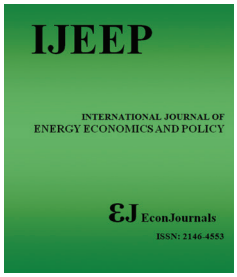

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Renewable Energy, Green Economic Growth and Food Security in Central Asian Countries: An Empirical Analysis

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ABSTRACT

The following paper explores an impact green economic growth, renewable energy consumption, and industrialization have on food security in Central Asian countries, namely Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. We used a POLS model to analyze relationships between selected factors and food security based on panel data for the period between 2001 and 2020, including variables such as the share of renewable electricity, green economic growth, level of industrialization, and arable land area. The results showed a positive impact green economic growth and industrialization have on food security in Central Asia, while renewable energy also contributes to its strengthening, although requires balanced resource management to prevent competition with agriculture. Country-by-country analysis has revealed some differences: Kazakhstan is facing the challenges of transitioning from fossil fuels, Kyrgyzstan and Tajikistan depend on international cooperation to implement renewable energy projects, Turkmenistan, despite having large natural gas reserves, needs to diversify energy resources, and Uzbekistan must find a balance between water resource management and energy needs in the face of a growing population. Results highlight the need for a tailored approach with policy recommendations including increased investment in green technologies, agricultural modernization support, energy industry's balanced development, and international cooperation for sustainable development and food security promotion in Central Asia.

Keywords: Green Economic Growth, Renewable Energy, Food Security, Central Asia, Sustainable Development, Environmental Policy
JEL Classifications: Q18, Q42, Q43

1. INTRODUCTION

Central Asia area includes Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. It is a region with unique natural resources and significant potential for economic development. However, regional nations face a multitude of challenges like climate change, dependence on fossil energy sources, and limited access to resources, especially water. Here, in the Central Asian countries, water resources are pivotal for power production and agriculture. Climate change and limited water resources make food security and sustainable green economic growth in the Central Asian region particularly pressing.

Green economic growth centered around reducing carbon footprint and efficient use of natural resources is becoming a priority for the Central Asian countries. In recent years, researchers such as (Abubakirova et al., 2023; Qin et al., 2022; Hao et al., 2022; Kaliakparova et al., 2020) have shown increased interest in transitioning to renewable energy sources, which could help decrease dependence on hydrocarbons and improve our environmental situation. Renewable energy in the region has the potential to improve food security by reducing environmental impacts and using resources sustainably.

With each Central Asian country having its own unique features, goals, and issues to address, there is a need for a comprehensive study of the relationship between green renewable energy, green economic growth, and food security. Kazakhstan has significant oil and natural gas reserves. This poses challenges for transitioning

to renewable energy. Kyrgyzstan and Tajikistan show significant hydropower potential, but also depend on international assistance for renewable energy projects. Turkmenistan, being one of the largest natural gas producers, needs diversification of its energy resources, while Uzbekistan prioritizes water management and energy efficiency technologies to ensure stable growth.

The objective of this study is to examine the impact renewable energy use, green economic growth, industrialization, and agricultural resources have on food security in the Central Asian countries. The paper uses panel data for the period between 2001 and 2020 and applies the POLS model to assess the relationship between these factors and food security. The focus is on how each Central Asian state's unique features shape their approaches to sustainable development.

The study contributes to approaching the factors requires to achieve sustainable economic growth and food security in the region. The results allow us to develop recommendations that will help Central Asian countries tackle environmental issues and achieve long-term sustainability.

2. LITERATURE REVIEW

2.1. Green Economic Growth, Renewable Energy and Food Security

Recent research shows considerable attention given to the role of green economic growth, renewable energy, and industrialization in ensuring food security, especially in developing regions worldwide.

He et al. (2024) have analyzed extensively how green economic growth and renewable energy affect food security in sub-Saharan Africa. Results of their study show a positive impact renewable energy and green economic growth have on food security while also uneven across regions. Meanwhile, industrialization is a negative factor due to emissions, which is especially critical for agriculture.

Dadzie et al. (2021) have studied sustainability of agricultural practices adapted to climate change using farming households in Ghana. The researchers found that traditional methods have only a minor impact on food security.

Zafeiriou et al. (2022) have assessed the impact of carbon emissions on agricultural profitability in the EU countries. The authors conclude that availability of renewable energy has contributed to reduced emissions, but analyzing its potential for improving food security will require further research.

Osabohien et al. (2023) have demonstrated that the combination of green economy and social protection contributes to improving food security in African countries highlighting the importance of an integrated approach to sustainable development.

Sarkodie et al. (2023) and Kinda (2021) have found mixed effects of green economy indicators on food security, in particular, a positive impact of renewable energy, and no significant impact of carbon dioxide emissions.

For the countries of Central Asia, transitioning to green economic growth and increased use of renewable energy are important if food security is the goal. Abubakirova et al. (2023) and Kaliakparova et al. (2020) have shown that in Kazakhstan and Uzbekistan, renewable energy consumption contributes to economic growth, which is a positive factor for food security. In Tajikistan and Kyrgyzstan, the impact of external investment was less significant. This highlighted these countries' differences in the needs and capabilities in the energy sector.

Hao et al. (2022) have offered an analytical model to assess WEF (water, energy, and food) security in Central Asian countries. Using the TOPSIS method and correlation analysis, the authors have found that among the countries in the region, Kazakhstan's level of WEF security is the highest allowing the state to effectively overcome the issues of sustainable development. The study by Hao et al. (2022) has identified significant opportunities for synergistic improvement between the three sectors, especially in Kazakhstan, where food distribution and supply are priority areas.

The research results confirm that the combination of green economic growth and increased renewable energy is important for regional sustainable development and can help mitigate the impact of climate change on food security in the countries of Central Asia.

2.2. Kazakhstan

Over the last years, researchers (Kakizhanova et al., 2024; Nurgabylov et al., 2024; Wang et al., 2020) have been actively studying the impact green economic growth and transitioning to renewable energy have on food security in Kazakhstan.

Saimova et al. (2020) highlight the importance of transitioning to low-carbon development to minimize agriculture's environmental impact while also ensuring sustainable food supply.

Poberezhskaya and Bychkova (2022) note that as a major fossil fuel exporter, Kazakhstan faces challenges in achieving climate goals due to its dependence on hydrocarbons.

Scientists Abdildin et al. (2021) in their article consider the possibilities of using green technologies to reduce the carbon footprint in Kazakhstan. The authors note that promotion of clean technologies remains low due to Kazakhstan's dependence on fossil energy sources.

Xenarios et al. (2024) discuss barriers to clean energy innovation in Kazakhstan, including low project profitability and a shortage of qualified personnel. Scientists conclude that the identified barriers obstruct transitioning to sustainable energy, ultimately affecting food security across the nation.

2.3. Kyrgyzstan

Komendantova et al. (2022) discuss the impact of various international initiatives, such as the Eurasian Economic Union (EAEU) and the Belt and Road Initiative (China), on Kyrgyzstan's sustainable development. The scientists argue that the use of renewable energy sources, especially solar and wind energy, might

contribute to Kyrgyzstan's economic development and decrease its dependence on fossil fuels.

Filipović et al. (2024) point out that transitioning to a sustainable energy system in Kyrgyzstan is associated with several issues, such as the lack of sufficient investment and support from international institutions.

Kosowska and Kosowski (2022) argue that despite the significant hydropower potential, Kyrgyzstan does not fully utilize it due to limitations related to seasonality and unreliability of energy supply.

Turdiev and Nizamiev (2024) note the importance of an environmental strategy to reduce poverty and developing tourism as an alternative source of economic activity.

Bazarbaeva et al. (2021) highlight the need for climate change adaptation and the creation of "green jobs," linking it to agriculture and renewable energy development.

2.4. Tajikistan

Tajikistan's hydropower resources are vast and essential in ensuring the country's energy and food security.

Xu et al. (2020) have studied sustainability of the Rogun hydropower plant, one of the largest hydropower projects, noting its importance for achieving Tajikistan's energy independence. The paper highlights the risk to sustainable development associated with social and environmental impacts of large dams.

Sidle et al. (2023) explore food security aspects in the mountainous regions of Central Asia. The study indicates that harsh climatic conditions and soil degradation limit agricultural productivity further exacerbating food security issue in the country. Hydropower resources are essential for irrigation but are also vulnerable to climate change.

Kosowska and Kosowski (2022) have discussed energy security issues in Tajikistan, highlighting seasonal variations and the country's dependence on hydropower. The study highlights potential challenges in the face of declining water levels, which could threaten both domestic energy consumption and exports to neighboring countries.

Filipović et al. (2024) have looked into Tajikistan's prospects for a green transition. The authors note that investing in renewable energy is important for sustainable economic development in all Central Asian countries. Green economic growth in Central Asian countries is constrained by structural issues such as low investment levels and complex regulatory frameworks.

2.5. Turkmenistan

Satymov et al. (2021) have offered scenarios for a complete transitioning to renewable energy. Scientists emphasize that solar and wind energy can fully cover the country's needs by 2050, despite the current dependence on fossil fuels.

Penjiyev (2024) discusses plans to develop hydrogen energy as one of the decarbonization pathways, which would potentially reduce Turkmenistan's carbon footprint and improve its energy independence.

Filipović et al. (2024) note that the high share of fossil fuel subsidies and low electricity tariffs hinder investments in renewable energy in Turkmenistan.

Hao et al. (2022) have offered an integrated methodology for assessing security within the WEF system. The authors have proven the need to improve availability of water and food to achieve sustainable development.

Qin et al. (2023) highlight the importance of integrated water, energy, food, and environment (WEFE) management to reduce natural resources pressure and improve the system's resilience. The researchers point out the need for a cross-sectoral approach to ensure balance between different economic sectors.

2.6. Uzbekistan

Djemilov and Kurpayanidi (2024) analyze alternative energy sources' potential for the country's economic growth and suggest policies promoting development of renewable energy for sustainable economic growth.

Tanaka (2022) examines China's participation in renewable energy projects in Uzbekistan under the Belt and Road Initiative, highlighting the importance of green investments for the power sector's sustainable development.

Usmanov and Khamdamov (2024) highlight the role of sustainable practices in long-term economic growth, noting that implementation of green practices in Uzbekistan could improve resource use and public health, despite existing issues in both legislation and investment.

Sangirova et al. (2024) note that green economy contributes to social wellbeing, reduces environmental risks, and optimizes the use of resources. A green economy creates jobs and improves overall environmental sustainability of the country.

Djalilova (2021) focuses on intricacies and opportunities of Uzbekistan's transition to renewable energy, which requires government support and strategies aimed at integrating into the global economy.

Butaboev and Akhunova (2023) analyze Uzbekistan's strategy for transitioning to a green economy, focusing on the need for rational use of natural resources and the development of renewable energy.

Song et al. (2023) study the WEFE (Water-Energy-Food-Environment) nexus in Uzbekistan and emphasize the need for an integrated approach to address water scarcity and improve resource sustainability.

Research shows that Central Asian countries still have a considerable way to go to achieve sustainable development. This

will require reforms, investments, and engaging international partners.

3. DATA AND METHODOLOGY

3.1. Theoretical Foundation and Model Specification

The study is based on the concept of sustainable development that emphasizes the need for a balance between economic growth and environmental constraints to ensure long-term social wellbeing and environmental protection. In the context of current issues such as climate change and an expanding population, sustainable development has become a highlight for improving food security and quality of life.

The model's objective is to study factors affecting food security in Central Asian countries with reference to aspects of green economic growth, industrialization, use of renewable energy sources, and arable land availability. Variables have been carefully selected to assess not only economic growth but also its environmental sustainability. The approach is based on methodology proposed by He et al. (2024) adapted to include indicators specific to sustainable development in countries of Central Asia (see Table 1).

The model is presented as follows:

$$ln(FS_{it}) = \beta_0 + \beta_1 ln(GEG_{it}) + \beta_2 ln(INDUS_{it}) + \beta_3 ln(REL_{it}) + \beta_4 ln(AL_{it}) + \beta_5 ln(REC_{it}) + \varepsilon_{it} \quad (1)$$

where
$ln(FS_{it})$ is the logarithm of the food security level for country i at time t,
$ln(GEG_{it})$ is the logarithm of the green economic growth rate,
$ln(INDUS_{it})$ is the logarithm of the industrialization rate,
$ln(REL_{it})$ is the logarithm of the renewable electricity's share,
$ln(AL_{it})$ is the logarithm of the arable land area,
$ln(REC_{it})$ is the logarithm of the renewable energy consumption's share,
β_0, β_1,…, β_5 are model parameters reflecting the effect of each explanatory variable on the logarithm of food security $ln(FS_{it})$, and ε_{it} is the model error.

Taking the logarithm of variables allows us to estimate elasticities further allowing to interpret coefficients as percentage changes in food security with a 1% change in explanatory variables.

Green Economic Growth (GEG_{it}) has been calculated in accordance with the approach offered in sustainable development research by He et al. (2024). The Green Economic Growth variable has been calculated using the following formula:

$$GEG_{it} = GDPC_{it} + Educ_{it} - Min_{it} - For_{it} - CO_{2it} \quad (2)$$

where
$GDPC_{it}$ is the gross domestic product per capita for country i at time t,
$Educ_{it}$ is government expenditure on education,
Min_{it} is mineral resource depletion,
For_{it} is forest resource depletion, and
CO_{2it} is carbon dioxide emissions damage.

The GEG_{it} value reflects environmentally adjusted economic growth heedful of education expenditure and subtracts the cost of natural resource depletion and pollution damage. The Green Economic Growth variable allows us to consider not only economic growth, but also its impact on sustainability and environmental wellbeing. This is perfectly consistent with the objectives of food security analysis.

The model (1) variables have been selected based on their impact on food security and sustainable development.

Green Economic Growth (GEG) includes adjustments for natural resource depletion and pollution damage, allowing us to consider environmental sustainability.

Industrialization (INDUS) might contribute to income growth and improved infrastructure, positively affecting food security. Renewable Electricity (REL) and Renewable Energy Consumption (REC) have been included to assess energy sustainability's role.

Arable land (AL) is essential in providing agricultural resources.

Each variable is expected to have a specific impact on food security:

- The green economic growth's positive impact is expected to increase food security through more sustainable development patterns.
- Increased industrialization should have a positive impact on food security through infrastructure development and economic opportunities.
- Increased use of renewable energy is assumed to be a sustainability factor decreasing dependence on fossil fuels and environmental pressure.

Table 1: Variable definitions and measurement

Code	Variable	Measurement	Source	Expectations
FS	Food Security	Food production per capita	FAO	Not Applicable
GEG	Green Economic Growth	$GDPC_{it}+Educ_{it}-Min_{it}-For_{it}-CO2_{it}$	Authors	Positive (+)
INDUS	Industrialization	Industry (including construction), value added (constant 2015 US$)	WDI	Positive (+)
REL	Renewable Electricity	Renewable electricity output (% of total electricity output)	WDI	Negative (-)
AL	Arable Land	Arable land (hectares)	WDI	Positive (+)
REC	Renewable Energy	Renewable energy consumption (% of total final energy consumption)	WDI	Positive (+)

$GDPC_{it}$ is gross domestic product per capita (current US$), $Educ_{it}$ is education expenditure (current US$), Min_{it} is the monetary value of depleted minerals (current US$), For_{it} is the monetary value of forest depletion (current US$), $CO2_{it}$ is carbon dioxide damage (current US$).
Source: Authors.

- Increased arable land is associated with better opportunities for food production.

The analysis of sustainable development and food security in the countries of Central Asia allows us to offer recommendations for policies to increase food security and to minimize environmental risks. The model allows taking into account important environmental factors contributing to creation of sustainable food supply systems.

The model is based on the assumption of a linear dependence of variable logarithms and does not take into account possible endogeneity of some factors, such as industrialization. Heteroscedasticity and autocorrelation may affect the accuracy of the results. The use of stable standard errors minimizes the impact of these limitations and offers a more reliable interpretation.

The model provides a structured approach to assessing the relationship between economic growth, environmental factors, and food security, thus making it relevant and meaningful for long-term sustainable policy in Central Asian countries.

3.2. Data and Estimation Technique

The study used panel data for the countries of Central Asia: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. The statistical data cover the period between 2001 and 2020 and include the following variables: green economic growth, industrialization level, share of renewable electricity, arable land area, and renewable energy consumption. The data sources were the World Bank (WDI) and the Food and Agriculture Organization of the United Nations (FAO).

The POLS model was used to assess the factors' impact on food security. The chosen research model allows analyzing panel data pooled across countries and time periods.

Diagnostic tests have been conducted to check the quality of the model. The Durbin-Watson test has been implemented for autocorrelation of residuals, and VIF analysis has been used to assess multicollinearity.

4. RESULTS

4.1. Description of Variables and Correlation Analysis

Table 2 presents descriptive statistics for key variables characterizing sustainable development and food security in Central Asian countries. Each variable has its mean and standard deviation for the full dataset as well as for each country individually: Kazakhstan (KAZ), Kyrgyzstan (KGZ), Tajikistan (TJK), Turkmenistan (TKM), and Uzbekistan (UZB).

The average food security level for the Central Asian countries is 2.54 with a deviation of 0.76 indicating differences in food resources availability. Kazakhstan shows the highest value of 3.76 (0.37) while Uzbekistan has the lowest value of 1.72 (0.4) indicating differences in food security among the countries.

The average value of green economic growth is 20.58 with a deviation of 4.34. In Kyrgyzstan and Tajikistan, this index shows a high stable level, which is reflected by zero or close to zero deviations. Kazakhstan shows a significantly higher deviation (9.13) indicating fluctuations in economic growth depending on extraction and sale of raw materials.

The industrialization indicator shows significant differences across regions with an overall average of 20.62 (3.35). Kazakhstan (24.15) and Turkmenistan (22.68) are the leaders in industrialization level. Uzbekistan's score (14.53) is significantly lower indicating differences in industrial development among the countries. The average value of the renewable electricity share is 3.33 (1.0). Kyrgyzstan and Tajikistan show almost full use of renewable energy (4.45 and 4.59 respectively), while Kazakhstan's and Turkmenistan's values are lower (2.58 and 2.45) indicating differences in the power sector structure.

The average arable land per capita is 14.93 (1.28). Kazakhstan stands out for its high availability of arable land (17.17). Tajikistan shows a relatively low value (13.56), which may limit its possibilities for agricultural production.

The average consumption of renewable energy in Central Asia is 1.26, although the standard deviation is high (2.37) indicating significant variation among countries. Kyrgyzstan and Tajikistan show high levels of renewable energy consumption (3.4 and 4.15). Turkmenistan's value (−2.3) is negative indicating significant use of traditional energy sources.

Table 3 presents correlations between variables for the analysis of Central Asian countries.

The analysis of correlations between the variables given in Table 3 allows us to identify main relationships characterizing food security and sustainable development in Central Asian countries.

The high positive correlation between food security (FS) and arable land area (AL) ($\rho = 0.58$) indicates importance of agricultural

Table 2: Description of variables and correlation analysis

Variable	Mean (standard deviation)					
	Full Sample	KAZ	KGZ	TJK	TKM	UZB
FS	2.54 (0.76)	3.76 (0.37)	2.71 (0.18)	2.02 (0.11)	2.5 (0.06)	1.72 (0.4)
GEG	20.58 (4.34)	16.25 (9.13)	21.9 (0.0)	21.92 (0.01)	21.63 (0.05)	21.2 (0.09)
INDUS	20.62 (3.35)	24.15 (0.16)	20.8 (0.06)	20.94 (0.17)	22.68 (0.07)	14.53 (0.0)
REL	3.33 (1.0)	2.58 (0.11)	4.45 (0.0)	4.59 (0.0)	2.45 (0.05)	2.56 (0.03)
AL	14.93 (1.28)	17.17 (0.01)	14.1 (0.02)	13.56 (0.01)	14.53 (0.0)	15.31 (0.01)
REC	1.26 (2.37)	0.82 (0.15)	3.4 (0.11)	4.15 (0.02)	−2.3 (0.0)	0.22 (0.32)

Source: Authors' compilation

land availability for food resourcing. Availability of arable land is essential for improved food security.

The positive correlation between food security and green economic growth (GEG) (ρ = 0.35) suggests that environmentally friendly economic development contributes to improved food security. Green economic growth is a healthy influence on social and economic wellbeing of Central Asian countries.

The positive correlation between industrialization (INDUS) and green economic growth (ρ = 0.44) suggests that industrial development with an environmentally sustainable approach has a positive effect on economic growth. For the Central Asian countries, this might suggest a successful introduction of technologies minimizing environmental impacts.

The negative correlation between renewable electricity (REL) and food security (ρ = −0.12) might indicate competition between agriculture and the power sector for resources such as water and land used for electric power generation. The growth of renewable energy may temporarily reduce availability of resources for the food sector.

The positive correlation between renewable energy consumption (REC) and food security (ρ = 0.43) suggests that introduction of sustainable energy solutions supports agriculture by decreasing dependence on traditional energy sources and reducing environmental impacts.

The correlation analysis confirms a positive impact an increase in arable land and development of green economic growth have on food security in Central Asian countries. Concurrently, industrialization supported by environmental measures could contribute to sustainable economic growth. A balance between the needs of power and agricultural sectors is required to ensure sustainability of food systems.

Table 3: Correlation analysis

Variable	FS	GEG	INDUS	REL	AL	REC
GEG	0.35	1.00				
INDUS	0.27	0.44	1.00			
REL	−0.12	−0.09	−0.14	1.00		
AL	0.58	0.36	0.32	−0.06	1.00	
REC	0.43	0.28	0.21	0.18	0.49	1.00

FS: Food Security, GEG: Green economic growth, INDUS: Industrialization, REL: Renewable electricity, AL: Arable land, REC: Renewable electricity.
Source: Authors

4.2. POLS Estimation Technique Results

Table 4 shows the results of the POLS analysis performed to estimate relationships between independent variables and food security in the countries of Central Asia.

The results show a positive and statistically significant impact a green economic growth has on food security in Kazakhstan (1.5%), Kyrgyzstan (0.5%), Tajikistan (4%), Turkmenistan (3%), and Uzbekistan (1%), as well as in the full dataset (1%). The results of the analysis point to a positive impact of green economic growth on food security thus confirming the importance of green technologies and sustainable growth for the region's food system.

Industrialization is positively correlated with food security as well. Coefficients show that a 1% increase in industrialization is associated with improved food security in the full dataset (2.5%), Kazakhstan (4.5%), Kyrgyzstan (7.5%), Tajikistan (2.0%), Turkmenistan (6.0%), and Uzbekistan (5.0%). This effect can be explained by income growth and improved infrastructure, which facilitate food access.

For renewable electricity, the results show a small negative impact on food security in the Central Asian countries, although this effect is statistically insignificant. A 1% increase in renewable electricity share is associated with a decrease in food security in the full dataset (0.4%), Kazakhstan (0.5%), Kyrgyzstan (0.3%), Tajikistan (0.6%), Turkmenistan (0.4%), and Uzbekistan (0.2%). The results might indicate competition between agriculture and renewable power sector for resources such as water.

Arable land area has been found to be a significant variable in all models. The results have shown that a 1% increase in arable land is associated with an increase in food security in the full dataset (2.6%), as well as in Kazakhstan (2.5%), Kyrgyzstan (3.0%), Tajikistan (2.2%), Turkmenistan (2.7%), and Uzbekistan (2.8%). The conclusion is that agricultural resources are indeed important for food security in Central Asian countries.

Renewable energy consumption has a positive impact on food security. The 1% increase is associated with an increase in food security in the full dataset (1.1%), Kazakhstan (1.0%), Kyrgyzstan (1.2%), Tajikistan (0.8%), Turkmenistan (1.1%), and Uzbekistan (1.3%). Central Asian policies aim to support sustainable agriculture and decrease dependence on traditional energy sources.

Table 4: POLS results

Dependent variable: Food production per capita						
Variable	**Full Sample**	**KAZ**	**KGZ**	**TJK**	**TKM**	**UZB**
Green economic growth	0.010*** (0.013)	0.015** (0.012)	0.005*** (0.016)	0.040* (0.009)	0.030** (0.010)	0.010*** (0.015)
Industrialization	0.025** (0.009)	0.045* (0.008)	0.075* (0.005)	0.020** (0.011)	0.060* (0.007)	0.050* (0.006)
Renewable electricity	−0.004 (0.180)	−0.005 (0.210)	−0.003 (0.310)	−0.006 (0.150)	−0.004 (0.250)	−0.002 (0.350)
Arable land	0.026*** (0.001)	0.025*** (0.001)	0.030*** (0.002)	0.022*** (0.005)	0.027*** (0.004)	0.028*** (0.003)
Renewable energy	0.011** (0.020)	0.010** (0.030)	0.012** (0.025)	0.008** (0.035)	0.011** (0.020)	0.013** (0.015)
Constant	1.502** (0.003)	1.704** (0.002)	1.340** (0.004)	1.210** (0.005)	1.582** (0.006)	1.670** (0.007)
R.sq.	0.65	0.62	0.58	0.54	0.60	0.64
F-Stat	5.23*** (0.001)	4.98** (0.002)	4.21** (0.005)	3.87** (0.007)	4.35*** (0.003)	4.76** (0.002)

The P value is in the bracket, *, **, *** means significant at 1%, 5% and 10%, respectively.
Source: Authors

Table 5: Results of the POLS model's key diagnostic tests

Tests	Statistics	Notes
Durbin-Watson (Autocorrelation)	2.00	The value is close to 2, there is no autocorrelation
VIF (Multicollinearity)		All values are below 10
• GEG	3.10	
• INDUS	2.85	
• REL	1.95	
• AL	4.25	
• REC	2.40	

Source: Authors

The results of the analysis confirm that green economic growth, industrialization, and renewable energy consumption in Central Asian countries do contribute to food security.

Table 5 shows diagnostic results for the POLS model confirming assumptions to be correct and absence of significant violations in the analysis.

The Durbin-Watson statistic value of 2.00 indicates absence of autocorrelation in the residuals. The model does not suffer from serial correlations, which is important for obtaining reliable coefficients and standard errors.

The VIF values for all independent variables are below 10 indicating absence of significant multicollinearity.

The results of the diagnostic tests suggest that the POLS model is stable enough for the analysis, and its coefficients can be interpreted safely.

5. CONCLUSION

The research uses panel data for Central Asian countries for the period between 2001 and 2020. The POLS model served as a basis for the research.

The results show a positive impact green economic growth and industrialization have on food security contributing to sustainable economic development and increasing access to food resources. Renewable energy can potentially support food security in Central Asian countries. The use of renewable energy requires careful planning to avoid competition with agriculture for water and land resources.

For each Central Asian country, model factors play out differently. Kazakhstan is heavily dependent on fossil fuels making transitioning to renewable energy a priority. Kyrgyzstan and Tajikistan, while limited in financial and technical resources, rely heavily on international cooperation to develop renewable energy. Concurrently, both countries show significant hydropower potential but also face the issue of seasonality in production, which leads to instability in energy supply in different times of the year. Turkmenistan, with its large natural gas reserves, needs to diversify energy resources despite a significant potential for switching to solar and wind energy. Uzbekistan, while actively developing and experiencing a shortage of water resources, faces the need for an integrated approach to achieving energy and food security. Uzbekistan's priority areas are development of energy-efficient technologies and water management, which is critical in the context of population growth and agricultural production.

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