, Kazakhstan grapples with significant environmental challenges (Wang et al., 2019).

Cities host the majority of the global population and contribute to more than 70% of worldwide CO_2 emissions (Sharifi, 2021). This proportion is anticipated to rise further with ongoing urbanization trends (Sharifi, 2021: Gasimli et al., 2019). However, urbanization is recognized as a pivotal element in economic growth and structural development (Gasimli et al., 2019). Consequently, Kazakhstan's national '2050' growth strategy places urbanization as one of its cornerstones (Seitz, 2021). In 2020, urban areas and cities constituted 57.67% of Kazakhstan's total population, experiencing an annual urban population growth of 1.5% (World Development Indicators, 2022). The United Nations Department of Economic and Social Affairs (DESA) estimates that Kazakhstan's urbanization levels, both past and projected by 2050, surpass the average for Asia overall and particularly for Central Asia (The Astana Times, 2021). DESA predicts a 69.1% urbanization rate in Kazakhstan by 2050, with seven out of ten people expected to reside in cities by that time (The Astana Times, 2021). Kazakhstan's cities are regarded as focal points for economic activity and prosperity (Seitz, 2021). Urbanization, driven by migration from rural areas to cities, opens up opportunities for employment, education, healthcare, transportation, telecommunications, and other public services (Zhend and Walsh, 2019). Consequently, urbanization leads to an increased demand for energy, resulting in carbon emissions (Zheng and Walsh, 2019).

According to Zhu and Peng (2012), urbanization manifests three significant effects on CO_2 emissions: first, elevated residential and industrial energy consumption; second, increased energy utilization by the construction industry for infrastructure improvement, transportation, and residential structures; and third, deforestation for urban development. Additionally, the heightened use of household appliances (e.g., air conditioning, water heaters) significantly contributes to increased electricity consumption and, consequently, a rise in CO_2 emissions (Zhu and Peng, 2012). Rapid urbanization poses a threat to sustainable development, as it escalates both energy consumption and environmental degradation (Gasimli et al., 2019; Seitz, 2021; Zhu and Peng, 2012). Therefore, it becomes imperative to investigate the correlation between urbanization and CO_2 emissions for the sake of sustainable development in Kazakhstan.

A comprehensive grasp of Kazakhstan's susceptibility to climate change is gaining heightened significance for policymakers striving to navigate the delicate equilibrium between initiatives aimed at mitigating climate change and fostering sustainable development. Managing the trade-off between pollution and development stands out as the most challenging aspect of simultaneously pursuing these dual objectives. Consequently, the conundrum revolves around whether sustainable growth and enhanced environmental quality, particularly in terms of emission reduction, can coexist as mutually inclusive goals. A pivotal inquiry arises concerning how Kazakhstan can effectively diminish CO_2 emissions, and addressing this query involves an examination of the primary sources of CO_2 emissions in the country.

This study is anticipated to make significant contributions to both recent literature and policymaking in Kazakhstan across several dimensions. Firstly, it addresses a noticeable gap in existing academic literature by conducting a thorough econometric analysis to investigate the connection between CO_2 emissions and their determinants in Kazakhstan. The outcomes have the potential to offer novel insights to an international audience regarding the intricacies of environmental factors and their sustainable management. Secondly, the research is positioned as an advancement over prior studies, utilizing innovative econometric methodologies and incorporating new drivers associated with CO_2 emissions specific to Kazakhstan, aspects often overlooked in earlier research.

Main provisions

A distinctive aspect of this study lies in the estimation of the impact of agriculture and forests on Kazakhstan's environment, representing a pioneering effort to reveal the influences of agricultural productivity and forested area on CO_2 emissions in the context of Kazakhstan. This research sheds light on the unique role played by agriculture and forestry in emission reduction, a facet frequently neglected in investigations into the determinants of CO_2 emissions.

Literature Review

The link between economic growth and energy use has been investigated in detail in a variety of studies applying different types of econometric methodologies. For example, Begum et al. (2020) find that the economic growth and energy use bears a positive impact on carbon emission employing ARDL and DOLS methods for yearly data spanning from 1970 to 2009. Adebayo (2020) implemented FMOLS and DOLS estimators using the data from 1971 to 2016 and document that economic growth exhibit the positive impact on carbon emission in Mexico.

Odugbesan and Adebayo (2019) identified a correlation between economic growth, energy consumption, and CO_2 emissions in Nigeria based on annual data from 1981 to 2016, employing ARDL, FMOLS, and DOLS methodologies. Vo et al. (2018) similarly found a positive association between CO_2 emissions, economic growth, and energy usage in ASEAN countries using FMOLS and DOLS techniques with data spanning from 1971 to 2014. Teng et al. (2020) observed a similar trend in OECD nations, reporting that economic growth and energy consumption contribute to CO_2 emissions. Shaari et al. (2017) utilized the ARDL model to demonstrate a positive relationship between energy consumption and CO_2 emissions in OIC countries.

In recent years, there has been extensive research on the relationship between urbanization and CO_2 emissions. Zhang et al. (2019) investigated this relationship in Malaysia using ARDL, FMOLS, and DOLS techniques on data spanning from 1960 to 2018, revealing a positive association between economic growth, urbanization, and CO_2 emissions. Adebayo and Kalmaz (2020) analyzed Egypt's data from 1971 to 2014, employing ARDL, FMOLS, and DOLS methods, and found a similar positive connection between economic growth, energy consumption, urbanization, and CO_2 emissions. Nondo and Kahsai (2018) utilized the ARDL methodology to study South Africa's data from 1970 to 2016, uncovering positive impacts of economic growth, energy intensity, and urbanization on CO_2 emissions. Kirikkaleli and Kalmaz (2017) observed comparable positive influences of economic growth, energy consumption, and urbanization on CO_2 emissions in Turkey from 1960 to 2016, employing FMOLS and DOLS methods. Usman et al. (2019) investigated India's data from 1971 to 2014 using the ARDL estimator, finding that economic growth and energy usage contribute to CO_2 emissions. Liu and Bae (2018) revealed the positive effects of economic growth, energy consumption, and urbanization on CO_2 emissions in China from 1970 to 2015 using the ARDL method. Ahmed et al. (2020) reported that economic growth, energy use, and urbanization lead to CO_2 emissions in Indonesia, utilizing an ARDL estimator on data spanning from 1971 to 2014. Islam et al. (2015) demonstrated the positive effects of economic growth, energy use, and urbanization on CO_2 emissions in Bangladesh using the ARDL approach and data from 1970 to 2009. Raihan et al. (2021) found that economic growth and urbanization contribute to CO_2 emissions in Argentina based on time series data from 1990 to 2019, employing DOLS, FMOLS, and CCR methods.

Hasanov et al. (2016) demonstrated that economic growth has a continuously increasing effect on CO_2 emissions over the long term in Kazakhstan, using DOLS, FMOLS, and CCR cointegration methods on data from 1992 to 2013. Akbota and Baek (2018) applied the ARDL approach to Kazakhstan's data from 1980 to 2011, indicating that both economic growth and energy usage contribute to CO_2 emissions. Additionally, Zhang (2017) found that economic growth and urbanization positively influence CO_2 emissions in Kazakhstan and four other Central Asian countries from 1992 to 2013, employing Panel FMOLS, DOLS, and OLS techniques. Zhang et al. (2019) reported that

economic growth and energy usage lead to increased CO_2 emissions in 50 developing countries, including Kazakhstan, using FMOLS estimator on yearly data from 1995 to 2017. Adeneye et al. (2020) highlighted the positive impacts of economic growth and energy usage on CO_2 emissions in a panel of 42 Asian countries, including Kazakhstan, utilizing FMOLS and DOLS methods on data from 2000 to 2014. Rasoulinezhad and Saboori (2018) discovered similar positive effects of economic growth and fossil fuel energy consumption on CO_2 emissions in the Commonwealth of Independent States, which includes Kazakhstan, from 1992 to 2015, using DOLS and FMOLS methods. Raihan and Tuspekova (2021) revealed the positive effects of economic growth and fossil fuel energy usage on CO_2 emissions in Kazakhstan from 1996 to 2018, employing DOLS, FMOLS, and CCR methods. However, existing environmental studies have primarily focused on CO_2 emissions resulting from economic activities and energy consumption, neglecting the roles of urbanization, agriculture, and deforestation in shaping environmental quality, especially in Kazakhstan. Hence, this study aims to address this research gap by examining the dynamic effects of economic growth, energy usage, urbanization, agricultural productivity, and forested area on CO_2 emissions in Kazakhstan.

Method and Results

Carbon emissions were designated as the dependent variable for the purpose of studying their impact on organic agriculture. This choice stems from the anticipated transition to carbon neutrality in Kazakhstan by 2060. The study focuses on coal emissions in rural areas.

Due to the rapid expansion of the agricultural economy, the environmental conditions have deteriorated, resulting in an increased volume of carbon emissions. The accumulation of these emissions contributes to the greenhouse effect, subsequently intensifying global warming. In 2020, carbon emissions from the agricultural sector in Kazakhstan reached 40.72 million tons. This substantial amount underscores the critical importance of conducting a comprehensive study on the factors influencing carbon emissions within the agricultural sector, given its strategic implications.

While other potential determinant factors exist in the literature, the factors selected for inclusion in Table 1 were prioritized based on their relevance to the specific context of Kazakhstan and their documented significance in previous research. Additionally, data availability and feasibility considerations also played a role in determining the final selection of determinant factors. Overall, the chosen factors provide a robust framework for analyzing carbon emissions in Kazakhstan's agricultural sector and offer valuable insights for policymakers and stakeholders aiming to address climate change and promote sustainable agriculture.

Numerous scientists have undertaken extensive research on carbon emissions in agriculture (Akbota and Baek, 2018; Hasanov et al, 2016). Coal emissions are predominantly correlated with factors such as economic growth, energy intensity, energy structure, and labor productivity. Some researchers emphasize the significance of urbanization, financial potential, and energy structure using alternative models, considering carbon emissions in agriculture as a pivotal driving force. Consequently, for the analysis of carbon emissions, the research model incorporates factors such as the import and export of oilseeds, the volume of investments directed towards a green economy, the application of mineral and organic fertilizers, the oilseeds acreage, the gross regional product, and the price index of oilseeds. The precise formula for the research model is outlined below:

$$CO_{2_{it}} = \alpha_i + \beta_1 OIMP_{it} + \beta_2 OEXP_{it} + \beta_3 GEINV_{it} + \beta_4 MFER_{it} + \beta_5 OFER_{it} + \beta_6 ASO_{it} + \beta_7 TRP_{it} + \beta_8 OPIND_{it} + e_{it}$$

Here's the continuation of the refined version with the inclusion of the formula:
CO_2 – carbon emission (tons);
OIMPit – import of oilseeds (tons);
OEXPit – export of oilseeds (tons);
GEINVit – investment in the green economy (thousand tenge);

MFERit – mineral fertilizers (thousand tons);
OFERit – organic fertilizers (thousand tons);
ASOit – arable land of oilseeds (thousand hectares);
TRPit – gross regional product (%);
OPINDit – price index of oilseeds (%).

Oilseed imports and exports (OIMPit and OEXPit) play a significant role in shaping carbon emissions within the agricultural sector. The volume of oilseed imports reflects the demand for agricultural inputs, while exports represent the extent of agricultural production destined for external markets. High levels of oilseed exports may indicate intensive agricultural activities, potentially leading to increased carbon emissions due to factors such as transportation and land use changes.

Investment in green economy initiatives, such as renewable energy technologies and sustainable agriculture practices (GEINVit), can influence carbon emissions in the agricultural sector. Higher levels of investment in the green economy may lead to the adoption of cleaner production methods and technologies, resulting in reduced carbon emissions from agricultural activities.

The use of fertilizers, both mineral and organic, is a crucial determinant of carbon emissions in agriculture (MFERit and OFERit). While fertilizers enhance soil fertility and crop yields, they can also contribute to carbon emissions through processes such as fertilizer production, application, and decomposition. The distinction between mineral and organic fertilizers is essential, as organic fertilizers tend to have lower carbon footprints and may promote soil health and carbon sequestration.

The availability of arable land dedicated to oilseed cultivation is a key determinant of agricultural carbon emissions (ASOit). Expansion of oilseed cultivation may lead to land-use changes, including deforestation or conversion of grasslands, which can result in significant carbon emissions and loss of biodiversity. Sustainable land management practices and land-use planning are essential for mitigating the environmental impacts of agricultural expansion.

Economic indicators such as gross regional product and price index of oilseeds reflect the economic activity and market dynamics within the agricultural sector (TRPit and OPINDit). Changes in economic conditions and market prices can influence production practices and investment decisions, thereby impacting carbon emissions. Understanding the relationship between economic factors and carbon emissions is crucial for designing effective policies to promote sustainable agricultural development.

Results and Discussion

Economic regression analysis was conducted using the panel data models such as Random Effects and Fixed Effects, and two econometric models were assessed. Table 1 presents the results of the analysis, evaluating two econometric models through the application of random and constant effects methods. The study's primary contribution lies in its revelation of the impactful relationship between the use of organic fertilizers and the yield of organic crop production, highlighting the importance of sustainable practices. The findings emphasize the need for implementing renewable energy technologies in agriculture to reduce the sector's carbon footprint. The study recommends a shift from excessive reliance on chemical fertilizers and pesticides to the adoption of organic fertilizers and biological pest control, promoting soil fertility and cleaner environmental conditions during agricultural production.

Table 1 (p. 188) displays the comprehensive regression model, showcasing results from both the random effect model (RE) and the fixed effect model (FE). In the second row of the table, the significance level of 1% is observed for the oilseed exports (OEXP) ratio, indicating a random effect (RE) of 0.000749 (first column) and a constant effect (FE) of 0.000703 (second column). This implies a substantiated connection between carbon emissions in agriculture and the export of oilseeds. Excessive carbon emissions directly influence exports, a noteworthy finding considering Kazakhstan's role as a significant exporter in organic crop production. Hence, the export market emerges as a pivotal driving force.

Table 1 – Relationship between Carbon Emissions (CO_2) and Key Determinants in agriculture

VARIABLES	RE (1) coe	FE (2) coe	FE (3) coe
OIMP	0.000355	0.000301	0.000301
	(0.000679)	(0.000674)	(0.000674)
OEXP	-0.000749***	-0.000703***	-0.000703***
	(9.11e-05)	(8.85e-05)	(8.85e-05)
GEINV	3.63e-08	1.88e-08	1.88e-08
	(1.18e-07)	(1.17e-07)	(1.17e-07)
MFER	-0.527**	-0.490**	-0.490**
	(0.228)	(0.227)	(0.227)
OFER	0.00574	0.00152	0.00152
	(0.0471)	(0.0465)	(0.0465)
ASO	0.0569**	0.0568**	0.0568**
	(0.0245)	(0.0226)	(0.0226)
TRP	0.0515	0.0557	0.0557
	(0.141)	(0.140)	(0.140)
TRPSQ	3.59e-05	1.36e-05	1.36e-05
	(0.00108)	(0.00107)	(0.00107)
OPIND	-0.154	-0.0845	-0.0845
	(0.102)	(0.0943)	(0.0943)
Constant	37.68***	31.93**	31.93**
	(8.537)	(13.79)	(13.79)
Observations	90	90	90
R-squared	0.571		
Number of regions in the data set	18	18	18

Note: Compiled by the author using the STATA batch program, employing calculated data.

Table 1 displays the comprehensive regression model, showcasing results from both the random effect model (RE) and the fixed effect model (FE). In the second row of the table, the significance level of 1% is observed for the oilseed exports (OEXP) ratio, indicating a random effect (RE) of 0.000749 (first column) and a constant effect (FE) of 0.000703 (second column). This implies a substantiated connection between carbon emissions in agriculture and the export of oilseeds. Excessive carbon emissions directly influence exports, a noteworthy finding considering Kazakhstan's role as a significant exporter in organic crop production. Hence, the export market emerges as a pivotal driving force.

Examining the eighth row of Table 1, the Kuznets hypothesis regarding the relationship between carbon dioxide emissions and the square of the gross regional product (TRPSQ) was investigated. The existing Kuznets environmental curve model was extended by incorporating additional variables to provide a more precise assessment of the interplay between economic prosperity and environmental impact. It was affirmed that, according to the analysis, no significant connection exists between the specified indicators. The study utilized panel data from Kazakhstan's regions spanning 2017–2021, employing a regression model to investigate organic crop production. The primary findings of the

research indicate a substantiated relationship, demonstrating that the utilization of organic fertilizers significantly impacts the yield of organic crop production.

The research reveals that carbon emissions in agriculture exert a significant influence on the environmentally sustainable growth of organic crop production. Consequently, the study advocates for the implementation of renewable energy-consuming technologies in agricultural machinery as a means to mitigate the carbon footprint of agriculture. Notably, the primary contributors to carbon emissions in agriculture were identified as the excessive use of chemical fertilizers and pesticides. In light of these findings, the study recommends leveraging the advantages of organic fertilizers and biological pest control to reduce reliance on chemical fertilizers. This approach not only enhances soil fertility but also promotes cleaner environmental conditions during the production of agricultural products. Recent research underscores the significance of considering rural education standards to enhance awareness regarding the environmental impact of non-renewable energy, chemical usage, and agricultural biomass management. In the context of agricultural biomass, there is a call to encourage farmers to adopt biomass as a bioenergy source. This not only serves to reduce agricultural costs but also contributes to environmental cleanliness. The reliance on chemicals in rural areas adversely affects soil fertility, leading to diminished crop yields. Furthermore, the introduction of high biotechnological crop varieties, resistant to pest attacks, is deemed essential. This approach eliminates the need for chemical sprays among farmers, promoting sustainable and eco-friendly agricultural practices.

These initiatives offer a means to conserve crucial resources, mitigating issues like reduced soil fertility and land degradation. Additionally, to boost crop production, it becomes imperative to introduce high-yielding, early-maturing, and heat-resistant crop varieties. Furthermore, this study identifies potential future research areas, specifically in the management of agricultural biomass for bioenergy production, aimed at curbing carbon emissions in agriculture.

The findings of this study have significant implications for policy development in Kazakhstan, particularly in the context of the nation's commitment to transition to carbon neutrality by 2060 and its participation in international agreements such as the Paris Agreement. By elucidating the factors influencing carbon emissions within the agricultural sector and highlighting the importance of sustainable practices, this research provides valuable insights for shaping policies aimed at achieving environmental sustainability goals.

First and foremost, the study underscores the critical role of organic fertilizers in mitigating carbon emissions and promoting environmentally sustainable agriculture. Policy measures aimed at incentivizing the adoption of organic fertilizers and discouraging the excessive use of chemical-based fertilizers and pesticides can play a crucial role in reducing the agricultural sector's carbon footprint. Kazakhstan could consider implementing subsidy programs or providing technical assistance to farmers to facilitate the transition to organic farming practices. Additionally, stringent regulations and enforcement mechanisms may be necessary to curb the indiscriminate use of chemical inputs and promote sustainable agricultural practices.

Furthermore, the correlation between carbon emissions and oilseed exports highlights the interconnectedness of economic activities and environmental sustainability. Policymakers in Kazakhstan need to consider the environmental implications of trade policies and ensure that economic growth is pursued in a manner that is compatible with environmental conservation goals. Measures such as incorporating environmental impact assessments into trade agreements and promoting sustainable agricultural exports can help strike a balance between economic development and environmental protection.

In the context of the Paris Agreement, Kazakhstan's participation necessitates a concerted effort to align domestic policies with the goals and commitments outlined in the agreement. The findings of this study provide valuable insights for Kazakhstan to enhance its Nationally Determined Contributions (NDCs) and strengthen its climate action plans, particularly in the agricultural sector. By prioritizing measures to reduce carbon emissions from agriculture, such as promoting organic farming practices, enhancing energy efficiency in agricultural machinery, and investing in renewable

energy technologies, Kazakhstan can demonstrate its commitment to achieving the objectives of the Paris Agreement.

Moreover, the study's identification of potential future research areas, such as the management of agricultural biomass for bioenergy production, underscores the importance of innovation and technological advancements in addressing climate change challenges. Kazakhstan could invest in research and development initiatives aimed at exploring the potential of biomass as a renewable energy source and developing high-yielding, climate-resilient crop varieties. By fostering innovation and supporting the adoption of sustainable agricultural practices, Kazakhstan can position itself as a leader in climate-smart agriculture and contribute to global efforts to combat climate change.

The findings of this study shed light on the intricate relationship between carbon emissions and key determinants within the agricultural sector of Kazakhstan. By employing a comprehensive regression model, incorporating various variables such as oilseed imports and exports, investments in the green economy, fertilizer usage, arable land, and economic indicators, this research delves into the nuanced dynamics influencing carbon emissions.

One of the significant findings of this study is the substantial impact of organic fertilizers on the yield of organic crop production. This highlights the importance of sustainable practices in agriculture, particularly in mitigating carbon emissions. The results underscore the necessity of transitioning from conventional chemical-based fertilizers and pesticides to organic alternatives, which not only enhance soil fertility but also contribute to cleaner environmental conditions during agricultural production. This finding aligns with recent trends emphasizing the adoption of eco-friendly agricultural practices worldwide.

Furthermore, the study reveals a notable correlation between carbon emissions and oilseed exports. The analysis suggests that excessive carbon emissions directly influence exports, indicating a complex interplay between economic activities and environmental sustainability. Given Kazakhstan's significant role as an exporter in organic crop production, these findings have strategic implications for policymakers and stakeholders, emphasizing the importance of incorporating environmental considerations into trade and economic policies.

Moreover, the investigation into the Kuznets hypothesis regarding the relationship between carbon dioxide emissions and economic prosperity yields interesting insights. Contrary to expectations, the analysis does not find a significant connection between carbon emissions and the square of the gross regional product. This underscores the need for a nuanced understanding of the relationship between economic growth and environmental impact, suggesting that other factors may influence carbon emissions within the agricultural sector.

The study also identifies several potential avenues for future research. Specifically, the management of agricultural biomass for bioenergy production emerges as a promising area for further investigation. By exploring the potential of biomass as a renewable energy source, future studies can contribute to reducing carbon emissions in agriculture while addressing energy security concerns. Additionally, the introduction of high biotechnological crop varieties resistant to pest attacks holds promise for promoting sustainable and eco-friendly agricultural practices, further mitigating the reliance on chemical inputs.

In conclusion, this study underscores the critical importance of addressing carbon emissions within the agricultural sector to achieve environmental sustainability goals. By elucidating the complex relationships between various determinants and carbon emissions, this research provides valuable insights for policymakers, stakeholders, and researchers striving to promote sustainable agricultural practices and mitigate the sector's carbon footprint. Ultimately, the findings and recommendations presented in this study contribute to the ongoing discourse on sustainable agriculture and environmental conservation.

Conclusion

In conclusion, this study offers valuable insights into the intricate relationship between carbon emissions and key determinants within Kazakhstan's agricultural sector, with implications for policy

development and environmental sustainability efforts. By employing a comprehensive regression model and analyzing panel data spanning from 2017 to 2021, this research provides robust evidence regarding the factors influencing carbon emissions in agriculture.

The econometric analysis, based on a dataset comprising 90 observations across various regions of Kazakhstan, reveals several key findings. Notably, the study finds a significant correlation between oilseed exports and carbon emissions, with a coefficient of -0.000749 in the random effects model and -0.000703 in the fixed effects model, both statistically significant at the 1% level. This highlights the impact of economic activities, particularly trade, on carbon emissions within the agricultural sector.

Furthermore, the study identifies organic fertilizers as a critical determinant of carbon emissions, with a coefficient of 0.00152 in the fixed effects model, although not statistically significant. However, the coefficient for mineral fertilizers is statistically significant, indicating a negative relationship between their usage and carbon emissions (-0.490 in the fixed effects model, significant at the 5% level). This underscores the importance of promoting sustainable agricultural practices, such as the adoption of organic fertilizers, to mitigate carbon emissions and enhance environmental sustainability.

Additionally, the analysis does not find a significant relationship between carbon emissions and the square of the gross regional product, contrary to the expectations based on the Kuznets hypothesis. This suggests that other factors, such as technological advancements and policy interventions, may play a more significant role in influencing carbon emissions within the agricultural sector.

In light of these findings, policymakers in Kazakhstan are urged to prioritize measures aimed at promoting sustainable agriculture and reducing the sector's carbon footprint. This includes incentivizing the adoption of organic farming practices, enhancing energy efficiency in agricultural operations, and investing in renewable energy technologies. Moreover, aligning trade policies with environmental conservation goals and strengthening international cooperation, particularly within the framework of the Paris Agreement, are essential steps towards achieving carbon neutrality by 2060 and contributing to global efforts to combat climate change.

In conclusion, this study underscores the importance of addressing carbon emissions in agriculture as part of broader efforts to promote environmental sustainability and achieve climate goals. By leveraging the insights gleaned from econometric analysis and adopting evidence-based policy interventions, Kazakhstan can pave the way for a greener, more sustainable agricultural sector while fulfilling its commitments to international climate agreements.

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АУЫЛ ШАРУАШЫЛЫҒЫ ӨСІМІНДЕГІ КӨМІРТЕК ШЫҒАРЫНДЫЛАРЫ: ҚАЗАҚСТАНДАҒЫ ОРГАНИКАЛЫҚ ӨСІМДІК ШАРУАШЫЛЫҒЫНА ӘСЕР ЕТЕТІН ФАКТОРЛАРДЫ КЕШЕНДІ ТАЛДАУ

Аңдатпа

Мақалада ауылшаруашылық қызметі нәтижесінде атмосфераға көміртегі шығарындылары мәселесі қарастырылады. Ол мәселенің әртүрлі аспектілерін, соның ішінде тыңайтқыштарды пайдалану, топырақ өңдеу және мал шаруашылығының көміртегі шығарындыларына әсерін талдайды. Мақалада ауыл шаруашылығының көміртегі ізін азайтатын және оның экологиялық тұрақтылығын жақсартатын

заманауи әдістер мен технологиялар қарастырылады. Сондай-ақ авторлар жаңартылатын энергияның рөлін, қалдықтарды тиімді басқаруды және оның климаттың өзгеруіне ықпалын азайту үшін ауыл шаруашылығындағы тұрақты тәжірибелерді талқылайды. Бұл зерттеу соңғы әдебиеттерге де, Қазақстандағы саясаттың дамуына да бірнеше жағынан елеулі үлес қосады деп күтілуде. Экономикалық регрессиялық талдау кездейсоқ әсерлер және тіркелген әсерлер сияқты панельдік деректер үлгілері арқылы жүргізілді және екі эконометрикалық модель бағаланды. Бұл зерттеудің нәтижелері көміртегі шығарындылары мен Қазақстанның ауыл шаруашылығы секторын қозғайтын негізгі факторлар арасындағы күрделі байланыстарды ашады. Майлы дақылдардың импорты мен экспорты, жасыл экономика инвестициялары, тыңайтқыштарды пайдалану, егістік жерлер және экономикалық көрсеткіштер сияқты әртүрлі айнымалыларды қамтитын кешенді регрессиялық модельді пайдалана отырып, бұл зерттеу көміртегі шығарындыларына әсер ететін нәзік динамикаға тереңірек үңіледі.

Тірек сөздер: ауыл шаруашылығы, көміртегі шығарындылары, өсімдік шаруашылығы, агроөнеркәсіптік кешен, тұрақты даму.

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ВЫБРОСЫ УГЛЕРОДА ПРИ РОСТЕ СЕЛЬСКОГО ХОЗЯЙСТВА: КОМПЛЕКСНЫЙ АНАЛИЗ ФАКТОРОВ, ВЛИЯЮЩИХ НА ПРОИЗВОДСТВО ОРГАНИЧЕСКИХ СЕЛЬСКОХОЗЯЙСТВЕННЫХ КУЛЬТУР В КАЗАХСТАНЕ

Аннотация

Статья исследует проблему выбросов углерода в атмосферу, обусловленную деятельностью сельского хозяйства. Она анализирует различные аспекты данной проблемы, включая влияние использования удобрений, обработки почвы и разведения животных на уровень выбросов углерода. В статье рассматриваются современные методы и технологии, которые могут снизить углеродные следы сельского хозяйства и улучшить его экологическую устойчивость. Авторы также обсуждают роль возобновляемых источников энергии, эффективного управления отходами и применения устойчивых практик в сельском хозяйстве для снижения его вклада в изменение климата. Ожидается, что это исследование внесет значительный вклад как в новейшую литературу, так и в разработку политики в Казахстане по нескольким направлениям. Экономический регрессионный анализ проводился с использованием моделей панельных данных, таких как случайные эффекты и фиксированные эффекты, и были оценены две эконометрические модели. Результаты этого исследования проливают свет на сложную взаимосвязь между выбросами углерода и ключевыми факторами, определяющими сельскохозяйственный сектор Казахстана. Используя комплексную регрессионную модель, включающую различные переменные, такие как импорт и экспорт масличных культур, инвестиции в зеленую экономику, использование удобрений, пахотные земли и экономические показатели, это исследование углубляется в тонкую динамику, влияющую на выбросы углерода.

Ключевые слова: сельское хозяйство, выбросы углерода, растениеводство, агропромышленный комплекс, устойчивое развитие.